EXHIBIT 1

PERMIT NO. MIG010000

STATE OF MICHIGAN

DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
WASTEWATER DISCHARGE GENERAL PERMIT

CONCENTRATED ANIMAL FEEDING OPERATIONS

In compliance with the provisions of the federal Clean Water Act (federal Water Pollution Control Act, 33 U.S.C. 1251 *et seq*., as amended); Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA); Part 41, Sewerage Systems, of the NREPA; and Michigan Executive Order 2019-06, Concentrated Animal Feeding Operations (CAFOs) are authorized to operate facilities specified in individual Certificates of Coverage (COCs) in accordance with effluent limitations, monitoring requirements and other conditions set forth in this general National Pollutant Discharge Elimination System (NPDES) permit (permit).

The applicability of this permit shall be limited to CAFOs that have not been determined by the Michigan Department of Environment, Great Lakes, and Energy (Department) to need an individual NPDES permit. New swine, poultry, and veal facilities with contaminated areas of the production area exposed to precipitation, including waste storage structures, are not eligible for this permit. “New” means populated after January 20, 2009. Egg processing, egg washing, and duck facilities are not eligible for this permit. Discharges which may cause or contribute to a violation of a water quality standard are not authorized by this permit.

In order to constitute a valid authorization to discharge, this permit must be complemented by a COC issued by the Department and copies of both must be kept at the permitted CAFO. The following will be identified in the COC (as appropriate):

- The rainfall event magnitude at the production area (Part I.B.1.a.2.)
- Data for the application rate table for crops not listed in the permit (Part I.B.3.c.2.)
- Notification of a Total Maximum Daily Load ( ) if the permittee’s production or land application areas are located within a watershed(s) covered by an approved *Escherichia coli (E. coli)*, and/or biota, and/or dissolved oxygen, and/or nutrient (nitrogen or phosphorus) TMDL (Part I.C.9.)
- The date by which the permittee must provide documentation of Natural Resources Conservation Standard (NRCS) 313 environmental equivalency for waste storage structures not meeting NRCS 313 and procured after the effective date of the COC
- Percent of outside materials allowed in the anaerobic digester associated with the CAFO permitted under the COC, if that percentage is greater than five (Part I.C.10.)

Unless specified otherwise, all contact with the Department required by this permit shall be to the position indicated in the COC.

This permit takes effect on April 1, 2020. The provisions of this permit are severable. After notice and opportunity for a hearing, this permit may be modified, suspended, or revoked in whole or in part during its term in accordance with applicable laws and rules.

This permit shall expire at midnight, **April 1, 2025**.

Issued: March 27, 2020.

Original signed by Christine Alexander
Christine Alexander, Manager
Permits Section
Water Resources Division

PERMIT FEE REQUIREMENTS

In accordance with Section 324.3120 of the NREPA, the permittee shall make payment of an annual permit fee to the Department for each October 1 the permit is in effect regardless of occurrence of discharge. The permittee shall submit the fee in response to the Department's annual notice. Payment may be made electronically via the Department's MiWaters system. The MiWaters website is located at https://miwaters.deq.state.mi.us. Payment shall be submitted or postmarked by January 15 for notices mailed by December 1. Payment shall be submitted or postmarked no later than 45 days after receiving the notice for notices mailed after December 1.

CONTESTED CASE INFORMATION

Any person who is aggrieved by this permit may file a sworn petition with the Michigan Administrative Hearing System within the Michigan Department of Licensing and Regulatory Affairs, c/o the Michigan Department of Environment, Great Lakes, and Energy, setting forth the conditions of the permit which are being challenged and specifying the grounds for the challenge. The Department of Licensing and Regulatory Affairs may reject any petition filed more than 60 days after issuance as being untimely.

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PART I

Section A. Effluent Limitations and Monitoring Requirements

1. Authorized Discharges and Overflows

During the period beginning on the effective date of this permit and lasting until the expiration of this permit, overflows and discharges are authorized per the following:

a. Overflows from CAFO Waste Storage Structures
Overflows from CAFO waste storage structures for cattle, horses, sheep, and existing swine, poultry, and veal facilities identified in Part I.B.1. are properly designed, constructed, and are operated and maintained in accordance with the requirements of this permit, the overflow is caused by precipitation events, and do not cause or contribute to an exceedance of Michigan's water quality standards.

b. Discharges from Land Application Areas
Discharges of CAFO waste to surface waters of the state that do not cause or contribute to an exceedance of Michigan's water quality standards are authorized from the land application areas managed in accordance with the Nutrient Management Plan (NMP) requirements set forth in Part I.B.3.

2. Monitoring Requirements

The discharge authorized in Part I.A.1. above, shall be monitored by the permittee as specified below.

Parameter	Units	Daily Maximum	Sample Type	Monitoring Frequency
Storage Structure Overflow				
Volume	Gal	(report)	Report Total Daily Volume	See Part I.A.2.b.
Discharge to Surface Waters of the State				
Volume	Gal	(report)	Report Total Daily Volume	See Part I.A.2.b.
5-Day Carbonaceous Biochemical Oxygen Demand (CBOD5)	mg/l	(report)	Grab	See Part I.A.2.b.
Escherichia coli (*E.coli*)	counts/100ml	(report)	Grab	See Part I.A.2.b.
Total Phosphorus (as P)	mg/l	(report)	Grab	See Part I.A.2.b.
Ammonia Nitrogen (as N)	mg/l	(report)	Grab	See Part I.A.2.b.
Total Suspended Solids (TSS)	mg/l	(report)	Grab	See Part I.A.2.b.

a. Narrative Standard
The receiving water shall contain no turbidity, color, oil films, floating solids, foams, settleable solids, or deposits as a result of a discharge which are or may become injurious to any designated use.

b. Monitoring Frequency
Discharges and overflows shall be monitored once daily by the permittee as specified above on any day on which a discharge occurs. The first sample shall occur within the first six hours of discharge, and then daily thereafter, until the end of the discharge event. All monitoring shall be in accordance with Part II.B.2. of this permit.

c. Monitoring Location and Reporting Requirements
Samples, measurements, and observations of all discharges and overflows shall be taken in compliance with the monitoring requirements in Part I.A.2., be representative of the discharge and are taken prior to the discharge entering surface waters. The permittee shall notify the Department in accordance with the reporting requirements set forth in Part II.C.6. of this permit and shall submit the monitoring requirements set forth in Part I.C.1. of this permit.

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Section A. Effluent Limits and Monitoring Requirements

3. Prohibited Discharges

a. This permit does not authorize any discharge to the groundwaters of the state. Such discharge may be authorized by a groundwater discharge permit issued pursuant to Part 22, Groundwater Quality, of the NREPA.

b. This permit does not authorize dry weather discharge or a discharge of CAFO waste and/or runoff that fails to meet the requirements of Part I.A.1. of this permit. Discharges due to overflows from storage structures at new swine, poultry, or veal facilities are prohibited. Discharges from land application activities that do not meet the requirements of Part I.A.1. of this permit or that cause an exceedance of Michigan's Water Quality Standards are prohibited. Any unauthorized discharges shall be monitored in accordance with Part I.A.2.

c. This permit does not authorize a discharge from new sand bedding.

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Section B. Nutrient Management Plan

The permittee shall implement the following requirements.

1. CAFO Waste Storage Structures

a. Volume Design Requirements
The permittee shall have distinct CAFO waste storage structures designed for each waste type (liquid, as defined in NRCS Standard 313 (2017), or solid, stackable manure) in place and operational at all times that are adequately designed, constructed, maintained, and operated as per Part I.B.1. to contain the total combined volume of all of the following:

1) All CAFO waste generated from the operation of the CAFO, in a six-month or greater time period, including residual solids in waste storage structures designed for liquids, normal precipitation and runoff, and drifted snow accumulation in the production area during the same time period. For under-barn storages, inaccessible concrete lined storages, soil lined storages (either earthen or natural clay base), or synthetic lined storages that receive manure, the residual solids shall be at least six inches, unless the permittee demonstrates annually a lesser amount is achievable. This is the operational volume of the storage structure.

2) For cattle, horses, and sheep, and existing (populated prior to January 20, 2009) swine, poultry, and veal facilities, all production area waste and all runoff and direct precipitation generated from the 25-year 24-hour rainfall event. The magnitude of the rainfall event will be specified in the COC. This is an emergency volume to be kept available to contain large rainfall events.

3) New (populated on or after January 20, 2009) swine, poultry, and veal facilities shall be designed to have all contaminated areas of the production area, including waste storage structures, totally enclosed and not subject to precipitation and, therefore, not needing room for the emergency volume in their storage structures.

4) An additional design capacity of a minimum of 12 inches of freeboard for storage structures that are subject to precipitation-caused runoff. For storage structures that are not subject to precipitation-caused runoff, the freeboard shall be a minimum of 6 inches. This is the freeboard volume.

5) Records documenting the current design volume of every CAFO waste storage structure, including volume for residual solids, design treatment volume, total design volume, volumes of the operational, emergency, and freeboard volumes, and approximate number of days of storage capacity shall be kept in the permittee's (CNMP) for a minimum of five years from the date of creation.

b. Physical Design and Construction Requirements

1) Depth Gauge
CAFO waste storage structures shall include an easily visible, clearly marked depth gauge. Clear, major divisions shall be marked to delineate the operational, emergency (if applicable), and freeboard volumes as specified above in Part I.B.1.a. The top mark of the gauge shall be placed level with the lowest point on the top of the storage structure wall or dike. The elevation for the gauge shall be re-established as necessary but not less than every five years to adjust for any movement or settling. Materials used must be durable and able to withstand freezing and thawing (e.g. large chain, heavy-duty PVC, steel rod). Any depth gauges that are destroyed or missing must be replaced immediately. Under-barn storages may be measured with a dipstick or similar device. For solid stackable CAFO waste storage, depth gauge levels may be permanently marked on sidewalls.

2) Structural Design
Records documenting or demonstrating the current structural design as required below, including as-built drawings and specifications, of any CAFO waste storage structures, whether or not currently

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in use, shall be kept with the permittee's CNMP for a minimum five years from the date of creation. Included in the CNMP submitted to the Department shall be a short description of the structural design of each structure (type of structure; dimensions including depth; liner material, thickness, and condition; depth from the design bottom elevation to the seasonal high water table), a statement whether a professional engineer's evaluation has been completed or not, and a brief description of the results of the evaluation (meets Natural Resources Conservation Service (NRCS) 313 2017 or provides environmental performance equivalent to NRCS 313 2005, 2014, or 2017).

a) New Storage Structures (constructed after the effective date of the COC)
Except as otherwise required by this permit, CAFO waste storage structures shall, at a minimum, be constructed in accordance with NRCS 313 2017.

b) Existing Storage Structures at Newly Permitted CAFOs (facilities without prior NPDES permit coverage)

In a permit application for coverage under this permit, the applicant shall either:

(a) For each existing storage structure document through an evaluation by a professional engineer that each structure is constructed in accordance with NRCS 313 2014 or 2017. Submit to the Department documentation signed by a professional engineer verifying that each structure is constructed in accordance with NRCS 313 2014 or 2017. Complete as-built plans, specifications, drawings, etc. shall be kept at the facility with the CNMP and do not need to be submitted unless requested by the Department, or

(b) For each existing storage structure, on a form provided by the Department and submitted to the Department, demonstrate environmental performance equivalent to NRCS 313 2014. The demonstration shall be accomplished through an evaluation by a professional engineer.

i. The applicant for a Newly Permitted CAFO must provide the documentation or demonstration required by (a) or (b) above prior to populating livestock to the numbers which would require an NPDES permit (per the definition of Part II.A. Large CAFO).

ii. Previously evaluated storage structures at permitted CAFOs shall have documentation demonstrating that the structure was constructed to, or provides equivalent environmental protection to, NRCS 313 2003, 2005, or 2014.

c) For Previously Permitted CAFOs acquiring previously constructed waste storage structures from an unpermitted facility, the COC shall specify the date by which the permittee shall meet the requirements of i) or ii) below, but that date shall be no more than two years from the acquisition of the structures.

i) For each existing storage structure, document through an evaluation by a professional engineer that each structure is constructed in accordance with NRCS 313 2014 or 2017. Submit to the Department documentation signed by a professional engineer verifying that each structure is constructed in accordance with NRCS 313 2014 or 2017. Complete as-built plans, specifications, drawings, etc. shall be kept at the facility with the CNMP and do not need to be submitted unless requested by the Department, or

ii) For each existing storage structure, on a form provided by the Department and submitted to the Department, demonstrate environmental performance equivalent to NRCS 313 2014. The demonstration shall be accomplished through an evaluation by a professional engineer.

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d) Waste Storage Structures for Solid Stackable Manure Not Subject to Precipitation
Waste storage structures that will hold solid stackable manure that is totally enclosed and not subject to precipitation, will also be designed and constructed so that storage shall, at a minimum, include the following:

i) All CAFO waste generated from the operation of the CAFO in a six-month or greater time period;

ii) CAFO waste shall be covered or stored inside a structure such that it is protected from wind and will not be contacted by precipitation;

iii) All wood in contact with litter should be pressure treated;

iv) The permittee shall include the basis and method for documenting six months storage capacity in accordance with Part I.B.1.d.2.

1) To determine storage capacity, the permittee may use any of the following methods, or in combination, to verify six months of poultry litter storage capacity:

A) Completed as-build drawings; or

B) Certified CNMP provider calculations which include information from the animal waste management report or CAFO facility calculations. The information at a minimum shall include stack characteristics, such as maximum stack heigth, maximum stack angle, and wall height.

2) To determine litter production, the permittee may use any of the following methods, or in combination, to verify six months of poultry litter storage capacity:

A) A three-year average of reported production (i.e., CAFO waste in cubic feet) in the CAFO facility's annual report. The three-year average shall consist of data from the highest three years during the last five years; or

B) If reported production is not available, data from the Midwest Plan Service (MWPS-18, Section 1 (2004)) shall be used in combination with any previous year's data.

v) All documentation and certification of six months of storage capacity shall be submitted to the department as part of the CNMP, and submitted to the department via MiWaters (https://miwaters.deq.state.mi.us), with the exception of the completed as-built drawings that shall be kept on site at the CAFO facility.

vi) storm water shall not run onto or under the stored CAFO waste; and

vii) a minimum of two feet separation distance to the seasonal high-water table or a minimum of one-foot separation if an impermeable barrier is used under the stored CAFO waste. Impermeable barriers must be constructed of at least 12 inches of compacted clay, at least four inches of concrete, or another material of similar structural integrity.

e) Existing Storage Structures Not Meeting Standards
Existing storage structures that do not meet the requirements above in Part I.B.1. and will not be upgraded to meet NRCS 313 Standards shall be maintained or permanently closed in accordance with Part I.C.3. Records of usage, maintenance, or closure shall be kept in the CNMP. A notification of discontinued use shall be made via MiWaters (https://miwaters.deq.state.mi.us). If a waste storage structure is to be closed, this shall be completed within six months from the notification.

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c. Inspection Requirements
The permittee shall develop a Storage Structure Inspection Plan to be kept in the CNMP. CAFO waste storage structures shall be inspected weekly. The results of the inspection shall be recorded on the "CAFO Inspection Record" form provided by the Department and kept in the CNMP for a minimum of 5 years from the date of creation. The plan shall include all of the following weekly inspections:

1) The CAFO waste storage structures for cracking, inadequate vegetative cover, woody vegetative growth, evidence of overflow, leaks, seeps, erosion, slumping, animal burrowing or breakthrough, and condition of the storage structure liner or stacking pad.

2) The depth of the CAFO waste in the storage structure and the available operating capacity as indicated by the depth gauge.

3) The collection system, lift stations, mechanical and electrical systems, transfer stations, control structures, and pump stations to ensure that valves, gates, and alarms are correctly set and all are properly functioning.

4) Any deficiencies found as a result of these inspections shall be corrected as soon as possible. Deficiencies and corrective actions taken shall be documented on the CAFO Inspection Record and kept in the CNMP for a minimum of 5 years from the date of creation.

d. Operation and Maintenance Requirements
The permittee shall implement a Storage Structure Operation and Maintenance Program that incorporates all the following management practices. The permittee shall initiate steps to correct any condition that is not in accordance with the Storage Structure Operation and Maintenance Program. A copy of the program shall be included in the CNMP. Specific records below shall be kept with the CNMP for a minimum of 5 years from the date of creation, unless specified otherwise below.

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1) In the event the level of CAFO waste in the storage structure rises above the maximum operational volume level and enters the emergency volume level, the Department shall be notified. The level in the storage structure shall be reduced and the emergency volume restored within one week, unless a longer time period is authorized by the Department. The removed CAFO waste shall be land applied in accordance with this permit or the Department shall be notified if another method of disposal is to be used. Descriptions of such events shall be recorded and kept in the CNMP for a minimum of 5 years from the date of creation.

2) During the period of November 1 to December 31 of each year, there shall be an available operational volume in the CAFO waste storage structures equal to the volume of CAFO waste generated from the operation of the CAFO in a six-month or greater time period (including normal precipitation and runoff in the production area during the same time period). The date of this determination shall be kept in the CNMP for a minimum of 5 years from the date of creation and shall be certified via MiWaters (https://miwaters.deq.state.mi.us) to the Department by January 14 of the next calendar year, in accordance with Part II.C.5.

3) Vegetation shall be maintained at a height that stabilizes earthen CAFO waste storage structures, provides for adequate visual inspection of the storage structures, and protects the integrity of the storage structure liners. The vegetation shall have sufficient density to prevent erosion. Woody vegetation shall be removed promptly from waste storage berms and other areas where roots may penetrate or disturb waste storage facility liners or waste treatment facilities.

4) Dike damage caused by erosion, slumping, or animal burrowing shall be corrected immediately and steps taken to prevent occurrences in the future.

5) The integrity of the CAFO waste storage structure liner shall be protected. Liner damages shall be corrected immediately, and steps taken to prevent future occurrences.

6) Problems with the collection system, lift stations, mechanical and electrical systems, transfer stations, control structures, and pump stations shall be corrected as soon as possible. Records of these inspections and records documenting any actions taken to correct deficiencies shall be kept with the CNMP for a minimum of five years from the date of creation. Deficiencies not corrected within 30 days must be accompanied by an explanation of the factors causing the delayed correction.

7) CAFO waste shall be stored only in storage structures as described in Part I.B.1.a., b., and d.

8) CAFO waste storage structures shall not contain human sanitary waste.

2. Best Management Practices Requirements

The following are designed to achieve the objective of preventing unauthorized discharges to surface waters of the state from production areas and land application activities.

a. Conservation Practices
The permittee shall maintain specific conservation practices near or at production areas, land application areas, and heavy use areas within pastures associated with the CAFO that are sufficient to control the runoff of pollutants to surface waters of the state in quantities that may cause or contribute to a violation of water quality standards. These practices shall be consistent with NRCS Conservation Practices and in compliance with the requirements of this permit. The permittee shall include within the CNMP a list of conservation practices used near or at production areas and land application areas. This list does not need to include temporary practices or other practices already required by this permit. Records documenting the inspection of the conservation practices (with the exception of those utilized on land application areas) shall be kept in the CNMP for a minimum of 5 years from the date of creation. Conservation practices on land application areas receiving CAFO waste shall be inspected and reported on the “Daily Manure Application Record.”

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b. Divert Clean Water
The permittee shall design and implement structures and management practices to divert clean storm water to prevent contact with contaminated portions of the production areas. Clean storm water may include roof runoff, runoff from adjacent land, and runoff from feed or silage storage areas where such runoff has not contacted feed, silage, or silage leachate. The permittee shall describe in the CNMP structures and management practices used to divert clean water from the production area and/or beneficial uses of diverted water if it will be collected for reuse.

c. Prevent Direct Contact of Animals with Surface Waters of the State
There shall be no access of animals to surface waters of the state at the production area of the CAFO. The permittee shall develop and implement appropriate controls to protect water quality by preventing access of animals to surface waters of the state and shall describe such controls in the CNMP. Records documenting the proper implementation of controls preventing access of animals to surface waters of the state shall be recorded on the "CAFO Inspection Report" form and kept in the CNMP for a minimum of 5 years from the date of creation.

d. Animal Mortality
The permittee shall handle, store, or dispose of dead animals in a manner that prevents contamination of surface waters of the state. Mortalities, including but not limited to any animal refuse (including but not limited to entrails and viscera or parts other than excrement), must not be disposed of in any liquid CAFO waste storage structure or storm water storage structure that is not specifically designed to treat animal mortalities, with the exception of leachate from properly designed and operated composting structures. Records documenting the proper management of animal mortalities shall be reported on the "CAFO Inspection Report" form and kept in the CNMP for a minimum of 5 years from the date of creation.

e. Chemical Disposal
The permittee shall prevent introduction of hazardous or toxic chemicals (for purposes of disposal) into CAFO waste storage structures. Examples of hazardous and toxic chemicals are pesticides and petroleum products/by-products. Identify in the CNMP appropriate practices that ensure chemicals that are not part of the normal agricultural practice at the production site and other contaminants handled at the CAFO are not disposed of in any CAFO waste or storm water storage or treatment system. Records documenting the proper management of chemicals to prevent their introduction into the CAFO waste storage structures, storm water storage, or treatment system, shall be reported on the "CAFO Inspection Report" and kept in the CNMP for a minimum of 5 years from the date of creation.

f. Inspection, Proper Operation, Maintenance, and Reporting
The permittee shall develop and implement an Inspection, Operation, and Maintenance Program that includes periodic visual inspections, proper operation, and maintenance of all CAFO waste-handling equipment including piping and transfer lines, and all runoff management devices (e.g., cleaning separators, barnyards, catch basins, screens) to prevent unauthorized discharges to surface waters and groundwaters of the state. A copy of the program shall be included in the CNMP. Specific inspection requirements include, but are not limited to, all of the following:

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1) Weekly visual inspections of all clean storm water diversion devices and runoff diversion structures and practices as described in Part I.B.2.b.

2) Daily visual inspections of water lines, including drinking water and cooling water lines, and above-ground piping and transfer lines, or an equivalent method of checking for water line leaks that incorporates the use of water meters, pressure gauges, or some other monitoring method.

3) Weekly inspections of all CAFO waste-handling equipment including piping and transfer lines, all runoff management devices, and devices channeling contaminated stormwater to storage and containment structures shall be accessible such that required visual inspections may occur. This may necessitate frequent removal of vegetation, snow, or other obstructions.

4) Any deficiencies shall be corrected as soon as possible.

5) Records of these inspections and records documenting any actions taken to correct deficiencies shall be recorded on the “CAFO Inspection Record” form provided by the Department and shall be kept in the CNMP for a minimum of five years from the date of creation. Deficiencies not corrected within 30 days must be accompanied by an explanation of the factors causing the delayed correction.

3. Land Application of CAFO Waste

a. Field-by-Field Assessment

The permittee shall conduct a field-by-field assessment of all land application areas. Each field shall be assessed prior to use for land application of CAFO waste. The assessment shall include field maps with location information (section, township, county, and crossroads, latitude and longitude of field center), and identify field-specific conditions, including, but not limited to, slopes, soil type, locations of tile outlets, tile risers and tile depth, conservation practices, and offsite conditions, such as buffers and distance or conveyance to surface waters of the state. The assessment shall also identify areas which, due to topography, activities, or other factors, have a potential for erosion. The assessment shall also identify fields, or portions of fields, that will be used for surface application of CAFO waste without incorporation or injection to frozen or snow-covered ground in accordance with Part III, Department 2005 Technical Standard for the Surface Application of CAFO Waste on Frozen or Snow-Covered Ground Without Incorporation or Injection. The results of this assessment, along with consideration of the form and source of the CAFO waste and all nutrient inputs in addition to those from CAFO waste, shall be used to ensure that the amount, timing, and method of application of CAFO waste:

1) does not exceed the capacity of the soil to assimilate the CAFO waste;

2) is in accordance with field-specific nutrient management practices that ensures appropriate agricultural utilization of the nutrients in the CAFO waste;

3) does not exceed the maximum annual land application rates specified in Part I.B.3.c. of this permit; and the basis (technology, or sampling methods and results) of any planned use of additional nitrogen above that rate shall be provided with the field by field assessment, and submitted and kept in the CNMP.

4) will not result in unauthorized discharges.

All assessments shall be kept in the CNMP for a minimum of 5 years from the date of creation. A particular field may be deleted from the CNMP once the field is no longer used for land application of CAFO waste; however, the field assessments must be kept in the CNMP for 5 years from the date created.

Any new fields shall be assessed prior to their use for land application activities. The Department shall be notified of the new fields prior to their use through submittal of a permit modification request via

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MiWaters (https://miwaters.deq.state.mi.us) that includes the field-by-field assessment required above, current (within the last three years) soil tests, planned crops, and realistic crop yield goals. The request will be public noticed for 15 calendar days via MiWaters (https://miwaters.deq.state.mi.us). The permittee may use the field 18 calendar days after submittal of the request unless notified otherwise by the Department.

b. Field Inspections
Prior to conducting land application of CAFO waste to fields determined to be suitable under Part I.B.3.a. above, the permittee shall perform the following inspections at the indicated frequency to ensure that unauthorized discharges do not occur as a result of the land application of CAFO waste. Records of inspections, monitoring, and sampling required by this section shall be recorded in the Land Application Log required by Part I.B.3.d.

1) CAFO waste shall be sampled a minimum of once per year to determine nutrient content and analyzed for total kjeldahl nitrogen (TKN), ammonium nitrogen, and total phosphorus. CAFO waste shall be sampled in a manner that produces a representative sample for analysis. Guidance for CAFO waste sampling protocols can be found in the North Central Regional Extension Publication 567 (1995) available from Michigan State University Extension. Analytical methods shall be as required by Part II.B.2. The CAFO waste test results shall be used to determine land application rates as described in Part I.B.3.c. below. Records of the nutrient levels and analysis methods shall be kept in the Land Application Log and in the CNMP for a minimum of 5 years from the date of creation.

2) Soils at land application sites shall be sampled a minimum of once every three years, analyzed to determine phosphorus levels, and the soil test results shall be used to determine land application rates as described in I.B.3.c. below. Sample soil using an 8-inch vertical core and take 20 or more cores in a random pattern spread evenly over each uniform field area. A uniform field area shall be no greater than 20 acres or it can be up to 40 acres if that field has one soil map unit and has been managed as a single field for the last ten years. The 20 cores shall be composited into one sample and analyzed using the Bray P1 method.

   Grid or zone sampling are also acceptable methods for sampling soils at land application sites. If grid or zone sampling methods are used, methods shall follow Michigan State University Extension Bulletin E498S (2006). The permittee shall include individual soil sample results and information documenting how soil sample zones are determined, and manure application rates are calculated.

   Records of the phosphorus levels shall be kept in the Land Application Log and in the CNMP for a minimum of 5 years from the date of creation.

3) The permittee shall inspect each field no earlier than 48 hours prior to each land application of CAFO waste to that field to evaluate the current suitability of the field for application. This inspection shall include, at a minimum, the state of all tile outlets, evidence of soil cracking, the moisture-holding capacity of the soil, crop maturity, and the condition of designated conservation practices (i.e., grassed waterways, buffers, diversions). Results and findings of all inspections shall be recorded in the Daily Manure Application Record.

4) The permittee shall visually inspect all tile outlets draining a given field immediately prior to the land application of CAFO wastes to that field. Tile outlets shall be inspected again upon completion of the land application to the field, or at the end of the working day should application continue on that field for more than one day. Include in the Daily Manure Application Record written descriptions of tile outlet inspection results and observe and compare color and odor of tile outlet effluents before and after land application.

5) All tiled fields to which CAFO wastes have been applied in the prior 30 days shall be visually inspected within 24 hours after the first rain event of one-half inch or greater, for signs of a discharge of CAFO waste. Written descriptions of tile inspection results shall be recorded in the Daily Manure Application Record. If an inspection reveals a discharge with color, odor, or other characteristics

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indicative of an unauthorized discharge of CAFO waste, the permittee shall immediately notify the Department in accordance with the reporting procedures set forth in Part I.C.1. and monitor the discharge in accordance with Part I.A.2. of the permit. A copy of the Daily Manure Application Record shall be kept with the Land Application Log.

6) The permittee shall inspect all land application equipment daily during use for leaks, structural integrity, and proper operation and maintenance. Land application equipment shall be calibrated annually to ensure proper application rates. Written records of inspections, date of inspections, and calibrations according to the manufacturer's specifications shall be retained in the Daily Manure Application Record.

c. Maximum Annual Land Application Rates

The permittee may use either the Bray P1 numerical limits or the Michigan Phosphorus Risk Assessment (MPRA) tool (Version 2.0, Nov. 2012) and the EGLE MPRA Guidance Document to determine maximum annual land application rates. The permittee must use one system for all land application areas. For purposes of this permit, the MPRA is for rate calculations only and "Distance to surface water and/or surface inlets" is interpreted as described in Part I.B.3.h. below. The permittee shall comply with all of the following land application rates:

1) Land Application Rate Prohibitions and Restrictions

All of the following land application rate prohibitions apply.

a) If the Bray P1 soil test result is 135 parts per million (ppm) phosphorus (P) or more, and the fields are not located within a watershed(s) covered by an approved phosphorus or nitrogen Total Maximum Daily Load (TMDL), CAFO waste applications shall be discontinued until nutrient use by crops reduces the Bray P1 soil test result to less than 135 ppm P including when MPRA is used. If the Bray P1 soil test result is 120 ppm P or more, and the fields are located in a watershed(s) covered by an approved phosphorus or nitrogen TMDL, CAFO waste applications shall be discontinued, until nutrient use by crops reduces the soil test result to less than 120 ppm P including when MPRA is used.

b) Fields where the MPRA risk is HIGH, CAFO waste shall not be applied.

c) The application rate shall not exceed the nitrogen (N) fertilizer recommendation (removal value for legumes) for the first crop year grown after the CAFO waste is applied as specified in Part I.B.3.c.2) b) below.

d) The application rate shall not exceed four years of P for each of the four crops planned for the next four years as calculated in Part I.B.3.c.2) b) below.

e) The total amount of N and P, regardless of source (manure, organic waste, commercial fertilizer, etc.), shall not exceed the first crop year nutrient requirements unless applying multiple crop years of P as allowed in 2) below. Only one year of N can be applied as stated in c) above, unless samples or other relevant data shows additional N is needed for or will be beneficial to the crop. Documentation justifying additional N must be kept in the CNMP for a minimum of 5 years from the date of creation.

2) Phosphorus Levels

a) If the Bray P1 soil test result is 68 ppm P or more, but less than 135 ppm P and the fields are not located within a watershed(s) covered by an approved phosphorus or nitrogen TMDL, or a MPRA risk of MEDIUM, application rates shall be based on the maximum rates of P in annual pounds per acre as calculated using the method described below. If the Bray P1soil test result is 60 ppm P or more, but less than 120 ppm P and the fields are located in a watershed(s) covered by an approved phosphorus or nitrogen TMDL, or a MPRA risk of LOW, application rates shall be based on the maximum rate of P in annual pounds per acre as calculated using the method described below.

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The realistic yield goal per acre, using the units specified in Table 1 below, for the planned crop multiplied by the number in the P column for that crop. The maximum annual application rates as calculated above shall be achieved by using the CAFO waste test results for P to determine the amount of CAFO waste that may be land applied per acre per year.

The result is the maximum annual pounds per acre of P that may be applied for the first crop planned after application of CAFO waste. If the one-year rate is impractical due to spreading equipment or crop production management, the permittee may apply up to two years of P at one time, but no P may be applied to that field for the second year. The two-year P application rate shall be the results calculated using the formula in Part 1.B.3.c.3)a)(3) below for each of the two crops planned for the next two years and those two annual results shall be added together to determine the maximum P application rate. In no case may the application rate exceed the N application rate as specified below.

b) If the Bray P1 soil test result is less than 68 ppm P and the fields are not located within a watershed(s) covered by an approved phosphorus or nitrogen TMDL, or 60 ppm P and the fields are located in a watershed(s) covered by an approved phosphorus or nitrogen TMDL, or a MPRA risk of LOW, the annual rate of CAFO waste application shall not exceed the N fertilizer recommendation (removal value for legumes) for the first crop year grown after the CAFO waste is applied. Information to determine N fertilizer recommendations or removal values can be found in Michigan State University Extension Bulletin E2904. The University of Minnesota Extension Bulletin “Guidance for Manure Application Rate” (2019) and University of Wisconsin Bulletin A2809 (2012) may be used for N fertilizer recommendations or removal rates for legumes. In no case may the application rate exceed four years of P calculated using the method described in Part I.B.3.c.2)a) above for each of the four crops planned for the next four years and those four annual results shall be added together to determine the maximum application rate. The maximum annual application rates as calculated above shall be achieved by using the CAFO waste test results for N to determine the amount of CAFO waste that may be land applied per acre per year.

3) Additionally, only one year of N can be applied as stated in Part I.B.3.c.1) c) above, unless samples or other relevant data demonstrate additional N is needed for, or will be beneficial to, the crop. Prior to application, the demonstration justifying additional N must be submitted to the Department via MiWaters (https://miwaters.deq.state.mi.us) for review. The demonstration will be public noticed for a period of 15 calendar days. The demonstration shall be kept in the CNMP for a minimum of 5 years from the date of creation. The permittee may apply the additional N following 18 calendar days after submittal of the request, unless notified otherwise by the Department.

a) Risk Assessment

(1) If using MPRA, CAFO waste may only be applied on fields that achieve a MPRA score of LOW or MEDIUM.

(2) In accordance with Part I.C.9., if the field is located in a watershed(s) covered by an approved phosphorus and nitrogen TMDL, CAFO waste may not be applied unless the MPRA risk is LOW.

(3) Allowable application rates of P shall be based on the rates of P in annual pounds (lbs.) per acre (ac) as calculated using the following formula:

Phosphorus Amount (lbs. P/ac) = Realistic Crop Yield Goal/ac x P (lb./unit yield for planned crop)

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The annual application rates allowable as calculated above shall be achieved by using the CAFO waste test results (required per Part I.B.3.b.1) for P to determine the amount of CAFO waste that may be land applied per acre per year as calculated using MPRA.

Three and four years of P may only be applied on fields with an MPRA score of LOW.
A multi-year P application rate shall be the results calculated using the formula above for each of the crops planned for the specified years and those annual results shall be added together to determine the maximum P application.

Table 1. Phosphate (P_2O_5) values are included for reference purposes.

Planned Crop	Harvest Form	Unit of Realistic Yield Goal per Acre	P	P_2O_5
			- - lb./unit of yield - -	
Alfalfa	Hay	ton	5.72	13.1
Alfalfa	Haylage	ton	2.38	5.45
Apple	Fruit	ton	0.19	0.44
Asparagus	Shoots	ton	1.1	2.51
Barley	Grain	bushel	0.17	0.38
Barley	Straw	ton	1.41	3.2
Beans (dry edible)	Grain	cwt	0.53	1.2
Beans (green, fresh)	Pods	ton	1.22	2.8
Blueberry	Fruit	ton	0.20	0.46
Bromegrass	Hay	ton	5.72	13
Buckwheat	Grain	bushel	0.11	0.25
Canola	Grain	bushel	0.40	0.91
Carrots	Root	ton	0.79	1.81
Cherries (sour)	Fruit	ton	0.3	0.69
Cherries (sweet)	Fruit	ton	0.37	0.85
Clover	Hay	ton	4.4	10
Clover-grass	Hay	ton	5.72	13
Corn	Grain	bushel	0.16	0.37
Corn	Stover	ton	3.61	8.2
Corn	Silage	ton	1.45	3.3
Corn	Sweet	ton	1.23	2.8
Cucumbers	Fruit	ton	0.47	1.1
Grapes	Fruit	ton	0.26	0.6
Millet	Grain	bushel	0.11	0.25
Mint	Hay	Ton	3.81	8.72
Oats	Grain	bushel	0.11	0.25
Oats	Straw	ton	1.23	2.8
Onions	Bulb	ton	1.14	2.6
Orchard grass	Hay	ton	7.48	17
Peaches	Fruit	ton	0.24	0.55
Pears	Fruit	ton	0.23	0.53
Peas	Fruit	ton	2.01	4.6
Peppers, Green	Fruit	Ton	0.6	1.37
Plums	Fruit	ton	0.2	0.46
Potato	Tubers	cwt	0.06	0.13
Rye	Grain	bushel	0.18	0.41
Rye	Straw	ton	1.63	3.7
Rye	Silage	ton	0.66	1.5
Sorghum	Grain	bushel	0.17	0.39
Sorghum-Sudangrass	Hay	ton	6.6	15
Sorghum-Sudangrass	Haylage	ton	2.02	4.6
Soybean	Grain	bushel	0.35	0.8
Spelts	Grain	bushel	0.17	0.38

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Table 1.	Phosphate (P_2O_5) values are included for reference purposes.			
Planned Crop	**Harvest Form**	**Unit of Realistic Yield Goal per Acre**	**P**	**P_2O_5**
			- - lb./unit of yield - -	
Squash	Fruit	ton	0.76	1.74
Sugar beets	Roots	ton	0.57	1.3
Sunflower	Grain	bushel	0.53	1.2
Timothy	Hay	ton	7.48	17
Tomatoes	Fruit	ton	0.57	1.3
Triticale	Silage	Ton	3.08	7.0
Wheat	Grain	bushel	0.28	0.63
Wheat	Straw	ton	1.45	3.3

For crops not listed in Table 1, the permittee shall provide in the permit application, the harvest form, unit of realistic yield goal per acre, P lb./unit of yield (in a format similar to that of Table 1) and supporting data. The Department will review the proposal, and upon approval, will list the approved numbers in the COC. The permittee may propose alternate land application rates and methodologies in the permit application. The Department will review the proposal and acceptable rates and methods, and upon approval, will public notice the proposal via MiWaters (https://miwaters.deq.state.mi.us) for a 15 day period. The alternate land application rates and methodologies will be included in the COC issued under this permit.

Methodology and calculations consistent with this Part I.B.3.c. and their results, shall be recorded in the Land Application Log.

d. Land Application Log
The results of land application inspections, monitoring, testing, and recordkeeping shall be recorded in the Department provided forms, "Daily Manure Application Record" and the "Land Application Summary for Previous Crop Year" which shall be kept up-to-date and kept in the CNMP for a minimum of 5 years from the date of creation. The permittee shall document in the log in writing, at a minimum, records required by Part I.B.3. and all of the following information and inspection results in the specified documents:

1) Daily Manure Application Record
   a) The time, date, quantity, method, location (Section, Township, County, latitude and longitude of field center), crop grown, and application rate for each location at which CAFO wastes are land applied.

   b) The description of the forecast and of the weather conditions at the time of application and for 24 hours prior to and following application based on visual observation.

   c) A review of the condition of conservation practices.

   d) A statement whether the land was frozen or snow-covered at the time of application.

2) Land Application Summary for Previous Crop Year
   a) The crop, the realistic yield goal, and actual yield for each location at which CAFO wastes are land applied, and the second-year crop (if applicable).

   b) Methodology and calculations showing the total nitrogen and phosphorus actually applied to each field receiving CAFO waste, identifying each source of manure used to calculate the application rate, identify all sources of nutrients, including sources other than CAFO waste.

   c) The total amount of nitrogen and phosphorus actually applied to each field receiving CAFO waste, irrespective of source, including documentation of calculations for the total amount applied.

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d) The reporting of additional N applied under the demonstration per Part I.B.3.c.3)a).

3) Forecast Records
Printouts or electronically maintained records of weather forecasts from the time of land application. Weather forecasts may also be saved as electronic files, in which case the files do not need to be physically located in the Land Application Log, but the log shall reference the location where the files are stored and shall be made available upon Department request.

e. Land Application Summary
The permittee shall submit the required "Land Application Summary" form via MiWaters (https://miwaters.deq.state.mi.us) within 30 days from each quarter ending March 31, June 30, September 30, and December 31 of each year and will include the following for each field on which CAFO waste was applied:

1) Dates of Application;

2) Field name and Location (latitude and longitude coordinates of center of field);

3) Acres applied;

4) Amount and units of manure applied per acre.

f. Prohibitions
Appropriate prohibitions, in compliance with the following, shall be included in the CNMP:

1) CAFO waste shall not be applied on land that is flooded or saturated with water at the time of land application.

2) CAFO waste shall not be applied during rainfall events.

3) CAFO waste shall not be applied during the months of January, February, or March unless the permittee submits a notification and meets the following conditions:

(a) CAFO waste shall only be applied when waste can be incorporated immediately following application, or injected;

(b) CAFO waste shall not be applied when two or more inches of frost and/or four or more inches of snow are present at the land application site at the time of application;

(c) CAFO waste shall not be applied within 100 feet of any surface water of the state, open tile line intake structures, sinkholes, agricultural well heads, included but not limited to roadside ditches that are conduits to surface waters of the state (with the exception of surface waters of the state that are up-gradient of the land application).

(d) Manure application on fields receiving CAFO waste must have a soil sample Bray P1 of no greater than 68 ppm P, or 60 ppm P if fields are located in watershed(s) covered by an approved phosphorus or nitrogen TMDL.

(e) Twenty-four (24) hours prior to the land application of CAFO waste, the Department shall be notified, through a Department form via MiWaters (https://miwaters.deq.state.mi.us). The notification must include all of the following:

i) a topographic map of the specific land application location showing the directional flow to surface waters;

ii) the planned application rate, with no more than 1 crop year of P that can be applied;

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iii) the current total storage structure capacity in days at the CAFO facility.

(f) All land application practices shall follow the requirements per Part I.B.3.

4) CAFO waste shall not be transferred to a recipient for land application of the CAFO waste during the months of January, February, or March. Land application does not mean CAFO waste that is transferred out of state, to a treatment facility, or composting facility.

5) CAFO waste application shall be delayed if rainfall exceeding one-half inch, or less if a lesser rainfall event is capable of producing an unauthorized discharge, is forecasted by the National Weather Service (NWS) during the planned time of application and within 24 hours after the time of the planned application. Forecast models to be used can be found on the internet at http://www.weather.gov/mdl/synop/products.php. Model data to be used for one-half inch shall be the following:

GFS MOS (MEX) Text Message by Station Forecast: If the Q24 is 4 and the P24 is 70 or more for the applicable time period, or the Q24 is 5 or greater (with any P24 number), then CAFO waste land application shall be delayed until the Q24 is less than 5, or both the Q24 is less than 4 and the P24 is less than 70 for the applicable time period. If the first two Q12 values are 4 and the corresponding P12 values are 70 or more for the applicable time period, or the Q12 values are 5 or greater (with any P12 numbers), then CAFO waste land application shall be delayed until the first two Q12 values are less than 5 or both the Q12 values are less than 4 and the corresponding P12 values are less than 70 for the applicable time period. For further details and instructions, utilize the "Instructions for Determining Precipitation Forecasts for CAFO Permits" located at https://www.michigan.gov/documents/deq/wrd-npdes-CAFO-PrecipitationInstructions_513072_7.pdf . The station to be used shall be that which is closest to the land application area. If no station is close, then use the closest 2 or 3 stations.

Different model data shall be used if it is determined that rainfall less than one-half inch on a particular field is capable of causing an unauthorized discharge. For example, using a Q24 rating of 3 or greater may be appropriate on higher risk fields. If the NWS website is revised and the required forecast models are not available, the permittee shall contact the Department for information on which forecast models to use. Instructions for using this website are available from the Department. Other forecast services may be used upon approval of the Department.

g. Methods

CAFO waste shall be subsurface injected or incorporated into the soil within 24 hours of application. CAFO waste subsurface injected into frozen or snow-covered ground shall have substantial soil coverage of the applied CAFO waste. During January, February, March all CAFO waste shall be incorporated immediately following application, or injected. The following exceptions apply during the period April 1 through December 31:

1) Injection or incorporation may not be feasible where CAFO wastes are applied to pastures, perennial crops such as alfalfa, cover crops, or where no-till practices are used. CAFO waste may be applied to pastures or perennial crops such as alfalfa, cover crops, or where no-till practices are used, only if the CAFO waste will not enter surface waters of the state. CAFO waste shall not be applied if the waste may enter surface waters of the state.

2) CAFO waste may be surface applied and not incorporated within 24 hours on ground that is frozen or snow-covered only if there is a field-by-field demonstration conducted within 48 hours prior to application. The demonstration shall be conducted in accordance with Part III. Department 2005 Technical Standard for the Surface Application of CAFO Waste on Frozen or Snow-Covered Ground Without Incorporation or Injection, showing that such land application will not result in a situation where CAFO waste may enter surface waters of the state. The demonstration shall be submitted to

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the Department 24 hours prior to application on frozen or snow-covered ground. Demonstrations shall be kept with the Land Application Log. CAFO waste surface applied to ground that is frozen or snow-covered shall be limited to no more than 1 crop year of P per winter season, including pastures, perennial crops such as alfalfa, cover crops, or where no-till practices are used.

h. Setbacks

1) If using the numerical Bray P1 method, the permittee shall comply with the setback requirements in a) and b) below.

a) CAFO waste shall not be applied within 100 feet of any surface water of the state, open tile line intake structures, sinkholes, agricultural well heads, including but not limited to roadside ditches that are conduits to surface waters of the state (with the exception of surface waters of the state that are up-gradient of the land application),

b) The permittee shall install and maintain a 35-foot wide permanent vegetated buffer along any surface water of the state, open tile line intake structures, sinkholes, agricultural well heads, including but not limited to roadside or any ditches that are conduits to surface waters of the state (with the exception of surface waters of the state that are up-gradient of the land application). CAFO waste shall not be applied within the 35-foot buffer.

2) The permittee may demonstrate an alternative practices compliance alternative consistent with 40 CFR 412.4(c)(5)(i) and (c)(5)(ii) that minimize risk of transport of nutrients to surface waters. The demonstration shall be submitted via MiWaters (https://miwaters.deq.state.mi.us) and be approved by the department and implemented per Department approval. This approved demonstration becomes a part of the CNMP.

3) If using MPRA, setbacks and/or permanent vegetative buffers shall be identified in the MPRA scoring worksheet, field-by-field assessment, and field maps. The permittee may choose from a) or b) below.

a) CAFO waste shall not be applied within 100 feet of any surface water of the state, open tile line intake structures, sinkholes, agricultural well heads, including but not limited to roadside ditches that are conduits to surface waters of the state (with the exception of surface waters of the state that are up-gradient of the land application), or

b) The permittee may choose to install and maintain a 35-foot wide permanent vegetated buffer as a substitute for 1) b) above. CAFO waste shall not be applied within the 35-foot permanent vegetated buffer.

4) CAFO waste shall not be applied within grassed waterways and swales that are conduits to surface waters of the state.

5) Setbacks and vegetated buffer widths shall be measured from the ordinary high-water mark, where applicable, or from the upper edge of the bank if the ordinary high-water mark cannot be determined. Setbacks and vegetated buffers for each field shall be shown on the CNMP field maps.

i. Non-Production Area Storm Water Management

The permittee shall implement practices including preventative maintenance, good housekeeping, and periodic inspections of at least once per year, to minimize and control pollutants in storm water discharges associated with the following areas:

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1) Immediate access roads and rail lines used or traveled by carriers of raw materials, waste material, or by-products used or created by the facility.

2) Sites used for handling material other than CAFO waste.

3) Refuse sites.

4) Sites used for the storage and maintenance of material handling equipment.

5) Shipping and receiving areas.

Records and descriptions of non-production area storm water management practices shall be kept in the CNMP for a minimum of 5 years from the date of creation.

4. Comprehensive Nutrient Management Plan (CNMP)

The CNMP shall apply to both production areas and land application areas and shall be a written document that describes the practices, methods, and actions the permittee takes to meet all of the requirements of the Nutrient Management Plan (NMP) per Part I.B.

a. Approval
The CNMP shall be certified by a Certified CNMP Provider.

b. Submittal
The CNMP shall be submitted to the Department with the application for coverage under this permit. All or parts of the CNMP shall be submitted via MiWaters (https://miwaters.deq.state.mi.us) on the template provided by the Department.

c. Contents
The CNMP submitted to the Department shall include all of the information and requirements specified in the NMP Section per Part I.B., an Executive Summary (a general description of the operation), and a map of the production area that includes all of the items specified in the permit application, the animal confinement area, the manure storage area, the raw materials storage area, treatment systems, and the waste containment areas, and that shows all clean water and production area waste flow paths, contaminated collection areas, pipes, control structures, valves, etc. The location of any areas used for storage of raw materials, including new sand bedding, shall be located in such a manner as to prohibit runoff to surface waters of the state.

d. Annual Review and Report
The permittee shall annually review the CNMP and update the CNMP as necessary to meet the requirements of Part I.B.

The permittee shall submit an annual report for the preceding January 1 through December 31 (reporting period) to the Department by April 1 of each year. The annual report shall be submitted via MiWaters (https://miwaters.deq.state.mi.us) on the "Annual Report Form for Concentrated Animal Feeding Operations (CAFO)" provided by the Department. The annual report shall include, but is not limited to, all of the following:

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1) the average number of animals, maximum number of animals at any one time, and the type of animals, whether in open confinement or housed under roof (beef cattle, broilers, layers, swine weighing 55 pounds or more, swine weighing less than 55 pounds, mature dairy cows, dairy heifers, veal calves, sheep and lambs, horses, turkeys, other);

2) estimated amount of total CAFO waste generated by the CAFO during the reporting period (tons or gallons);

3) estimated amount of total CAFO waste transferred to other persons (manifested waste) by the CAFO during the reporting period (tons or gallons);

4) total number of acres for land application covered by the CNMP developed in accordance with this permit;

5) total number of acres under control of the CAFO that were used for land application of CAFO waste during the reporting period;

6) a field-specific spreading plan which identifies where and how much CAFO waste will be applied to fields for the upcoming 12 months, what crops will be grown on those fields, and the realistic crop yield goals of those crops. The plan must account for all CAFO waste expected to be generated in the upcoming 12 months including waste to be transferred under manifest;

7) the Land Application Summary for Previous Crop Year per Part I.B.3.d.2.;

8) a statement indicating whether the current version of the CAFO's CNMP was approved by a certified CNMP provider; and

9) a summary of all CAFO waste discharges from the production area that have occurred during the reporting period, including date, time, and approximate volume.

e. CNMP Revisions
Prior to revisions to the CNMP, the CAFO owner or operator must provide the most current version of the CNMP and identify changes from the previous version to the Department for review. If the Department determines the revisions are significant, the Department must notify the public and make the changes available for review and comment. Significant revisions of the CNMP shall be public noticed for a period of 15 calendar days and may result in a permit modification. The CNMP shall be submitted via MiWaters (https://miwaters.deq.state.mi.us). Significant change includes the following:

1) Addition of new land application areas not previously included in the CAFO’s CNMP per Part I.B.3.a.

2) Any changes to the maximum field-specific annual rates of application or to the maximum amounts of nitrogen and phosphorus derived from all sources for each crop, as expressed in accordance with the narrative rate approach per Part I.B.3.c.

3) Addition of any crop or other uses not included in the terms of the CAFO’s CNMP and corresponding field-specific rates of application per Part I.B.3.c.3).

4) Changes to site-specific components of the CAFO’s CNMP, where such changes are likely to increase the risk of nitrogen and phosphorus transport from the site to surface waters of the state per Part I.B.3.c.

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5) An increase in the number of animals that results in a 10 percent or greater increase in the volume of either the manure alone or the total CAFO waste generated per year as compared to the volumes identified in the application or the most recently submitted Significant Change due to this Part I.B.4.e.5).

6) An increase in the number of animals that results in a 10 percent or greater decrease in the waste storage capacity time, as identified in the application or the most recently submitted Significant Change due to this Part I.B.4.e.6) or results in a waste storage capacity of less than 6 months.

7) The construction or procurement of a new animal housing facility or waste storage facility.

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Section C. Other Requirements

1. Reporting of Overflows and Discharges from CAFO Waste Storage Structures and Land Application

If, for any reason, there is an overflow from CAFO waste storage structures and/or a discharge of pollutants to a surface water of the state from CAFO waste storage structures, production areas, or land application areas, the permittee shall report the overflow and/or discharge to the Department in accordance with the reporting requirements set forth in Part II.C.6. Discharges to surface waters shall also be reported to the Clerk of the local unit of government and the County Health Department within 24 hours after the discharge begins. The permittee shall also submit the completed "CAFO Discharge Monitoring Report" form to the Department via MiWaters (https://miwaters.deq.state.mi.us). In addition, the permittee shall keep a copy of the report in the CNMP for a minimum of 5 years from the date of creation. The report shall include all of the following information:

a. a description of the overflow and/or discharge and its cause, including a description of the flow path to the surface water of the state;

b. the period of overflow and/or discharge, including exact dates and times, the anticipated time it is expected to continue, and steps taken or planned to reduce, eliminate, and prevent recurrence of the overflow and/or discharge;

c. monitoring results as required by Part I.A.2.;

d. in the event of a discharge through tile lines, the permittee shall identify and document, for field(s) from which the discharge occurred, the location of tile and depth of tile. The permittee shall also document field conditions at the time of the discharge, determine why the discharge occurred, and how to prevent future discharges; and

e. if the permittee believes that the discharge is an authorized discharge, the permittee shall include a demonstration that the discharge meets the requirements of Part I.A.1.a. and/or Part I.A.1.b., as appropriate.

2. Construction or Procurement of New Waste Storage Structures or Facilities

Before the construction, alteration, or within 30 days of procurement of a waste storage structure, facility, or portions thereof, notification shall be submitted to the Department via MiWaters (https://miwaters.deq.state.mi.us). New waste storage and transfer structures shall be built to NRCS 313 2017 Standard. Complete as-built plans, specifications, drawings, etc. shall be kept in the CNMP. As-built plans must be signed and stamped by a licensed professional engineer and state that the structure was built to the NRCS 313 2017 standard. Signed and stamped design drawings do not constitute as-built plans. Required supporting documentation may include soils reports documenting suitability of liner material, groundwater investigations reports, pictures, survey notes, concrete batch tickets, etc.

3. Closure of Structures and Facilities

The following conditions shall apply to the closure of lagoons, CAFO waste storage structures, earthen or synthetic lined basins, other manure and wastewater facilities, and silage facilities (collectively referred to as "structure(s)" for the remainder of this Part I.C.3.

No structure shall be permanently abandoned. Structures shall be maintained at all times until closed in compliance with this section. All structures must be properly closed if the permittee ceases operation. In addition, any structure that is not in use for a period of twelve (12) consecutive months must be properly closed, unless the permittee intends to resume use of the structure at a later date and either: (a) maintains the structure as though it were actively in use, to prevent compromise of structural integrity and ensure compliance with final effluent limitations, or (b) removes CAFO waste to a depth of one foot or less and refills the structure with clean water to preserve the integrity of the synthetic or earthen liner. In either case, the permittee shall conduct routine inspections, maintenance, and recordkeeping in compliance with this permit as though the structure were in use. The permittee shall notify the Department via MiWaters (https://miwaters.deq.state.mi.us) 30 days prior

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Section C. Other Requirements

to closing structures, or upon deciding that the structures will be maintained as specified in (a) or (b) above. Thirty days prior to restoration of the use of the structure, the permittee shall notify the Department via MiWaters (https://miwaters.deq.state.mi.us) and provide the opportunity for inspection.

The permittee shall accomplish closure by removing all waste materials to the maximum extent practicable. This shall include agitation and the addition of clean water as necessary to remove the waste materials. The permittee shall utilize as guidance the closure techniques contained in NRCS Conservation Practice Standard No. 360, Waste Facility Closure. All removed materials shall be utilized or disposed of in accordance with the permittee's approved CNMP, unless otherwise authorized by the Department.

Unless the structure is being maintained for possible future use in accordance with the requirements above, completion of closure for structures shall occur as promptly as practicable after the permittee ceases to operate or, if the permittee has not ceased operations, 12 months from the date on which the use of the structure ceased, unless otherwise authorized by the Department.

4. Standards, Specifications and Practices

The published standards, specifications, and practices referenced in this permit are those which are in effect upon the effective date of this permit, unless otherwise provided by law. NRCS Conservation Practice Standards referred to in this permit are currently contained in Section IV, Conservation Practices and Michigan Construction Specifications, of the Michigan NRCS Field Office Technical Guide.

5. Facility Contact

The "Facility Contact" was specified in the application. The permittee may replace the facility contact at any time and shall notify the Department via MiWaters (https://miwaters.deq.state.mi.us) within 10 days after replacement (including the name, address, and telephone number of the new facility contact). The Department shall be notified in writing within 10 days after a change in any of the contact information (such as address or telephone number) from what was specified in the application.

a. The facility contact shall be any of the following (or a duly authorized representative of this person):
    - For a corporation or a company, a principal executive officer of at least the level of vice president, or a designated representative, if the representative is responsible for the overall operation of the facility from which the discharge described in the permit application or other NPDES form originates.
    - For a partnership, a general partner.
    - For a sole proprietorship, the proprietor.
    - For a municipal, state, or other public facility, either a principal executive officer, the mayor, village president, city or village manager or other duly authorized employee.

b. A person is a duly authorized representative only if both of the following requirements are met:
    - The authorization is made in writing to the Department by a person described in paragraph a. of this section.
    - The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity such as the position of plant manager, operator of a well or a well field, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters for the facility (a duly authorized representative may thus be either a named individual or any individual occupying a named position).

Nothing in this section obviates the permittee from properly submitting reports and forms as required by law.

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Section C. Other Requirements

6. Expiration and Reissuance

On or before October 1, 2024 a permittee seeking continued authorization to discharge under this permit beyond the permit's expiration date shall submit to the Department an application for reissuance via MiWaters (https://miwaters.deq.state.mi.us). Without a timely application for reissuance, the permittee's authorization to discharge will expire on April 1, 2025. With a timely application for reissuance, the permittee shall continue to be subject to the terms and conditions of the expired permit until the Department takes action on the application, unless this permit is terminated or revoked. Upon determination by the Department to grant or deny coverage under this permit, the proposed decision will be public noticed for a period of 15 calendar days via MiWaters (https://miwaters.deq.state.mi.us)

If this permit is terminated or revoked, the Department will notify the permittee in writing and all authorizations to discharge under the permit shall expire on the date of termination or revocation. If this permit is modified, the Department will notify the permittee in writing of any required action. Upon the effective date of the modified permit, the permittee shall be subject to the terms and conditions of the modified permit, unless the Department notifies the permittee otherwise.

If the discharge authorized under this permit is terminated, the permittee shall submit to the Department an NPDES Permit Notice of Termination request via MiWaters (https://miwaters.deq.state.mi.us). However, the permittee may submit a request for termination via MiWaters (https://miwaters.deq.state.mi.us) if all the following are met:

a. the facility has ceased operation; and/or is no longer a CAFO;

b. the permittee has demonstrated to the satisfaction of the Department that there is no remaining potential for a discharge of CAFO waste that was generated while the operation was a CAFO.

7. Requirement to Obtain Individual Permit

The Department may require any person who is authorized to discharge by a COC and this permit to apply for and obtain an individual NPDES permit if any of the following circumstances apply:

a. the discharge is a significant contributor to pollution as determined by the Department on a case-by-case basis;

b. the discharger is not complying, or has not complied, with the conditions of the permit;

c. a change has occurred in the availability of demonstrated technology or practices for the control or abatement of waste applicable to the point source discharge;

d. effluent standards and limitations are promulgated for point source discharges subject to this permit; or

e. the Department determines that the criteria under which the permit was issued no longer apply.

Any person may request the Department to take action pursuant to the provisions of Rule 2191 (Rule 323.2191 of the Michigan Administrative Code).

8. Requirements for Land Application Not Under the Control of the CAFO Permittee

In cases where CAFO waste is sold, given away, or otherwise transferred to another person (recipient) such that the land application of that CAFO waste is no longer under the operational control of the CAFO owner or operator that generates the CAFO waste (generator), the "Manifest for CAFO Waste" form shall be completed and used to track the transfer and use of the CAFO waste. The "Manifest for CAFO Waste" form shall be kept with the CNMP for 5 years from the date of creation. CAFO waste shall not be transferred to a recipient for land application of that waste during the months of January, February, or March.

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Section C. Other Requirements

a. Prior to transfer of the CAFO waste, the CAFO owner or operator shall utilize the “Manifest for CAFO Waste” form provided by the Department to record all of the following:

1) a manifest document number;

2) the generator's name, mailing address, and telephone number;

3) the name, address, and contact information of the recipient of the CAFO waste;

4) the generator shall provide to the recipient, the nutrient content of the CAFO waste to be transferred, in sufficient detail to be used in determining the agronomic land application rates;

5) the total quantity, by units of weight or volume, and the number and size of the loads or containers used to transfer that quantity of CAFO waste;

6) a statement that informs the recipient of his/her responsibility to properly manage the land application of the CAFO waste as necessary to ensure there is no illegal discharge of pollutants to surface waters of the state;

7) the following certification by the generator: "I hereby declare that the CAFO waste is accurately described above and is suitable for land application";

8) other certification statements as may be required by the Department;

9) the latitude and longitude center of the site or sites used by the recipient for land application or other disposal or use of the CAFO waste; and

10) signatures of the generator and recipient with dates of signature.

b. Prior to manifesting CAFO waste, the generator shall receive from the recipient, the soil phosphorus levels using the Bray P1 test method, no older than three years, that the recipient will use to determine the agronomic rates of land application of the CAFO waste.

c. The generator shall do all of the following with respect to the manifest:

1) sign and date the manifest certification prior to transfer of the CAFO waste;

2) obtain a dated signature of the recipient on the manifest and the date of acceptance of the CAFO waste;

3) obtain a copy of the completed signed “Manifest for CAFO Waste” form;

4) obtain the completed “Daily Manure Application Summary” from the recipient for each field on which the generator’s CAFO waste was applied;

5) provide a signed copy to the recipient; and

6) advise the recipient of his or her responsibilities to complete the “Manifest for CAFO Waste” form; if not completed at time of delivery, obtain a copy of the “Manifest for CAFO Waste” form from the recipient within 30 days of the transfer of the CAFO waste.

d. One “Manifest for CAFO Waste” form may be used for multiple loads or containers of the same CAFO waste transferred to the same recipient. The “Manifest for CAFO Waste” form shall list separately each address or location (latitude and longitude of field center) used by the recipient for land application or other disposal or use of the CAFO waste. Each separate address or location listing shall include the quantities of CAFO waste transferred to that location and dates of transfer.

Section C. Other Requirements

e. The generator shall not sell, give away, or otherwise transfer CAFO waste to a recipient if any of the following are true:

1) the recipient fails or refuses to provide accurate and complete information on the manifest in a timely manner;

2) the “Manifest for CAFO Waste” form indicates improper land application, use, or otherwise transferred;

3) the generator learns that there has been improper land application, use, or otherwise transferred of the manifested CAFO waste; and/or

4) appropriate jurisdiction has determined that the recipient has improperly land applied, used, or otherwise transferred of a manifested CAFO waste.

f. If the generator has been prohibited from selling, giving, or otherwise transferring CAFO waste to a particular recipient under Part I.C.8.e, above, and the generator wishes to resume selling, giving, or otherwise transferring CAFO waste to that particular recipient, then one of the following shall be accomplished:

1) For improper paperwork only, such as incomplete or inaccurate information on the “Manifest for CAFO Waste” form, the recipient must provide the correct, complete information.

2) For improper land application, use, or disposal of the CAFO waste by the recipient, the generator must submit a demonstration, to the Department via MiWaters (https://miwaters.deq.state.mi.us), that the improper land application, use, or disposal has been corrected, and the Department has responded to the demonstration with its approval of the demonstration.

g. The CAFO generator shall submit the required ”Land Application Summary” form for fields on which the recipient applied the generator’s CAFO waste via MiWaters (https://miwaters.deq.state.mi.us) within 30 days from each quarter ending March 31, June 30, September 30, and December 31 of each year and will include the following:

1) recipient name and phone or e-mail contact information;

2) date of transfer; and

3) If CAFO waste is used for land application of manure:

   a) dates of land application;

   b) field location (latitude and longitude of center of field);

   c) soil test results (and year of test) of fields;

   d) amount (and units) of manure applied; and

   e) manure source; or

   f) and number of acres applied.

4) If CAFO waste is not used for land application of manure:

   a) other use (digestor, composting, broker, etc.);

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Section C. Other Requirements

b) volume or tons of CAFO waste transferred.

h. The requirements of Part I.C.8. do not apply to quantities of CAFO waste less than one (1) pickup truck load, one (1) cubic yard, or one (1) ton per recipient per day.

9. Total Maximum Daily Load (TMDL) Waters

a. Nitrogen or Phosphorus TMDL
The Department expects that full compliance with the conditions of this permit will allow the permittee to meet the pollutant loading capacity(ies) set forth for nitrogen or phosphorus in an approved Total Maximum Daily Load (TMDL). The permittee's COC will indicate if the permittee's production area or land application areas are located within a watershed(s) covered by an approved nitrogen or phosphorus TMDL.

b. *E. coli*, Biota, Dissolved Oxygen TMDL
The permittee's COC will indicate if the permittee's production area or land application areas are located within a watershed(s) covered by an approved *E. coli*, biota, or dissolved oxygen TMDL. The Department has developed and published the "Total Maximum Daily Load (TMDL) Guidance for Concentrated Animal Feeding Operations (CAFO)" regarding how to evaluate operations and determine additional pollutant control measures. The permittee shall complete the following actions within 24 months of receiving notification from the Department:

1) Conduct a comprehensive evaluation of its operations. A comprehensive evaluation shall identify sources of pollutants that have the potential to reach surface waters from production areas and/or land application areas.

2) Determine whether additional pollutant control measures need to be identified and implemented to meet the permittee's pollutant loading (or "concentration" in the case of *E. coli*) capacity(ies) set forth in the approved TMDL. Pollutant control measures, shall at a minimum, include those that prevent surface runoff and subsurface drainage of CAFO waste from land application areas.

3) Submit a written TMDL Evaluation Report via MiWaters (https://miwaters.deq.state.mi.us) to the Department based on one of the following:

a) If the permittee, based on the comprehensive evaluation, determines that the pollutant loading or concentration allocation(s) established in the approved TMDL are being met, then the written TMDL Evaluation Report justifying that determination shall be submitted to the Department for approval, or

b) If the permittee determines that the pollutant loading or concentration allocation(s) established in the approved TMDL is being exceeded, then the written TMDL Evaluation Report submitted to the Department shall identify additional pollutant control measures that need to be implemented by the permittee to achieve compliance with the pollutant loading or concentration allocation(s) established in the approved TMDL. The permittee's written TMDL Evaluation Report shall also include an implementation schedule for each identified additional pollutant control measure.

Upon approval of the Department, and if the written report identifies needed additional pollutant control measures, the permittee shall implement the additional pollutant control measures according to the implementation schedule. The approved written TMDL Evaluation Report detailing the additional pollutant control measures and the associated implementation schedule shall be kept in the CNMP for a period of 5 years from the date of creation, and shall be an enforceable part of this permit.

PART I

Section C. Other Requirements

10. Treatment System

The CAFO may include an anaerobic digester-based treatment system. The application for coverage under this permit shall include a description of the construction and operation of the anaerobic digester-based treatment system, including a schematic or flow diagram of the process, a listing of all outside materials (non-CAFO waste) to be added to the digester, the percentage input to the digester comprised of outside materials, and a contingency plan in the event of system failures including computer malfunctions. The contingency plan shall address the actions to be taken by the permittee if the digester-based treatment system must be bypassed for any reason, including handling and storage of partially digested contents, and notifications per Part II.C.9.c. and d. of this permit.

Outside materials up to 20 percent the total digester volume may be added to the digester to enhance operation. Quantities of outside materials more than 5 percent of the total digester volume will be listed in the COC issued under this permit. The Department may prohibit the use of certain outside materials. The permittee shall keep in the CNMP for a minimum of 5 years from the date of creation, the reports of the quantities and identity of outside materials added to the digester. Outside materials not listed in the application shall not be added to the digester without prior approval from the Department. The outputs from the treatment system shall be stored and managed in accordance with the permit. The digester shall be operated consistently with the information provided in the application for coverage under this permit.

11. Document Availability

Copies of all documents required by this permit, including the CNMP, Land Application Log, inspection records, soil tests received by the recipient of manifested CAFO waste, etc., shall be kept at the permitted facility for a minimum of 5 years from the date of creation and made available to the Department upon request.

PART II

Section A. Definitions

Animal Feeding Operation (AFO) means a lot or facility that meets both of the following conditions:

1. Animals, other than aquatic animals, have been, are, or will be stabled or confined and fed or maintained for a total of 45 calendar days or more in any 12-month period.
2. Crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over the portion of the lot or facility where animals are confined. Two or more AFOs under common ownership are considered to be a single AFO if they adjoin each other or if they use a common area or system for the disposal of wastes. Common area includes land application areas.

Concentrated Animal Feeding Operation (CAFO) means any AFO that requests coverage under the permit for which the Department determines that this permit is appropriate for the applicant's operation. A CAFO includes both production areas and land application areas.

CAFO Process Wastewater means water directly or indirectly used in the operation of a CAFO for any of the following:

1. Spillage or overflow from animal or poultry watering systems.
2. Washing, cleaning, or flushing pens, barns, manure pits, or other AFO facilities.
3. Direct contact swimming, washing, or spray cooling of animals.
4. Dust control.
5. Any water which comes into contact with, or is a constituent of, any raw materials, products, or byproducts, including manure, litter, feed, milk, eggs, or bedding.

CAFO Waste means CAFO process wastewater, manure, production area waste, effluents from the properly and successfully operated treatment system, or any combination thereof.

Certificate of Coverage (COC) is a document, issued by the Department, which authorizes a discharge under a general permit.

Certified CNMP Provider is a person that attains and maintains certification requirements through a program approved by the United States Department of Agriculture Natural Resources Conservation Service (NRCS).

CNMP means Comprehensive Nutrient Management Plan and is the plan developed by the permittee to implement the requirements of the NMP.

Department means the Michigan Department of Environment, Great Lakes, and Energy (Formerly Michigan Department of Environmental Quality).

Discharge as used in this permit means the addition of any waste, waste effluent, wastewater, pollutant, or any combination thereof to any surface water of the state.

Grassed Waterway means a natural or constructed channel for storm water drainage that originates and is located within a field used for growing crops, and that is used to carry surface water at a non-erosive velocity to a stable outlet and is established with suitable and adequate permanent vegetation.

Incorporation means a mechanical operation that physically mixes the surface-applied CAFO waste into the soil so that a significant amount of the surface-applied CAFO waste is not present on the land surface within one hour after mixing. Incorporation also means the soaking into the soil of "liquids being used for irrigation water" such that liquids and significant solid residues do not remain on the land surface. "Liquids being used for irrigation water" are contaminated runoff, milk house waste, or liquids from CAFO waste treated to separate liquids and solids. "Liquids being used for irrigation water" does not include untreated liquid manures.

Land Application means spraying or spreading of biosolids, CAFO waste, wastewater and/or derivatives onto the land surface, injecting below the land surface, or incorporating into the soil so that the biosolids, CAFO waste, wastewater and/or derivatives can either condition the soil or fertilize crops or vegetation grown in the soil.

Land Application Area means land under the control of an AFO owner or operator, whether it is owned, rented, leased, or subject to an access agreement to which CAFO waste is or may be applied. Land application area includes land not owned by the AFO owner or operator but where the AFO owner or operator has control of the land application of CAFO waste.

PART II

Section A. Definitions

Large CAFO is an AFO that stables or confines as many as or more than the numbers of animals specified in any of the following categories:

1. 700 mature dairy cattle (whether milked or dry cows)
2. 1,000 veal calves
3. 1,000 cattle other than mature dairy cows or veal calves. Cattle include heifers, steers, bulls, calves, and cow/calf pairs
4. 2,500 swine each weighing 55 pounds or more
5. 10,000 swine each weighing less than 55 pounds
6. 500 horses
7. 10,000 sheep or lambs
8. 55,000 turkeys
9. 30,000 laying hens or broilers, if the AFO uses a liquid manure handling system
10. 125,000 chickens (other than laying hens), if the AFO uses other than a liquid manure handling system
11. 82,000 laying hens, if the AFO uses other than a liquid manure handling system
12. 30,000 ducks, if the AFO uses other than a liquid manure handling system
13. 5,000 ducks, if the AFO uses a liquid manure handling system

Large CAFOs are required to obtain NPDES permits under Michigan Rule No. 323.2196.

Manure means animal excrement and is defined to include bedding, compost, and raw materials, or other materials commingled with animal excrement or set aside for disposal.

Maximum Annual Phosphorus Land Application Rate means the maximum quantity, per calendar year, of phosphorus (usually expressed in pounds per acre) that is allowed to be applied to crop fields where CAFO waste is spread, including the phosphorus contained in the CAFO waste.

New CAFO means a CAFO that is newly built and was not in production (i.e., animals were not on site) prior to January 30, 2004. New CAFO also means existing facilities where, due to expansion in production, the process or production equipment is totally replaced or new processes are added that are substantially independent of an existing source at the same site, after February 27, 2004. This does not include replacement due to acts of God or upgrades in technology that serve the existing production. This definition does not apply to “New” as used for swine, poultry, and veal facilities in Part I.B.1.a.3).

NMP means Nutrient Management Plan and is the section in the permit that sets forth requirements and conditions to ensure that water quality standards are met.

No-Till Practices means where the field will not receive tillage from time of land application until after harvest of the next crop.

NRCS means the Natural Resources Conservation Service of the United States Department of Agriculture.

NRCS 313 means the NRCS Michigan Statewide Technical Guide, Section IV, Conservation Practice No. 313, Waste Storage Facility, dated either June 2003, November 2005,August 2014, or November 2017.

Overflow means a release of CAFO waste resulting from the filling of CAFO waste storage structures beyond the point at which no more CAFO waste or storm water can be contained by the structure.

Pastureland is land that is primarily used for the production of forage upon which animals graze. Pastureland is characterized by a predominance of vegetation consisting of desirable forage species. Sites such as loafing areas, confinement areas, or feedlots which have animal densities that preclude a predominance of desirable forage species are not considered pastureland. Heavy-use areas within pastures adjacent to, or associated with, the CAFO are part of the pasture and are not part of the production area. Examples of heavy-use areas include animal travel lanes and small areas immediately adjacent to feed and watering stations.

Perennial means a plant that has a life cycle of more than two years.

PART II

Section A. Definitions

Production Area is the portion of the CAFO that includes all areas used for animal product production activities. This includes but is not limited to the animal confinement area, the manure storage area, the raw materials storage area, treatment systems, and the waste containment areas. The animal confinement area includes open lots, housed lots, feedlots, confinement houses, stall barns, free stall barns, milk rooms, milking centers, cow yards, barnyards, medication pens, walkers, animal walkways (not within pasture areas), and stables. The manure storage area includes lagoons, runoff ponds, storage sheds, stockpiles, under-house or pit storages, liquid impoundments, static piles, and composting piles. The raw materials storage area includes feed silos, silage bunkers, and bedding materials (including new sand used for bedding). The waste containment area includes settling basins and areas within berms and diversions which separate uncontaminated storm water. Also included in the definition of "production area" is any egg washing or egg processing facility, and any area used in the storage, handling, treatment, or disposal of mortalities. Production areas do not include pasture lands or land application areas.

Production Area Waste means manure and any waste from the production area and any precipitation (e.g., rain or snow) which comes into contact with, or is contaminated by, manure or any of the components listed in the definition for "production area." Production area waste also includes treatment system feedstock and runoff from treatment system areas. Production area waste does not include clean water that is diverted, nor does it include water from land application areas.

Realistic Crop Yield Goals means expected crop yields based on soil productivity potential, the crop management practices utilized, and crop yield records for multiple years for the field. Yield goals shall be adjusted to counteract unusually low or high yields. When a field's history is not available, another referenced source shall be used to estimate yield goal. A realistic crop yield goal is one which is achievable in three out of five crop years. If the goal is not achieved in at least three out of five years, then the goal shall be re-evaluated and revised.

Regional Administrator is the Region 5 Administrator, United States Environmental Protection Agency (USEPA), located at R-19J, 77 West Jackson Boulevard, Chicago, Illinois 60604.

Silage Leachate means a liquid, containing organic constituents, that results from the storage of harvested plant materials, which usually has a high-water content.

Solid Stackable Manure means manure and manure mixed with bedding that can be piled up or stacked and will maintain a piled condition. It will also have the characteristic that it can be shoveled with a pitchfork.

Swale means a shallow, channel-like, linear depression within a field used for growing crops that is at a low spot on a hillslope and is used to transport storm water. It may or may not be vegetated.

Waste Storage Structure means both pond-type storage structures and fabricated storage structures.

Tile means a conduit, such as corrugated plastic tubing, tile, or pipe, installed beneath the ground surface to collect and/or convey drainage water.

Vegetated Buffer means a narrow, permanent strip of dense perennial vegetation, established parallel to the contours of and perpendicular to the dominant slope of the field, for the purposes of slowing water runoff, enhancing water infiltration, and minimizing the risk of any potential nutrients or pollutants from leaving the field and reaching surface waters of the state.

Water Quality Standards means the Part 4 Water Quality Standards developed under Part 31 of Act No. 451 of the Public Acts of 1994, as amended, being Rules 323.1041 through 323.1117 of the Michigan Administrative Code.

25-year, 24-hour rainfall event or **100-year, 24-hour rainfall event** means the maximum 24-hour precipitation event with a probable recurrence interval of once in 25 years or 100 years, respectively as determined by the "NOAA ATLAS-14 Precipitation Frequency Data Server (PFDS)" https://hdsc.nws.noaa.gov/hdsc/pfds/).

PART II

Section B. Monitoring Procedures

1. Representative Samples

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. Test Procedures

Test procedures for the analysis of pollutants shall conform to regulations promulgated pursuant to Section 304(h) of the Federal Act (40 CFR Part 136 – Guidelines Establishing Test Procedures for the Analysis of Pollutants), unless specified otherwise in this permit. Test procedures used shall be sufficiently sensitive to determine compliance with applicable effluent limitations. Requests to use test procedures not promulgated under 40 CFR Part 136 for pollutant monitoring required by this permit shall be made in accordance with the Alternate Test Procedures regulations specified in 40 CFR 136.4. These requests shall be submitted to the Manager of the Permits Section, Water Resources Division, Michigan Department of Environment, Great Lakes, and Energy, P.O. Box 30458, Lansing, Michigan, 48909-7958. The permittee may use such procedures upon approval.

The permittee shall periodically calibrate and perform maintenance procedures on all analytical instrumentation at intervals to ensure accuracy of measurements. The calibration and maintenance shall be performed as part of the permittee’s laboratory Quality Control/Quality Assurance program.

3. Instrumentation

The permittee shall periodically calibrate and perform maintenance procedures on all monitoring instrumentation at intervals to ensure accuracy of measurements.

4. Recording Results

For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information: 1) the exact place, date, and time of measurement or sampling; 2) the person(s) who performed the measurement or sample collection; 3) the dates the analyses were performed; 4) the person(s) who performed the analyses; 5) the analytical techniques or methods used; 6) the date of and person responsible for equipment calibration; and 7) the results of all required analyses. Records shall be kept in the CNMP for a minimum of five years from the date of creation.

5. Records Retention

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained for a minimum of five (5) years from the date of creation, or longer if requested by the Regional Administrator or the Department.

PART II

Section C. Reporting Requirements

1. Start-up Notification

If the permittee will not populate with animals during the first 60 days following the effective date of the certificate of coverage issued under this permit then the permittee shall notify the Department within 14 days following the effective date of the certificate of coverage issued under this permit. Subsequently, the Department shall be notified 60 days prior to population with animals.

2. Submittal Requirements for Self-Monitoring Data

Part 31, of the NREPA, (specifically Section 324.3110(7)), and R 323.2155(2) of Part 21, Wastewater Discharge Permits, promulgated under Part 31, of the NREPA, allows the Department to specify the forms to be utilized for reporting the required self-monitoring data. Unless instructed on the effluent limitations page to conduct "Retained Self-Monitoring" the permittee shall submit self-monitoring data via the Department's MiWaters system.

The permittee shall utilize the information provided on the MiWaters website at https://miwaters.deq.state.mi.us, to access and submit the electronic forms. Both monthly summary and daily data shall be submitted to the Department no later than the 20th day of the month following each month of the authorized discharge period(s). The permittee may be allowed to submit the electronic forms after this date if the Department has granted an extension to the submittal date.

3. Retained Self-Monitoring Requirements

If instructed on the effluent limits page (or otherwise authorized by the Department in accordance with the provisions of this permit) to conduct retained self-monitoring, the permittee shall maintain a year-to-date log of retained self-monitoring results and, upon request, provide such log for inspection to the staff of the Department. Retained self-monitoring results are public information and shall be promptly provided to the public upon request.

The permittee shall certify, in writing, to the Department, on or before January 10th (April 1st for animal feeding operation facilities) of each year, that: 1) all retained self-monitoring requirements have been complied with and a year-to-date log has been maintained; and 2) the application on which this permit is based still accurately describes the discharge. With this annual certification, the permittee shall submit a summary of the previous year's monitoring data. The summary shall include maximum values for samples to be reported as daily maximums and/or monthly maximums and minimum values for any daily minimum samples.

Retained self-monitoring may be denied to a permittee by notification in writing from the Department. In such cases, the permittee shall submit self-monitoring data in accordance with Part II.C.2., above. Such a denial may be rescinded by the Department upon written notification to the permittee. Reissuance or modification of this permit or reissuance or modification of an individual permittee's authorization to discharge shall not affect previous approval or denial for retained self-monitoring unless the Department provides notification in writing to the permittee.

4. Additional Monitoring by Permittee

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report. Such increased frequency shall also be indicated.

Monitoring required pursuant to Part 41, Sewerage Systems, of the NREPA, or Rule 35 of the Mobile Home Park Commission Act (Public Act 96 of 1987) for assurance of proper facility operation shall be submitted as required by the Department.

PART II

Section C. Reporting Requirements

5. Compliance Dates Notification

Within 14 days of every compliance date specified in this permit, the permittee shall submit a notification to the Department via MiWaters (https://miwaters.deq.state.mi.us) indicating whether or not the particular requirement was accomplished. If the requirement was not accomplished, the notification shall include an explanation of the failure to accomplish the requirement, actions taken or planned by the permittee to correct the situation, and an estimate of when the requirement will be accomplished. If a report is required to be submitted by a specified date and the permittee accomplishes this, a separate notification is not required.

6. Noncompliance Notification

Compliance with all applicable requirements set forth in the Federal Act, Parts 31 and 41 of the NREPA, and related regulations and rules is required. All instances of noncompliance shall be reported as follows:

a. 24-Hour Reporting
Any noncompliance which may endanger health or the environment (including maximum and/or minimum daily concentration discharge limitation exceedances) shall be reported, verbally, within 24 hours from the time the permittee becomes aware of the noncompliance. A submission via MiWaters (https://miwaters.deq.state.mi.us) shall also be provided within five (5) days.

b. Other Reporting
The permittee shall report, via MiWaters (https://miwaters.deq.state.mi.us), all other instances of noncompliance not described in a. above at the time monitoring reports are submitted; or, in the case of retained self-monitoring, within five (5) days from the time the permittee becomes aware of the noncompliance.

Reporting shall include: (1) a description of the discharge and cause of noncompliance; and (2) the period of noncompliance, including exact dates and times, or, if not yet corrected, the anticipated time the noncompliance is expected to continue, and the steps taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

7. Spill Notification

The permittee shall immediately report via MiWaters (https://miwaters.deq.state.mi.us) any release of any polluting material which occurs to the surface waters or groundwaters of the state, unless the permittee has determined that the release is not in excess of the threshold reporting quantities specified in the Part 5 Rules (R 324.2001 through R 324.2009 of the Michigan Administrative Code), by calling the Department at the number indicated on the second page of this permit (or, if this is a general permit, on the COC); or, if the notice is provided after regular working hours, call the Department's 24-hour Pollution Emergency Alerting System telephone number, 1-800-292-4706.

Within ten (10) days of the release, the permittee shall submit to the Department via MiWaters (https://miwaters.deq.state.mi.us), a full written explanation as to the cause of the release, the discovery of the release, response (clean-up and/or recovery) measures taken, and preventative measures taken or a schedule for completion of measures to be taken to prevent reoccurrence of similar releases.

8. Upset Noncompliance Notification

If a process "upset" (defined as an exceptional incident in which there is unintentional and temporary noncompliance with technology based permit effluent limitations because of factors beyond the reasonable control of the permittee) has occurred, the permittee who wishes to establish the affirmative defense of upset, shall notify the Department by telephone within 24 hours of becoming aware of such conditions; and within five (5) days, provide in writing, the following information:

a. that an upset occurred, and that the permittee can identify the specific cause(s) of the upset;

b. that the permitted wastewater treatment facility was, at the time, being properly operated and maintained (note that an upset does not include noncompliance to the extent caused by operational error,

PART II

Section C. Reporting Requirements

improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation); and

c. that the permittee has specified and acted on all responsible steps to minimize or correct any adverse impact in the environment resulting from noncompliance with this permit.

No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review.

In any enforcement proceedings, the permittee, seeking to establish the occurrence of an upset, has the burden of proof.

9. Bypass Prohibition and Notification

a. Bypass Prohibition
Bypass is prohibited, and the Department may take an enforcement action, unless:

1) bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;

2) there were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate backup equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass; and

3) the permittee submitted notices as required under 9.b. or 9.c. below.

b. Notice of Anticipated Bypass
If the permittee knows in advance of the need for a bypass, it shall submit prior notice to the Department, if possible, at least ten (10) days before the date of the bypass and provide information about the anticipated bypass as required by the Department. The Department may approve an anticipated bypass, after considering its adverse effects, if it will meet the three (3) conditions listed in 9.a. above.

c. Notice of Unanticipated Bypass
The permittee shall submit notice to the Department of an unanticipated bypass by calling the Department at the number indicated on the second page of this permit (if the notice is provided after regular working hours, use the following number: 1-800-292-4706) as soon as possible, but no later than 24 hours from the time the permittee becomes aware of the circumstances.

d. Written Report of Bypass
A written submission shall be provided within five (5) working days of commencing any bypass to the Department, and at additional times as directed by the Department. The written submission shall contain a description of the bypass and its cause; the period of bypass, including exact dates and times, and if the bypass has not been corrected, the anticipated time it is expected to continue; steps taken or planned to reduce, eliminate, and prevent reoccurrence of the bypass; and other information as required by the Department.

e. Bypass Not Exceeding Limitations
The permittee may allow any bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to ensure efficient operation. These bypasses are not subject to the provisions of 9.a., 9.b., 9.c., and 9.d., above. This provision does not relieve the permittee of any notification responsibilities under Part II.C.11. of this permit.

PART II

Section C. Reporting Requirements

f. Definitions

1) Bypass means the intentional diversion of waste streams from any portion of a treatment facility.

2) Severe property damage means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

10. Bioaccumulative Chemicals of Concern (BCC)

Consistent with the requirements of R 323.1098 and R 323.1215 of the Michigan Administrative Code, the permittee is prohibited from undertaking any action that would result in a lowering of water quality from an increased loading of a BCC unless an increased use request and antidegradation demonstration have been submitted and approved by the Department.

11. Notification of Changes in Discharge

The permittee shall notify the Department, via MiWaters (https://miwaters.deq.state.mi.us), as soon as possible but no later than 10 days of knowing, or having reason to believe, that any activity or change has occurred or will occur which would result in the discharge of: (1) detectable levels of chemicals on the current Michigan Critical Materials Register, priority pollutants or hazardous substances set forth in 40 CFR 122.21, Appendix D, or the Pollutants of Initial Focus in the Great Lakes Water Quality Initiative specified in 40 CFR 132.6, Table 6, which were not acknowledged in the application or listed in the application at less than detectable levels; (2) detectable levels of any other chemical not listed in the application or listed at less than detection, for which the application specifically requested information; or (3) any chemical at levels greater than five times the average level reported in the complete application (see the first page of this permit, for the date(s) the complete application was submitted). Any other monitoring results obtained as a requirement of this permit shall be reported in accordance with the compliance schedules.

12. Changes in Facility Operations

Any anticipated action or activity, including but not limited to facility expansion, production increases, or process modification, which will result in new or increased loadings of pollutants to the receiving waters must be reported to the Department by a) submission of an increased use request (application) and all information required under R 323.1098 (Antidegradation) of the Water Quality Standards <u>or</u> b) by notice if the following conditions are met: (1) the action or activity will not result in a change in the types of wastewater discharged or result in a greater quantity of wastewater than currently authorized by this permit; (2) the action or activity will not result in violations of the effluent limitations specified in this permit; (3) the action or activity is not prohibited by the requirements of Part II.C.10.; and (4) the action or activity will not require notification pursuant to Part II.C.11. Following such notice, the permit or, if applicable, the facility's COC may be modified according to applicable laws and rules to specify and limit any pollutant not previously limited.

13. Transfer of Ownership or Control

In the event of any change in control or ownership of facilities from which the authorized discharge emanates, the permittee shall submit to the Department via MiWaters (https://miwaters.deq.state.mi.us) within 30 days of the actual transfer of ownership or control a written agreement between the current permittee and the new permittee containing: (1) the legal name and address of the new owner; (2) a specific date for the effective transfer of permit responsibility, coverage and liability; and (3) a certification of the continuity of or any changes in operations, wastewater discharge, or wastewater treatment.

If the new permittee is proposing changes in operations, wastewater discharge, or wastewater treatment, the Department may propose modification of this permit in accordance with applicable laws and rules.

PART II

Section C. Reporting Requirements

14. Operations and Maintenance Manual

For wastewater treatment facilities that serve the public (and are thus subject to Part 41 of the NREPA), Section 4104 of Part 41 and associated Rule 2957 of the Michigan Administrative Code allow the Department to require an Operations and Maintenance (O&M) Manual from the facility. An up-to-date copy of the O&M Manual shall be kept at the facility and shall be provided to the Department upon request. The Department may review the O&M Manual in whole or in part at its discretion and require modifications to it if portions are determined to be inadequate.

At a minimum, the O&M Manual shall include the following information: permit standards; descriptions and operation information for all equipment; staffing information; laboratory requirements; record keeping requirements; a maintenance plan for equipment; an emergency operating plan; safety program information; and copies of all pertinent forms, as-built plans, and manufacturer's manuals.

Certification of the existence and accuracy of the O&M Manual shall be submitted to the Department at least sixty days prior to start-up of a new wastewater treatment facility. Recertification shall be submitted sixty days prior to start-up of any substantial improvements or modifications made to an existing wastewater treatment facility.

15. Signatory Requirements

All applications, reports, or information submitted to the Department in accordance with the conditions of this permit and that require a signature shall be signed and certified as described in the Federal Act and the NREPA.

The Federal Act provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance, shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than 6 months per violation, or by both.

The NREPA (Section 3115(2)) provides that a person who at the time of the violation knew or should have known that he or she discharged a substance contrary to this part, or contrary to a permit, COC, or order issued or rule promulgated under this part, or who intentionally makes a false statement, representation, or certification in an application for or form pertaining to a permit or COC or in a notice or report required by the terms and conditions of an issued permit or COC, or who intentionally renders inaccurate a monitoring device or record required to be maintained by the Department, is guilty of a felony and shall be fined not less than $2,500.00 or more than $25,000.00 for each violation. The court may impose an additional fine of not more than $25,000.00 for each day during which the unlawful discharge occurred. If the conviction is for a violation committed after a first conviction of the person under this subsection, the court shall impose a fine of not less than $25,000.00 per day and not more than $50,000.00 per day of violation. Upon conviction, in addition to a fine, the court in its discretion may sentence the defendant to imprisonment for not more than 2 years or impose probation upon a person for a violation of this part. With the exception of the issuance of criminal complaints, issuance of warrants, and the holding of an arraignment, the circuit court for the county in which the violation occurred has exclusive jurisdiction. However, the person shall not be subject to the penalties of this subsection if the discharge of the effluent is in conformance with and obedient to a rule, order, permit, or COC of the Department. In addition to a fine, the attorney general may file a civil suit in a court of competent jurisdiction to recover the full value of the injuries done to the natural resources of the state and the costs of surveillance and enforcement by the state resulting from the violation.

16. Electronic Reporting

Upon notice by the Department that electronic reporting tools are available for specific reports or notifications, the permittee shall submit electronically via MiWaters (https://miwaters.deq.state.mi.us) all such reports or notifications as required by this permit, on forms provided by the Department.

PART II

Section D. Management Responsibilities

1. Duty to Comply

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit, more frequently than, or at a level in excess of, that authorized, shall constitute a violation of the permit.

It is the duty of the permittee to comply with all the terms and conditions of this permit. Any noncompliance with the Effluent Limitations, Special Conditions, or terms of this permit constitutes a violation of the NREPA and/or the Federal Act and constitutes grounds for enforcement action; for permit or Certificate of Coverage (COC) termination, revocation and reissuance, or modification; or denial of an application for permit or COC renewal.

It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

2. Facilities Operation

The permittee shall, at all times, properly operate and maintain all treatment or control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit. Proper operation and maintenance include adequate laboratory controls and appropriate quality assurance procedures.

3. Power Failures

In order to maintain compliance with the effluent limitations of this permit and prevent unauthorized discharges, the permittee shall either:

a. provide an alternative power source sufficient to operate facilities utilized by the permittee to maintain compliance with the effluent limitations and conditions of this permit; or

b. upon the reduction, loss, or failure of one or more of the primary sources of power to facilities utilized by the permittee to maintain compliance with the effluent limitations and conditions of this permit, the permittee shall halt, reduce or otherwise control production and/or all discharge in order to maintain compliance with the effluent limitations and conditions of this permit.

4. Adverse Impact

The permittee shall take all reasonable steps to minimize or prevent any adverse impact to the surface waters or groundwaters of the state resulting from noncompliance with any effluent limitation specified in this permit including, but not limited to, such accelerated or additional monitoring as necessary to determine the nature and impact of the discharge in noncompliance.

5. Containment Facilities

The permittee shall provide facilities for containment of any accidental losses of polluting materials in accordance with the requirements of the Part 5 Rules (R 324.2001 through R 324.2009 of the Michigan Administrative Code). For a Publicly Owned Treatment Work (POTW), these facilities shall be approved under Part 41 of the NREPA.

PART II

Section D. Management Responsibilities

6. Waste Treatment Residues

Residuals (i.e. solids, sludges, biosolids, filter backwash, scrubber water, ash, grit, or other pollutants or wastes) removed from or resulting from treatment or control of wastewaters, including those that are generated during treatment or left over after treatment or control has ceased, shall be disposed of in an environmentally compatible manner and according to applicable laws and rules. These laws may include, but are not limited to, Part 31, Water Resources Protection; Part 55, Air Pollution Control; Part 111, Hazardous Waste Management; Part 115, Solid Waste Management; Part 121, Liquid Industrial By-Products; Part 301 Inland Lakes and Streams; and Part 303 Wetlands Protection, of the NREPA. Such disposal shall not result in any unlawful pollution of the air, surface waters, or groundwaters of the state.

7. Right of Entry

The permittee shall allow the Department, any agent appointed by the Department, and the Regional Administrator or their designee, upon the presentation of credentials and, for animal feeding operation facilities, following appropriate biosecurity protocols:

a. to enter upon the permittee's premises where an effluent source is located or any place in which records are required to be kept under the terms and conditions of this permit; and

b. at reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect process facilities, treatment works, monitoring methods and equipment regulated or required under this permit; and to sample any discharge of pollutants.

8. Availability of Reports

Except for data determined to be confidential under Section 308 of the Federal Act and Rule 2128 (R 323.2128 of the Michigan Administrative Code), reports prepared in accordance with the terms of this permit and required to be submitted to the Department, shall be available for public inspection via MiWaters (https://miwaters.deq.state.mi.us). As required by the Federal Act, effluent data shall not be considered confidential. Knowingly making any false statement on any such report may result in the imposition of criminal penalties as provided for in Section 309 of the Federal Act and Sections 3112, 3115, 4106 and 4110 of the NREPA.

9. Duty to Provide Information

The permittee shall furnish to the Department via MiWaters (https://miwaters.deq.state.mi.us), within a reasonable time, any information which the Department may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or the facility's COC, or to determine compliance with this permit. The permittee shall also furnish to the Department, upon request, copies of records required to be kept by this permit.

Where the permittee becomes aware that it failed to submit any relevant facts in a permit application or submitted incorrect information in a permit application or in any report to the Department, it shall promptly submit such facts or information.

PART II

Section E. Activities Not Authorized by this Permit

1. Discharge to the Groundwaters

This permit does not authorize any discharge to the groundwaters. Such discharge may be authorized by a groundwater discharge permit issued pursuant to the NREPA.

2. POTW Construction

This permit does not authorize or approve the construction or modification of any physical structures or facilities at a POTW. Approval for the construction or modification of any physical structures or facilities at a POTW shall be by permit issued under Part 41 of the NREPA.

3. Civil and Criminal Liability

Except as provided in permit conditions on "Bypass" (Part II.C.9. pursuant to 40 CFR 122.41(m)), nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance, whether or not such noncompliance is due to factors beyond the permittee’s control, such as accidents, equipment breakdowns, or labor disputes.

4. Oil and Hazardous Substance Liability

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee may be subject under Section 311 of the Federal Act except as are exempted by federal regulations.

5. State Laws

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable state law or regulation under authority preserved by Section 510 of the Federal Act.

6. Property Rights

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize violation of any federal, state or local laws or regulations, nor does it obviate the necessity of obtaining such permits, including any other Department of Environment, Great Lakes, and Energy permits, or approvals from other units of government as may be required by law.

PART III

Technical Standard for the Surface Application of Concentrated Animal Feeding Operations Waste on Frozen or Snow-Covered Ground Without Incorporation or Injection

When Concentrated Animal Feeding Operation (CAFO) waste is surface-applied to frozen or snow-covered ground, without incorporation or injection, and that application is followed by rainfall or temperatures rising above freezing, the CAFO waste can run off into lakes, streams, or drains. Documented evidence shows that this runoff can cause resource damage to the surface waters of the state. Therefore, in accordance with Title 40 of the Code of Federal Regulations, Section 123.36, Establishment of Technical Standards for Concentrated Animal Feeding Operations, and State Rule 323.2196(5), CAFO Permits, the Michigan Department of Environmental Quality, (DEQ), Water Bureau, establishes the following Technical Standard. This Technical Standard shall be used for field-by-field assessments, as required by National Pollutant Discharge Elimination System permits issued to CAFOs, to ensure that the land application of CAFO waste to frozen or snow-covered ground, without incorporation or injection, will not result in CAFO waste entering the waters of the state.

Based on the frozen and/or snow-covered conditions, the minimal settling and breaking down of the waste during these conditions, and the inability to predict or control snowmelt and rainfall, there are no practices that can ensure the runoff from fields with surface-applied waste on frozen or snow-covered ground will not be polluted. This standard assumes that surface runoff from snowmelt and/or rainfall will occur, and that the runoff will be polluted if CAFO waste is surface-applied on frozen or snow-covered ground. Therefore, the way to prevent these discharges is to apply CAFO waste only to fields, or portions of fields, where the runoff will not reach surface waters.

A field-by-field assessment must be completed, and all of the following requirements must be met and documented:

1. The Natural Resources Conservation Service's Manure Application Risk Index (MARI)* has been completed to identify fields, or portions of fields, that scored 37 or lower on the MARI.

2. An on-site field inspection of the entire field, or portion of field, that scored 37 or lower under the MARI has been completed. The inspection will take into consideration the slope and location of surface waters, tile line risers, and other conduits to surface water.

3. Based on the on-site field inspection, the Comprehensive Nutrient Management Plan (CNMP) will include documentation on topographic maps, the fields or portions of fields where the runoff will not flow to surface waters, and designate those areas as the only areas authorized for surface application without incorporation to frozen or snow-covered ground.

4. The findings of the inspection and documentation in the CNMP will be approved by a certified CNMP provider.

This assessment must be incorporated into the CNMP, and submitted as part of the CNMP Executive Summary each year.

* Grigar, J., and Lemunyon, J. A Procedure for Determining the Land Available for Winter Spreading of Manure in Michigan. NRCS publication. (Available on the EGLE NPDES website)

__ORIGINAL SIGNED________________ April 19, 2005

Richard A. Powers, Chief Date
Water Bureau

EXHIBIT 2

Vol. 16 No. 4 October 2011

Michigan Dairy Review

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Economics of Liquid Manure Transport and Land Application

Tim Harrigan
Dept. of Biosystems and Agricultural Engineering

Many of the questions that manure managers have relate to capacity, cost, and labor requirements of manure hauling systems. As farms have consolidated and increased in size manure handling equipment has evolved to transport and apply manure quickly and efficiently. Large spreader tanks, in excess of 10,000 gal, have been developed, the use of in-field manure transfer systems have improved the productivity of over-the-road nurse trucks, boom extensions have reduced the need for in-field truck maneuvering, and high-capacity pit and spreader pumps have reduced the time needed for loading, unloading and land application. We recently completed an economic evaluation of liquid manure hauling costs and labor needs with top-loading tank spreader systems on dairy farms based on the hauling rates (gal/hr) and efficiencies we observed on several well-managed livestock farms.

The cropping systems included acreage in alfalfa, corn silage and corn grain. The average manure hauling distance was 1, 1.5, 2, and 2.5 miles for 175-, 350-, 700- and 1400-cow farms, respectively. Some fields were as far as 2 miles from the manure storage on the 175-cow herd, 3 miles for the 350- and 700-cow herds, and 4 miles for the 1,400-cow herd. Tank spreaders ranged from 3,000 to 9,000 gal and the equipment used was sized to complete annual manure hauling operations in about twenty, 10-hr days (200 hr).

The economic evaluation included costs for agitation and pumping, over-the-road transport and land application by either injection with a 6-point injector or surface broadcast with tillage incorporation. The hauling rate declined rapidly as the distance increased. Compared with fields near the storage facility, the hauling rate fell by 20% with a 1-mile haul, 40% with a 2-mile haul and 50% with a 3-mile haul.

175-cow Dairy Example

The 175-cow dairy applied about 1.53 million gal/yr with an average hauling distance of 1 mile, but some fields were as much as 2 miles from the manure storage. Transport and application was with a 3,000 gal tank spreader and 120 hp tractor. Tillage incorporation was with an 18-ft disk and 140 hp tractor. The farm-average hauling rate was about 10,000 gal/hr, but the field-average rate ranged from 12,000 gal/hr for fields near the pit to 7,600 gal/hr for outlying fields. Eighteen days were needed for transport and land application.

The total cost for pumping, agitation, hauling, land application and tillage incorporation was 1.18 cents/gal (Figure 1 on page 14). Transport and land application accounted for two-thirds of the total cost. Manure agitation and pumping included 16 labor hours for set-up and agitation, plus agitation while the pump was filling the spreader. Pumping and agitation was about 14% of the total cost. Thirty-one hours were needed for tillage incorporation at a cost of $14.30/acre. Tillage incorporation accounted for 20% of the total hauling cost. The total cost for these operations was $103/cow per year or $74/acre.

Slurry injection eliminated the need for tillage incorporation and helped reduce odor and nitrogen loss, but increased the cost of transport and land application by a small amount. When slurry injection was used the farm-average hauling rate fell about 13% to 8,900 gal/hr. The field-average rate ranged from 10,300 gal/hr near the pit to 6,800 gal/hr for the outlying fields. Two additional days were needed for injection compared with a surface broadcast application because the unloading rate was less and more time was needed for maintenance of injectors. However, when the time for tillage incorporation was added to the time for surface broadcast, about 10 more hr (one additional day) was needed for broadcast and incorporation than for injection on the 175-cow farm.

The total cost for injection (1.22 cents/gal) was about 3% greater for broadcast with tillage incorporation. The annual cost for pumping, agitation, transport and injection was $73/acre or $107/cow per year, about $4/cow per year, more than with broadcast and incorporation.

1,400-cow Dairy Example

The 1,400-cow dairy applied 12.2 million gal/year with an average hauling distance of 2.5 miles but some fields were as far as 4 miles from the manure storage. Four 9,000 gal tank spreaders with 240 hp tractors were used for transport and broadcast application. The farm-average hauling rate was 72,400 gal/hr, but the field-average rate ranged from 90,300 gal/hr within 1 mile of the farm to 48,600 gal/hr with a 4-mile haul. Manure was incorporated with a 32-ft disk and 180 hp tractor. Two large lagoon pumps were used for pit pumping and agitation.

The total cost for pumping, agitation, hauling, land application and tillage incorporation was 1.34 cents/gal (Figure 2). Transport and land application accounted for 79%, pumping and agitation was 13% and tillage incorporation was 8% of the total cost. Surface broadcast application required 217 hr (21.7 days), tillage incorporation required 136 hr (13.6 days).

When slurry injection was used the farm-average hauling rate was 58,600 gal/hr, but the field-average rate ranged from 71,000 gal/hr near the storage to 42,700 gal/hr for outlying fields. Twenty-six days (260 hr) were needed for injection compared with 21.7 days (217 hr) for a broadcast application, but when the time needed for incorporation was included, the broadcast application required 90 more machine hours than injection. The total cost of injection (1.48 cents/gal) was 10% greater than broadcast with tillage incorporation. The annual cost for pumping, agitation, transport and injection was about $84/acre or $129/cow per year, about $13/cow per year greater than broadcast and incorporation.

Summary

Manure transport and land application is an expensive and time consuming process. The cost for pit agitation, pumping, and transport and land application ranged from 1.18 cents/gal ($103/cow/yr) for broadcast and incorporation for a 175-cow herd with a 1-mile haul to 1.48 cents/gal ($129/cow per year) for a 1,400-cow herd with tank spreaders, nurse trucks and subsurface injection. There was no cost advantage for large farms when manure handling equipment was selected to complete field operations within about 20, 10-hr days (200 hr) per year. The hauling efficiencies of larger tank spreaders were offset by the greater hauling distance for the larger herds.

Custom manure haulers have the skill, labor and specialized equipment to handle manure efficiently and effectively. Custom hire of manure application services may be a good management choice for many dairies. Based on a current value of $0.50/lb for commercial nitrogen, phosphorus and potassium, the nutrient value of liquid dairy manure with an analysis of 24 lb N:18lb P_2O_5:29 lb K_2O is about $36/1,000 gal. Manure managers can recover handling costs by testing soil and manure and reducing commercial fertilizer purchases when crop nutrient needs can be met by manure nutrients.

For additional information about the economic analysis and results reported in this article see, Hadrich, J.C., T.M. Harrigan and C.A. Wolf. 2010. Economic Comparison of Liquid Manure Transport and Land Application. Applied Engineering in Agriculture 26(5): 743-758. To contact by email, write to Tim Harrigan <harriga1@anr.msu.edu>.

EXHIBIT 3

Testimony Excerpt of

EGLE Environmental Quality Analyst;
Thad Cleary

STATE OF MICHIGAN

MICHIGAN ADMINISTRATION HEARING SYSTEM

In the matter of:	Docket No.:	20-009773
Petition of Michigan Farm Bureau; Michigan Milk Producers Association; Michigan Allied Poultry Industries; Foremost Farms USA; Michigan Pork Producers Association; Dairy Farmers of America; Select Milk Producers, Inc.; and 126 Identified Livestock Farms /	Permit No.:	MIG010000
	Part:	Part 31, Water Resources Protection
	Agency:	Department of Environment, Great Lakes and Energy
	Case Type:	Water Resources Division

HEARING - VOLUME NO. IV

BEFORE DANIEL PULTER, ADMINISTRATIVE LAW JUDGE

Via Microsoft Teams Meeting

Thursday, December 9, 2021, 9:00 a.m.

APPEARANCES:

For the Petitioners:
MR. ZACHARY CHAD LARSEN (P72189)
MR. MICHAEL JOHN PATTWELL (P72419)
Clark Hill, PLC
212 East Cesar E. Chavez Avenue
Lansing, Michigan 48906
(517) 318-3053

For the Respondent:
MS. ELIZABETH ANNE MORRISSEAU (P81899)
MS. JENNIFER A. ROSA (P58226)
Assistant Attorneys General
Department of Attorney General
525 West Ottawa Street
G. Mennen Building, 6th Floor
Lansing, Michigan 48933
(517) 373-7540

Waste on Frozen or Snow-Covered Ground Without Incorporation or Injection." That technical standard has been included in every CAFO General Permit since 2005.

Q Are you generally aware of how CAFOs operate under the 2015 CAFO General Permit?

A Yes.

Q Based on your education, training, and experience, and with the benefit of hindsight and additional data not available to your predecessors who developed the permit, do you believe that the 2015 CAFO General Permit is now sufficiently protective of water quality?

A No.

Q Please explain more fully.

A The 2015 CAFO General Permit has exceptions to the winter ban of manure land application that allow for the land application of manure on frozen or snow-covered fields. The permit only requires six months of manure storage, which results in manure applications occurring when there is a higher risk of potential impacts to surface water quality. The permit allows manure application to occur on crop fields, up until soil test Bray P1 test levels reach 150 ppm, which is agronomically 4 to 5 times higher than the amount of phosphorus that is needed to grow most crops.

Q Did you work on the 2020 CAFO General Permit?

A I provided input on a few components of the permit.

concentration of phosphorous be in soil for land application?

A **I do not know what the exact number is, but I am confident that it is below the 150 ppm current limit, which is 4 to 5 times above agronomic rates. In a watershed project where we are paying for farmers to do variable rate manure applications, based on 2.5 acre grid soil sampling, we are requiring that the highest target for soil test phosphorus levels be 70 ppm. By allowing the buildup of soil phosphorus levels up to 5 times the needed agronomic rates, this practice is more about cheap manure disposal, than it is about the utilization of manure for crop production.**

Q What do you mean?

A **It is understood that different soil types have different capabilities of holding phosphorus in the soil profile. The current 75 ppm to 150 ppm standard does not take soil type into consideration. Thirty years ago, the understanding was that most of the phosphorus lost to surface waters was attached to soil particles that were eroded and deposited in the stream. There is an understanding by scientists today, that soluble phosphorus in surface runoff or tile line discharges contributes phosphorus to surface waters. When the 75 ppm to 150 ppm standards were established 25 to 30 years ago, it's not clear if soluble phosphorus and tile lines were considered at all. The recently released**

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EXHIBIT 4

Testimony Excerpt of

CAFO Owner and Plaintiff;

Robert Dykhius

STATE OF MICHIGAN

MICHIGAN ADMINISTRATION HEARING SYSTEM

In the matter of:	Docket No.:	20-009773
Petition of Michigan Farm Bureau; Michigan Milk Producers Association; Michigan Allied Poultry Industries; Foremost Farms USA; Michigan Pork Producers Association; Dairy Farmers of America; Select Milk Producers, Inc.; and 126 Identified Livestock Farms /	Permit No.:	MIG010000
	Part:	Part 31, Water Resources Protection
	Agency:	Department of Environment, Great Lakes and Energy
	Case Type:	Water Resources Division

HEARING - VOLUME NO. VIII

BEFORE DANIEL PULTER, ADMINISTRATIVE LAW JUDGE

Via Microsoft Teams Meeting

Wednesday, December 15, 2021, 9:00 a.m.

APPEARANCES:

For the Petitioners:
MR. ZACHARY CHAD LARSEN (P72189)
MR. MICHAEL JOHN PATTWELL (P72419)
Clark Hill, PLC
212 East Cesar E. Chavez Avenue
Lansing, Michigan 48906
(517) 318-3053

For the Respondent:
MS. ELIZABETH ANNE MORRISSEAU (P81899)
MS. JENNIFER A. ROSA (P58226)
Assistant Attorneys General
Department of Attorney General
525 West Ottawa Street
G. Mennen Building, 6th Floor
Lansing, Michigan 48933
(517) 373-7540

fertilizers?

A **There are often issues with overspreading or overreaching in application. Commercial fertilizer is sprayed in such a manner that you are often applying not only to the areas that you intend to fertilize but it also sprays beyond the intended areas. You fly beyond your "coverage level." So, in this case, it will likely result in spray beyond the fields and into the buffer areas.**

Q Are there any other practical concerns you would have as a farmer?

A **That soil in the setback areas will not get the bacteria provided by manure and other positive impacts on crop growth from manure -- such as those discussed earlier in my testimony.**

Q What is your understanding of EGLE's reduction of allowable phosphorus in fields that are available for land application?

A **Generally, EGLE is reducing the amount of allowable phosphorus in a field that is used for land application from 150 ppm to 135 ppm and then to 120 ppm for any land that is in a Total Maximum Daily Load ("TMDL") watershed.**

Q How will EGLE's proposed reduction affect the availability of farms that you currently use for land application?

A **At our, main larger CAFO, most of the fields have been over the 150-ppm threshold but the levels are lowering due to**

crop removal. EGLE has been allowing us to put low levels of dilute manure on the field. Because the levels have been lowering, the fields would become available for land application soon. But they will not under these conditions.

Q To your knowledge, are any of the fields that you use for land application in areas that are under a Total Maximum Daily Load restriction for nitrogen or phosphorus?

A Yes. Significant areas of our farm are within the TMDL for the Macatawa Watershed.

Q How will the additional TMDL restrictions imposed by EGLE in the 2020 General Permit affect your farm?

A It is very hard to say because the additional TMDL restrictions -- beyond the reduction of phosphorus levels for fields -- are not all defined. The permit simply says that additional measures will need to be proposed and required by EGLE.

However, I expect that because of the additional restrictions in TMDL areas, it will be tougher to make long-term commitments to facilities in those areas. It is the kiss of death for some business in those areas. Some older farms will not get reinvestment or they will need to become smaller so they are not CAFOs and can avoid these restrictions.

Q Do you ever have to apply CAFO manure as a means of addressing stressed crops?

EXHIBIT 5

EGLE Unit Supervisor, Water Quality and Aquatic Nuisance Control Permits Unit;

Sylvia Heaton

STATE OF MICHIGAN

MICHIGAN ADMINISTRATION HEARING SYSTEM

In the matter of:	Docket No.:	20-009773
Petition of Michigan Farm Bureau; Michigan Milk Producers Association; Michigan Allied Poultry Industries; Foremost Farms USA; Michigan Pork Producers Association; Dairy Farmers of America; Select Milk Producers, Inc.; and 126 Identified Livestock Farms /	Permit No.:	MIG010000
	Part:	Part 31, Water Resources Protection
	Agency:	Department of Environment, Great Lakes and Energy
	Case Type:	Water Resources Division

HEARING - VOLUME NO. V

BEFORE DANIEL PULTER, ADMINISTRATIVE LAW JUDGE

Via Microsoft Teams Meeting

Friday, December 10, 2021, 9:00 a.m.

APPEARANCES:

For the Petitioners:
MR. ZACHARY CHAD LARSEN (P72189)
MR. MICHAEL JOHN PATTWELL (P72419)
Clark Hill, PLC
212 East Cesar E. Chavez Avenue
Lansing, Michigan 48906
(517) 318-3053

For the Respondent:
MS. ELIZABETH ANNE MORRISSEAU (P81899)
MS. JENNIFER A. ROSA (P58226)
Assistant Attorneys General
Department of Attorney General
525 West Ottawa Street
G. Mennen Building, 6th Floor
Lansing, Michigan 48933
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pollutants beyond the use of technology-based limits warrants their inclusion in the permit. The requirement of a Comprehensive Nutrient Management Plan (CNMP) is something unique to CAFO permits, but is still considered to be a technology-based requirement. And technology-based effluent requirements, in whatever form they take, are a required element of all NPDES permits. For instance, the CAFO regulations specify nine minimum elements that must be included in the CNMP. The permit contains conditions that address the CNMP requirements as enforceable terms of the permit.

Q Please describe your work related to developing effluent limits for CAFOs.

A My direct work involved supervising one permit writer in our unit that developed permits in the CAFO program. The permit was drafted by the permit writer, and I would review the draft permit for accuracies and whether or not it met state and federal guidelines.

Q Are you familiar with Exhibit R-96?

A Yes. It is the 2015 CAFO General Permit, the previous CAFO Permit to the one issued in 2020.

Q Were you involved with developing that permit?

A No. I was in a different section of the division at the time the 2015 CAFO permit was developed and issued.

Q Are you generally aware of how CAFOs operate under the 2015

CAFO General Permit?
A **Yes. The 2015 CAFO General Permit lays out the specific language and conditions that had to be followed by CAFO permittees.**
Q And are you familiar, generally, with the scope of compliance with the 2015 permit?
A **Yes, I am generally familiar with the scope of compliance issues in the 2015 CAFO General Permit even though I was not working in the Permit Section at that time.**
Q Based on your education, training, and experience, and with the benefit of hindsight and additional data not available to your predecessors who developed the permit, do you believe that the 2015 CAFO General Permit is now sufficiently protective of water quality?
A **No, I do not believe the 2015 CAFO General Permit is sufficient to protect water quality.**
Q Please explain more fully.
A **The 2015 CAFO General Permit did not include requirements that limited the application of manure on frozen ground, nor did it require the monitoring of manure discharges from CAFOs to determine if those discharges were meeting water quality standards as required by federal regulations. The 2015 CAFO General Permit also did not contain adequate requirements for manifested waste, so the Department did not have a clear picture where manure was being manifested, and**

A Yes. I created draft conditions and then would run them by WRD Management (Chris Alexander), the EPA (Juilianne Soscha), and the staff person in my unit who was helping with the CAFO permit (Megan McMahon), and CAFO Specialist (Bruce Washburn) for final review and revisions. Some of the specific requirements I and others helped to draft were the monitoring requirements for CAFO discharges (the sampling guidance), the MPRA Guidance document, and the TMDL Guidance document.

Q Were there multiple drafts of the permit?

A Yes.

Q Please explain.

A The Department met with a diverse group of stakeholders prior to developing the draft 2020 CAFO General Permit. The meetings were held to take input on what the present concerns were and what changes the department should make to the 2015 permit. In developing permits in general, there must be a draft document initially on which the public and EPA can provide comment. After the stakeholder meetings, the Department developed a draft permit that we could share first with the EPA for their review and comment. We made changes to that draft permit based on the EPA's concerns. Once the draft permit was ready for public notice, we shared it on MiWaters as part of the public notice process. The numerous comments and need for many changes resulted in

several drafts of the permit. Once public notice had ended, and comments were reviewed and addressed, additional changes were made. This was the permit document that was ultimately made final and issued. There are also several copies of the draft permit that were my personal working drafts that included handwritten notes to keep track of internal discussions.

Q Putting those working drafts aside, you mentioned several versions of the 2020 CAFO General Permit. Let us make sure that we keep them organized. First, is Exhibit R-98 an accurate copy of the pre-public notice draft permit that you shared with the EPA, along with the associated documents?

A Yes. We had some formatting issues, as we indicated in the cover email, but Exhibit R-98 is the package of documents we sent to the EPA before the public notice period. The pre-public notice draft permit itself is located at AR 008892 through AR 008930.

Q And is Exhibit R-71 an accurate copy of the draft permit that went out for public notice?

A Yes.

Q And is Exhibit R-99 an accurate copy of the redline permit that includes changes made in response to public comment?

A Yes.

Q And Exhibit R-45 is the final 2020 CAFO General Permit?

A Yes.

A The Department used the information shared by stakeholders and Department staff to refine the draft permit language and develop the first draft of the 2020 CAFO General Permit. This is the draft we then shared with the EPA for their pre-public notice review and comment, included within Exhibit R-98.

Q Before we move on to talking about discussion with the EPA, I would like to ask whether there were any commonalities between stakeholder concerns and concerns expressed by the Livestock Committee.

A Yes. Some of the shared concerns with the Livestock Committee and CAFO owners on the stakeholder group were that there were outdated references that needed to be updated. Shared concerns with the environmental stakeholders were that manure discharges were occurring and impacting water quality.

Q Where did their recommendations diverge?

A Some CAFO permittees believed that no permits were necessary, but more importantly, that CAFO discharges were not responsible for impacting water quality. This concern had no factual basis and was disregarded because federal regulations require NPDES permits for point sources (i.e., CAFOs), and it was obvious from the inspections, site visits, and environmental information collected from discharges, that permits are necessary to regulate the

amount and location where manure is applied to protect water quality.

Q Did you meet with the EPA as part of the permit development process?

A Yes. I met with the EPA CAFO program staff via phone calls on a regular basis to determine how the permit needed to be revised to be compliant with federal CAFO rules. A version of the draft permit was shared informally with the EPA to obtain an initial review of the draft to begin conversations on whether or not the state was making all the changes necessary to be consistent with federal rules. I began working with the EPA and sharing our first draft version of the 2020 CAFO General Permit on August 23, 2019. The EPA conducted an informal review of the first draft it received from WRD, and we had several calls with them on September 5, 2019, September 17, 2019, and September 18, 2019 to discuss their comments. The EPA then gave us written feedback on the draft pre-public notice version of the draft permit on September 25, 2019.

Q Is Exhibit R-110 a true and correct version of those comments?

A Yes.

Q With reference to Exhibit R-110, can you point out which of the EPA's preliminary comments were driven by federal regulations?

informational meetings prior to the start of the formal public hearings on the draft CAFO General Permit. There were three informational meetings that coincided with the joint public hearings, and these were held on December 3, 5, and 9, 2019, at various locations in the state. On December 3, the meetings were held in Adrian, on December 5, the meetings were held in Grand Rapids, and on December 9, the meetings were held in Lansing. In addition to those meetings, the Department also met with approximately 50 individual CAFO permittees as well as specific industry groups to address their concerns regarding the draft CAFO General Permit.

Q Do you recognize Exhibit R-19?

A Yes.

Q What is it?

A Exhibit R-19 is the Fact Sheet associated with the pre-public notice versions (Exhibit R-98) of the draft permit that was shared with the EPA on August 23, 2019. The Fact Sheet outlines the major changes that were made to the permit and discusses why those changes were made.

Q Do you recognize Exhibit R-112?

A Yes.

Q What is it?

A This is the Response to Public Comment document developed by the Department in response to the 2,400 plus comments

as well.

Q Okay.

A Process waste water.

Q And does this permit require CAFOs to separate out manure from those other components of CAFO waste?

A No. It does not.

Q And are those other waste components typically stored in lagoons or storage structures along with manure?

A I think sometimes, yes.

Q And the 2020 permit doesn't require the treatment of any of those non-manure components of CAFO waste before land applying it, does it?

A No.

Q Ms. Heaton, are you aware of the rules governing the applica- -- land application of biosolids?

A I am not. I'm just -- I'm familiar with the term "biosolids," but not familiar with any of the regulations.

Q Okay.

MR. MICHAELS: I think I'm done and thank you very much, again, Ms. Heaton, for your time today and for your long career working for the people of the state of Michigan. Thank you.

THE WITNESS: Thank you. It was very nice meeting you.

MR. MICHAELS: You, too.

indication of whether this comment was submitted on behalf of their personal or professional expertise?

A **I would venture to say that it's professional. It says, "The following is a collaborative effort of certified CNMP providers within the State, representing 272 permitted facilities" which is almost the majority of facilities, you know, the CAFO facilities. So I would say in a professional capacity rather than a personal.**

Q And this would be separate and distinct from any Farm Bureau comment on the general permit; correct?

A **Yes. These were different than what the Michigan Farm Bureau supplied and -- they may not have liked it but it's what they did. The CNMP providers provided very -- I thought personally very good comments that helped me when I was, you know, writing this permit, developing this permit. You know, where we -- where we essentially struggled with some appropriate measures, they were able to help. And certainly the -- certainly the language, like specifically the language for the dry stackable storage requirements for the poultry when we met with the poultry sector, the poultry industry, Allison Brink and others were very, very, very helpful in terms of helping us with language. We had a meeting with those folks specifically. We knew what we needed to address the six-month storage capacity for poultry that hadn't currently been in permit before, and we started**

with some language but quickly realized with talking with them that we weren't sure what we were talking about and they pointed us in the right direction and said, "No, we think this is what you need. Is this the type of storage requirements? Will this type of language get you the information that you need?" And we said, "Oh, yes, thank you very much" and --

Q And what did you do with that, the language that they proposed?

A Essentially dropped that into the permit, used that exact language with a little bit of tweaking because you have to -- you have to say that permit language appropriately within the permit, you know. But that -- the concept was there and almost 95 percent of the language was there. So that was very helpful because they helped us come up with that, so --

Q So turning now to -- you spoke with Judge Pulter a little bit about the 200- -- the buffer and setback requirements. Going back to the 2015 General Permit, can you discuss what those buffer and setback requir- -- or conditions were in that permit?

A So, yes. So in the -- in the 2015 permit, sorry, I was just looking for it, but I don't need it unless you want to bring it up. But the 2015 permit had included the MPRA and it included 100-foot setback, and it included a 35-foot buffer.

EXHIBIT 6

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MI/EGLE/WRD-20/014

MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY
WATER RESOURCES DIVISION
APRIL 2020

STAFF REPORT

ALGAL TOXIN MONITORING IN MICHIGAN INLAND LAKES: 2016-2019 RESULTS

Introduction

The term “harmful algal bloom (HAB)” generally describes accumulations of cyanobacteria that are aesthetically unappealing and produce algal toxins. In 2015 the Michigan Department of Environment, Great Lakes, and Energy (EGLE), Water Resources Division (WRD), developed the following definition of a HAB (Kohlhepp, 2015): “An algal bloom in recreational waters is harmful if microcystin levels are at or above the 20 micrograms per liter (µg/L) World Health Organization non-drinking water guideline, or other algal toxins are at or above appropriate guidelines that have been reviewed by EGLE-WRD.” A key concept of this HAB definition is that while high chlorophyll *a* concentration and visible surface/water column algal accumulations can indicate potential problems, the WRD’s focus is on the potential harm that toxins represent. Thus, water samples must be analyzed for the presence of toxins to confirm that a bloom may, in fact, be potentially harmful to humans, pets, or wildlife. Visible appearance of blooms cannot be used as a reliable predictor of toxin content.

Cyanobacteria are one of the oldest life forms on Earth (e.g., Schirrmeister et al., 2016) that can live in terrestrial, marine, and freshwater environments (Chorus and Bartram, 1999). The potential harmful effects of cyanobacteria on animals have been documented as far back as the 19th century (Francis, 1878; Arthur, 1889). More recent work has focused on the potential harmful effects of cyanobacterial toxins on humans and pets (Koreivienė et al., 2014; Trevino-Garrison et al., 2015; Zhang et al., 2015). Incidences of cyanobacterial blooms have increased worldwide in the last several decades (Carmichael, 2008; O’Neil et al., 2012; Taranu et al., 2015; Scholz et al., 2017). Given future climate scenarios and the increased amount of nutrients required for more intensive agricultural practices, the frequency, duration, and magnitude of cyanobacteria blooms are expected to increase worldwide (Jöhnk et al., 2008; Reichwaldt and Ghadouani, 2011; Posch et al., 2012; Michalak et al., 2013; Paerl, 2018).

In Michigan, previous research on inland lake HABs has focused on zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena bugensis*) invasions and the subsequent increases in cyanobacteria biomass and microcystin production (Raikow et al., 2004; Sarnelle et al., 2005; Wilson et al., 2005; Knoll et al., 2008; Woller-Skar, 2009; Sarnelle et al., 2010; White et al., 2017; Gaskill and Woller-Skar, 2018). Other research has focused on cyanobacteria and microcystin production dynamics in specific water bodies of interest, particularly in west Michigan (Hong et al., 2006; Rediske et al., 2007; Gillett and Steinman, 2011; Xie et al., 2011; Xie et al., 2012; Gillett et al., 2015) and Ford and Belleville Lakes (Washtenaw and Wayne Counties; Lehman, 2007; Lehman et al., 2009; Lehman, 2014). EGLE has been monitoring the number of citizen and staff complaints regarding nuisance algae and cyanobacteria (Parker, 2014; 2015; 2016a; 2016b; 2018a; Stieber, 2019; Baldwin, 2020) and monitoring the concentration of the cyanobacterial toxins microcystin, anatoxin-a, and cylindrospermopsin in the State of Michigan for the last several years (Holden, 2016; Parker, 2017; 2018b; 2019).

This report summarizes cyanobacteria toxin monitoring from 2016 through 2019. This report is an update to the 2016-2018 data summary by Parker (2019) with 2019 data incorporated. The purpose of this report is to: (1) evaluate the geographical extent of HABs throughout Michigan (i.e., how widespread is the problem?); (2) compare microcystin concentrations between cyanobacterial scums and nearby ambient water; and (3) explore any patterns that can explain cyanobacterial bloom occurrence throughout the state. For information on efficacy of commercial test strips and exploration of microcystin relationships with chemical/physical variables in lakes across the state, see Parker (2019). Raw data from 2016-2018 are available in past reports (Parker, 2017; 2018b; 2019). Raw data from 2019 are available at the end of this report (Appendix 1).

Sites

The lakes that are assessed in this report can be placed in three broad categories: randomly-selected lakes that were sampled for limnological parameters as part of the Inland Lakes Status and Trend Program (Walterhouse, 2015), targeted lakes that were visited because EGLE staff were aware of previous cyanobacteria blooms that had taken place in them, or because they were sampled as part of Total Maximum Daily Load (TMDL) development, and lakes that EGLE received complaints about either from citizens or staff (Figure 1).

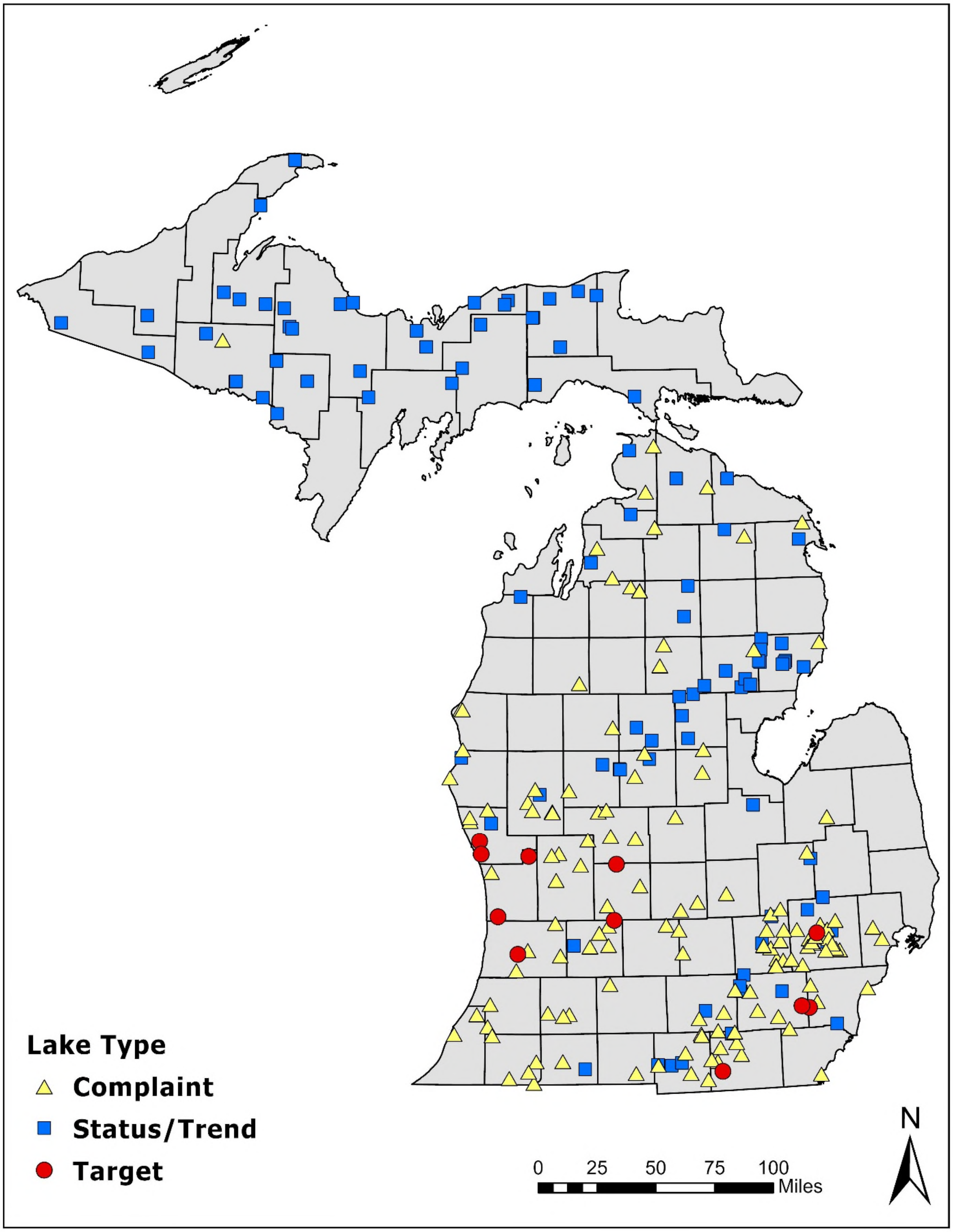


Figure 1. Different types of lakes sampled for cyanobacterial toxins from 2016-2019.

Field Methods

Sampling occurred between early May and late November, with most monitoring occurring in August and September. During a monitoring event at a lake, EGLE-WRD staff typically took pictures of algal conditions, collected general water chemistry in the center of the lake (if accessible by boat), and collected water samples for cyanobacteria toxin analysis from up to four locations around the lake. If a water body was inaccessible by boat, then only shoreline samples were collected for toxin analysis and nutrient and chlorophyll samples were not collected. The cyanobacteria toxin samples were analyzed using both Abraxis (Abraxis, Inc., Warminster, Pennsylvania) test strips to assess microcystin presence/absence and tandem liquid chromatography mass spectrometry (LC/MS/MS) for quantitative assessment of a suite of cyanobacterial toxins including microcystins, cylindrospermopsin, nodularin, and anatoxin-a (Table 1).

Water Samples - General Chemistry

Water sample parameters collected at the status and trend lakes, targeted lakes, and some response lakes were generally similar. At all lakes, temperature, dissolved oxygen, conductivity, pH, chlorophyll *a* concentration, chlorophyll relative fluorescence unit, phycocyanin concentration, and phycocyanin relative fluorescence unit were measured using an EXO sonde (YSI Incorporated, Yellow Springs, Ohio). In some cases, with the response lakes, the staff who were available to collect the water samples did not have access to an EXO sonde unit. In those cases, only water samples were collected for the purpose of cyanobacteria toxin analysis. Nutrient surface water samples were collected at approximately 0.5 feet below the water surface using new, 250 milliliter (ml) polypropylene sample bottles that were triple-rinsed with site water. At targeted lakes and response lakes where a boat could be taken to the center of the lake, the following samples were collected: total phosphorus, Kjeldahl nitrogen, nitrate+nitrite, ortho-phosphate, and chlorophyll *a*. The total phosphorus, Kjeldahl nitrogen, and nitrate+nitrite were preserved with sulfuric acid in the field. Chlorophyll *a* samples were collected as an integrated sample of the photic zone (twice the Secchi depth) and preserved with magnesium carbonate in the field. The samples were analyzed at the EGLE Environmental Laboratory using standard United States Environmental Protection Agency (USEPA) methods (Table 1). At the status and trend lakes the same nutrient samples were collected, excluding ortho-phosphate. The August status and trend water chemistry samples were collected by the Michigan Department of Natural Resources-Fisheries Division staff and analyzed by the Great Lakes Environmental Center, Traverse City, Michigan. Following collection, sample bottles were placed on ice or refrigerated for transport and storage prior to delivery to the laboratory. At targeted lakes, the nutrient samples were not collected at every sampling event if sampling occurred several times over a week.

Water Samples - Algal Toxins

At most lakes that were sampled by boat, one sample over the deepest part of the lake and at least three shoreline samples were collected in 250 ml polyethylene terephthalate sample bottles at the water surface. Shoreline samples were typically collected at 1- to 6-foot depths. If sampling by boat, the shoreline sampling locations were distributed approximately evenly around the shoreline of the lake. However, downwind locations, areas that may be used for recreation, or beaches were preferentially targeted. When boat access was not available, attempts were made to sample an even distribution of the shoreline; however, sampling locations were limited to areas of public access and/or private property that EGLE workers received permission to access. Prior to sampling, bottles were triple-rinsed with site water and samples were collected from an undisturbed area of water. Cyanobacteria toxin samples at the targeted and response lakes were collected at the water surface (i.e., the bottles were not submerged under water). At the status and trend lakes, sample bottles were collected about

0.5 feet below the water surface. When scum accumulations were present, and accumulated in a localized area, one surface scum sample was collected and one ambient (non-scum) sample was collected outside of the accumulation (Figure 2). The ambient samples were collected within 5-15 feet from the edge of the scum accumulations. In cases where surface scums were omnipresent either throughout an entire lake, or throughout a very large section of a lake with no clear demarcation between the scum and ambient water, only a scum sample was collected.

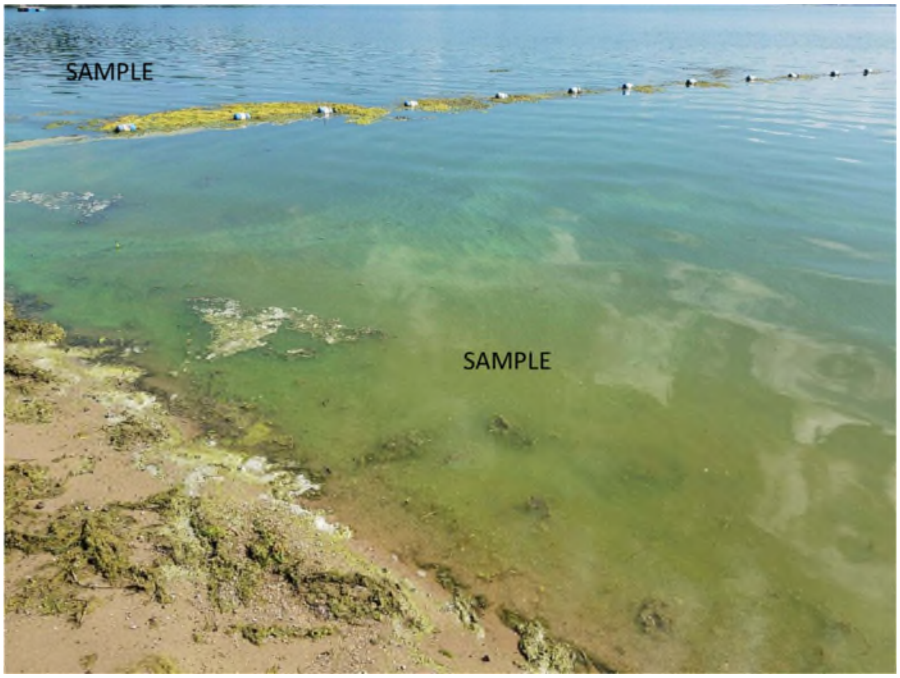


Figure 2. Example of a localized cyanobacteria scum accumulation in which a sample was collected from the scum and the nearby ambient water.

At response lakes, often only shoreline samples were collected from an area with a cyanobacteria accumulation present, or in an area that previously had high concentrations of microcystins. Most of the samples were collected by EGLE staff, although in some cases citizens collected water samples and turned them into EGLE district offices.

Ambient water and scum samples that were analyzed using qualitative and quantitative methods were kept on ice during transport back to the laboratory. Microcystin presence/absence and relative concentration estimate was determined using test strips. If the initial test strip indicated that microcystins were present in the sample, then it was delivered to the Michigan Department of Human Health and Services (MDHHS) laboratory for quantitative analysis. Quantitative analysis of anatoxin-a, cylindrospermopsin, and 10 microcystin congeners (Table 1) was performed using LC/MS/MS. If the Abraxis test strips indicated that no microcystin was present in any samples from a lake, then only one sample was sent to the MDHHS laboratory for further quantitative analysis. As detailed in Parker (2019), commercially-available microcystin test strips have proven to be reliable indicators of microcystin presence/absence.

Microcystin samples were held on ice or refrigerated for no more than 48 hours prior to analysis. If microcystin samples needed to be held longer than 48 hours, they were frozen with care taken to reduce volume to allow for expansion. EGLE-WRD staff analyzed the July status and trend samples and all targeted lake samples using the test strips. The August status and trend samples were analyzed by staff of the Great Lakes Environmental Center and one sample from each lake was analyzed by the MDHHS laboratory.

Table 1. Analytical methods and reporting limits.

Parameter	Analytical Method	Reporting Level (µg/l)
Microcystin RR	LC/MS/MS	0.5
Microcystin YR	LC/MS/MS	0.5
Microcystin HTYR	LC/MS/MS	0.5
Microcystin LR	LC/MS/MS	0.5
Microcystin LR ASP3	LC/MS/MS	0.5
Microcystin WR	LC/MS/MS	0.5
Microcystin LA	LC/MS/MS	0.5
Microcystin LY	LC/MS/MS	0.5
Microcystin LW	LC/MS/MS	0.5
Microcystin LF	LC/MS/MS	0.5
Nodularin	LC/MS/MS	0.5
Anatoxin-a	LC/MS/MS	0.5
Cylindrospermopsin	LC/MS/MS	0.5
Qualitative total microcystin	Abraxis test strips (PN52022)	1
Total Phosphorus	EPA 365.4	10
Kjeldahl Nitrogen	EPA 351.2	100
Ammonia	EPA 350.1	10
Nitrate+Nitrite	EPA 353.2	10
Ortho-phosphate	EPA 365.1	10
Chlorophyll a	10200H (Standard Methods)	1

Data Analysis

The number of water bodies that experienced at least one cyanobacteria bloom between 2016 and 2019 was quantified by reviewing field and laboratory data, photographs from sites that were visited by EGLE staff, and by reviewing photographs that were sent to EGLE from citizens and staff. The distribution of cyanobacteria blooms was assessed along a north-south gradient in Michigan. Centroid latitudes for each Michigan county were calculated with the Calculate Geometry tool function in ArcMap 10.4 (ESRI, 2011) using the NAD 1983 Geographic Coordinate System. For coastal counties, islands were excluded from the calculations, so latitude centroids were only for the mainland. A linear regression was performed on the number of confirmed cyanobacteria blooms (log +1- transformed) in a county versus the centroid latitude for all 83 Michigan counties.

Shoreline development factors (SDF) and maximum depths of water bodies that had experienced cyanobacteria blooms were compared between three lake types: reservoirs, natural lakes with dams, and natural lakes with no water level control structure. “Natural” lakes were defined as having no dam or water control structure at the lake outlet, “natural with dam” is defined as a naturally occurring lake but with some type of water level control structure at the outlet, and “reservoir” was defined as an impoundment (lentic environment only exists because flowing water was impounded). Lake type classifications were mostly obtained from the MiSwims database. Depths and SDF were compared using Analysis of Variance (ANOVA) with Tukey’s honestly significant difference post-hoc testing. Maximum lake depths were mostly obtained from the MiSwims database. In some cases, where depth data were not available for a lake, other reliable sources were located, such as consultant or Michigan Department of Natural Resources reports. A database of calculated SDF values for all Michigan lakes was provided by P. Tyning (Progressive AE, Grand Rapids, Michigan). SDF is the degree of a lake’s shoreline irregularity and is expressed as the ratio of shoreline length to the circumference of a circle of area equal to the lake’s area (Horne and Goldman, 1994). A lake with the least amount of shoreline would be perfectly circular and would have an SDF of 1.0. As shorelines become more irregular (less circular) the SDF increases. A Welch t test was used to compare the microcystin concentrations of all side-by-side scum and ambient water samples that were collected from 2016-2019. Statistical significance for all tests was set at $\alpha = 0.05$.

Results

From 2016-2019, water samples were collected and analyzed for cyanobacteria toxins from 100 different status and trend lakes, 112 complaint water bodies, and 11 targeted lakes. Of the 100 status and trend lakes that were sampled, only three had samples with detectable concentrations of microcystin, with the highest being 6.8 µg/l. Nine of the 11 targeted lakes contained microcystin. Of those nine targeted lakes with microcystin, six had samples with elevated concentrations that were >20 µg/l (Parker, 2017; 2018b).

The number of water bodies that EGLE has received complaints about has increased in the last three years (Figure 3; Parker, 2019). From 2016-2019, EGLE received complaints about algae in 162 different water bodies. A categorization of the number of samples collected from those water bodies, whether cyanobacteria blooms were present, and whether cyanobacterial toxins were found is shown in Figure 4 and detailed as follows: The 162 different water bodies that EGLE received complaints about can be placed into one of three broad categories: (1) water bodies that could be sampled by EGLE staff within a few days of receiving the complaint; (2) water bodies that were not sampled because EGLE staff were able to determine that the material was not cyanobacteria (typically filamentous green algae, pollen, duckweed), staff were not available to sample, or a bloom had dissipated by the time staff were available to sample; and (3) EGLE received a complaint about algae of cyanobacteria after it occurred (sometimes in the winter months).

Because some complaints about cyanobacteria blooms were confirmed, but never sampled, it was important to separate the number of water bodies with confirmed blooms (86) from the number of water bodies that were sampled (112) in Figure 4. Of the 86 complaint water bodies with confirmed cyanobacteria blooms, 63 of them were sampled by EGLE. Of those 63 water bodies, 38 contained toxins. An important caveat about the mismatch of the 25 water bodies that had confirmed blooms, but no toxins detected, is that most of those lakes were sampled after the bloom had dissipated (sometimes after one day). Only in rare cases were cyanobacterial scums sampled and no toxins detected. Thus, the number of lakes that contained toxins is likely under-estimated. Finally, of the 38 water bodies with detected cyanobacterial toxins, 24 of them contained elevated toxin concentrations. In this case "elevated" toxins were defined as total microcystin concentrations ≥10 µg/l (23 water bodies) and one water body with elevated concentrations of anatoxin-a. Although recreational standards for anatoxin-a have not been established by the USEPA or World Health Organization, it was found in high concentrations in a private pond after several canine deaths occurred following contact with it (Parker, 2020).

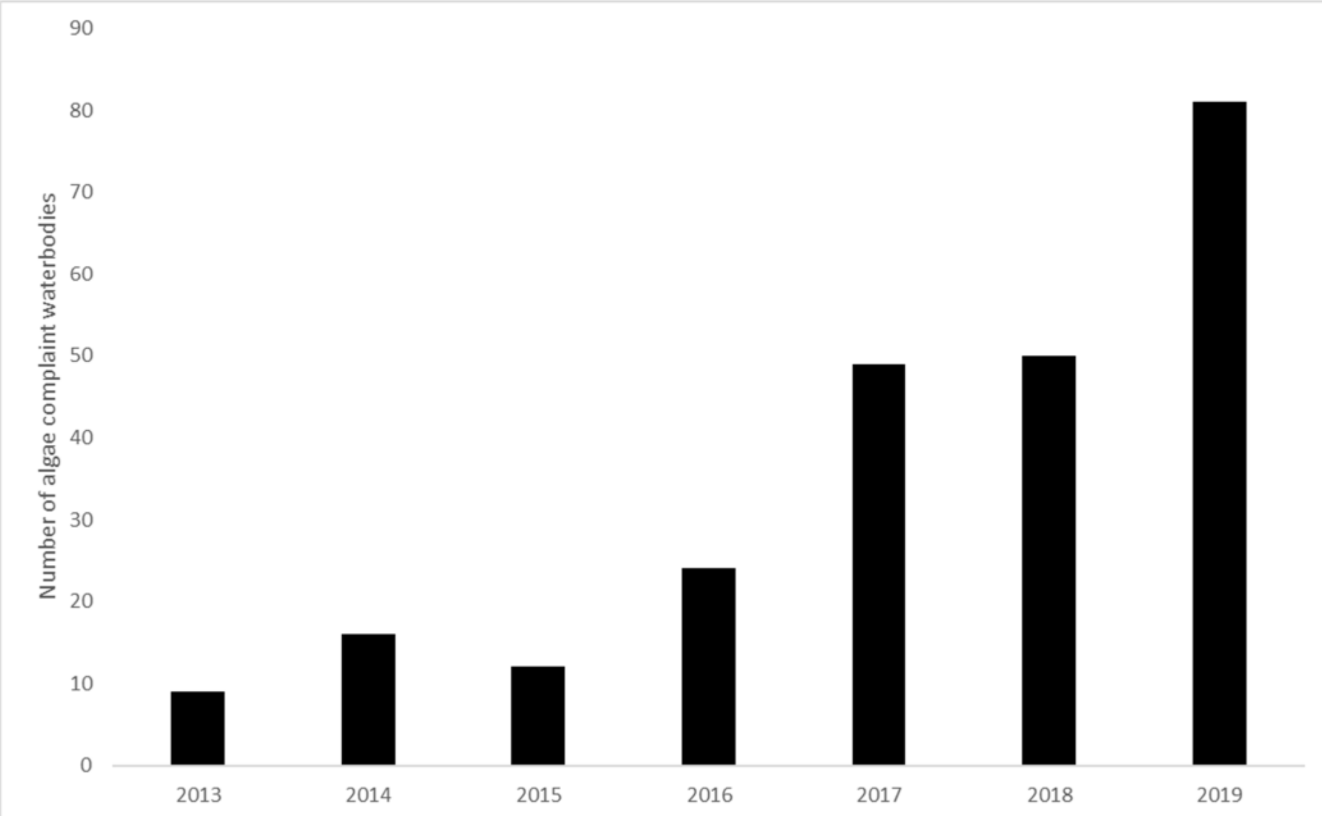


Figure 3. Number of different water bodies with complaints about algae or cyanobacteria from 2013-2019.

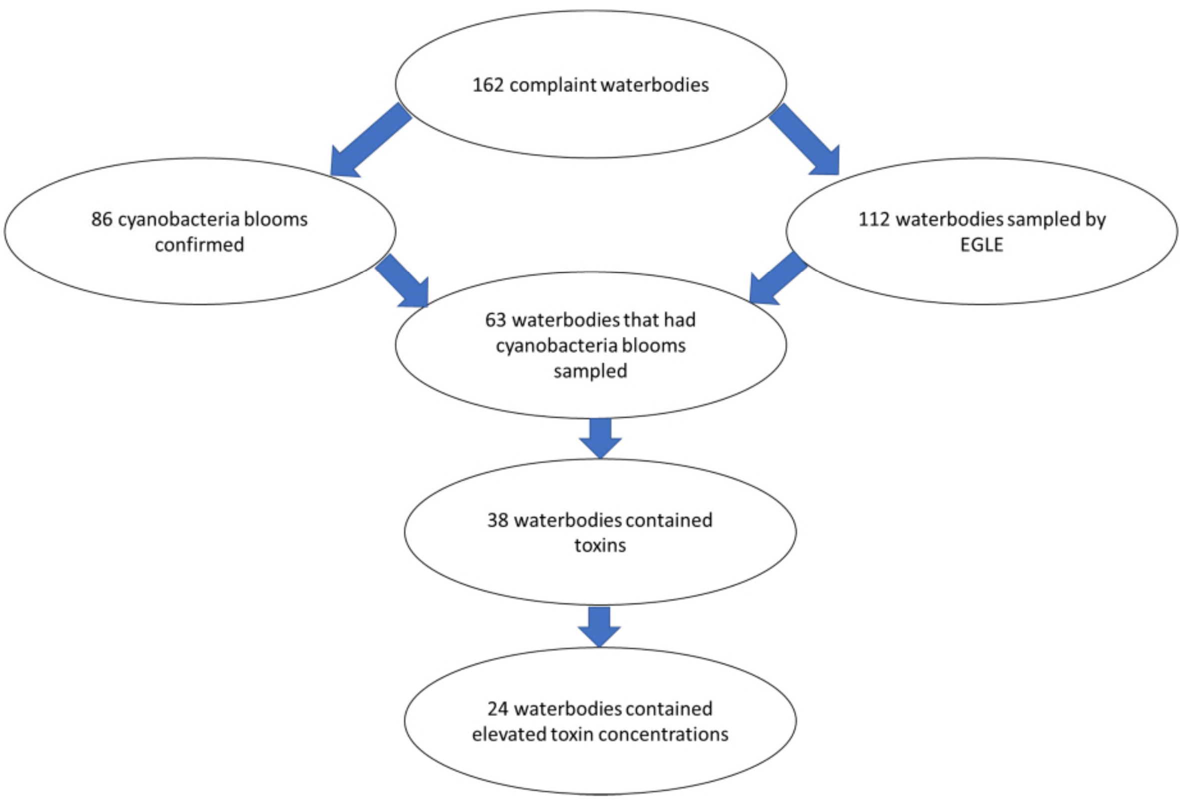


Figure 4. Diagram of the number of complaints received and the break-down of water bodies containing cyanobacteria and toxins.

Throughout the state from 2016-2019, EGLE staff either observed, or were alerted to, 93 confirmed cyanobacteria blooms (note: this number includes the 86 complaint water bodies and water bodies that were targeted for monitoring [targeted and TMDL lakes] by EGLE). All but three of those blooms were in the Lower Peninsula, with the majority of those in the southern half. There was a significant inverse relationship ($R^2 = 0.21$, $p < 0.001$; Figure 5) between the number of blooms per county and the county centroid latitudes, which confirmed our visual interpretation of the map in Figure 6.

Of the lakes that had blooms, a slight majority were either reservoirs or natural lakes with a lake level control structure (24 percent reservoir, 30 percent natural with a dam, 46 percent natural; Figure 6). The exact number of impounded lakes throughout the state has been an elusive number for some time. Brown (1943) estimated that there were 700-800 impoundments (defined as any lake with a dam greater than 2 feet high) throughout the state, although dams were constructed after that report. The United States Army Corps of Engineers has a list of 1,059 impoundments in Michigan in its National Inventory of Dams, although that list includes many small dams that create impoundments < 5 acres in size. Nevertheless, even with the 1,059-impoundment figure, that would put the total number of Michigan lakes that are impounded in some way at approximately 10 percent of all lakes in the state.

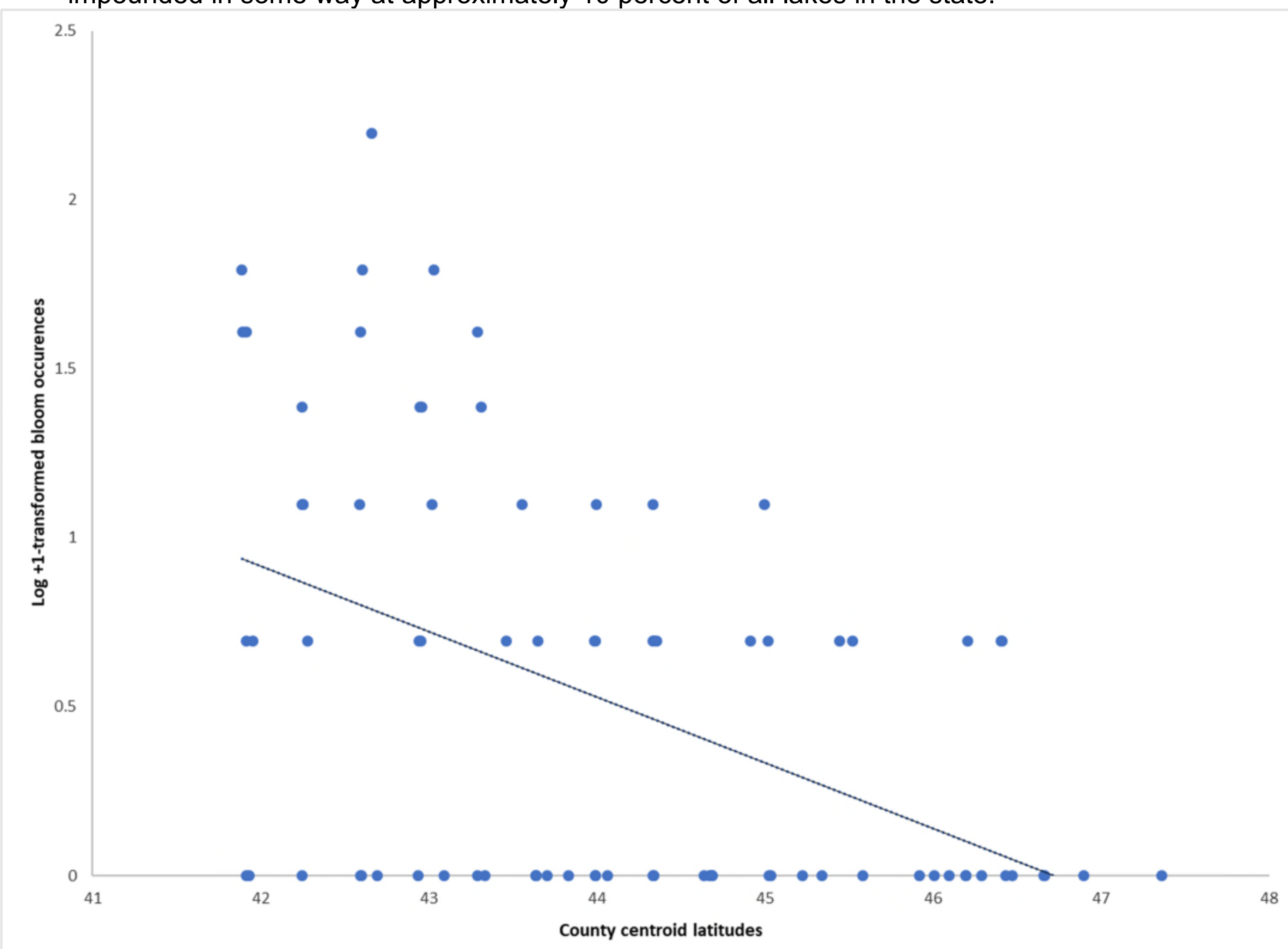
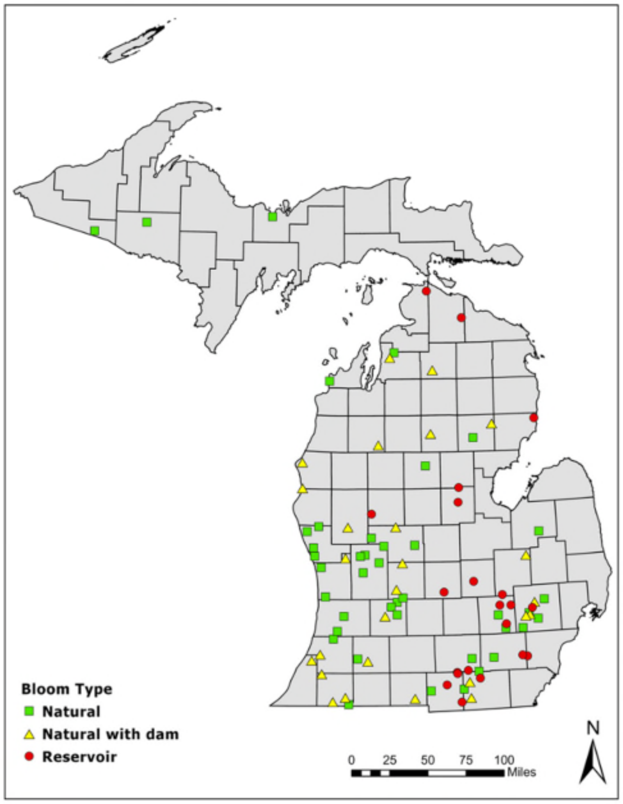


Figure 5. Regression of Log +1-transformed bloom occurrences per county and county centroid latitude.



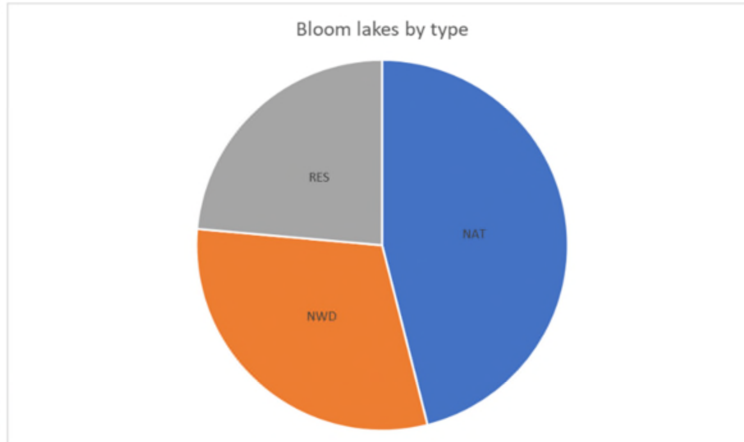


Figure 6. Map of confirmed cyanobacteria blooms by lake type and pie chart of different lake types that experienced blooms (NAT = natural, NWD = natural with dam, RES = reservoir). Note: Map does not include five cyanobacteria blooms that occurred in rivers, wetlands, or private ponds.

An initial comparison of depths between natural lakes, natural lakes with dams, and reservoirs that had experienced cyanobacteria blooms revealed no differences between lake types (ANOVA: $F = 1.6$, $df = 2, 80$, $p = 0.2$). However, this was largely driven by Hardy Dam Pond.

The Hardy Dam Pond is a very large water body (2,772 acres) that was created by impounding the Muskegon River with a 106-foot hydroelectric dam (the largest in Michigan). The location of the dam is in an area where the Muskegon River has its steepest drop in elevation (Alexander, 2006). The resulting bathymetry of the impoundment is characterized by relatively shallow depths in the artificially inundated areas along the edges, and then a deep, narrow valley where the historic river channel was. Because of the sharply contrasting bathymetry, the average depth of the impoundment is 34.5 feet; however, the maximum depth is 110 feet. Because of the unique nature of Hardy Dam Pond and its singular effect on the depth analysis, an additional evaluation was performed excluding that water body.

When Hardy Dam Pond was excluded from the ANOVA, there were significant depth differences between water body types (ANOVA: $F = 3.4$, $df = 2, 79$, $p = 0.04$; Table 2), with reservoirs being shallower than natural lakes with dams (Figure 7). There were also significant differences in SDFs between water body types with reservoirs having significantly greater SDFs than both natural and natural with dam lakes (ANOVA: $F = 6.4$, $df = 2, 83$, $p < 0.01$; Table 2; Figure 8).

A comparison of microcystin concentrations from side-by-side samples of cyanobacterial scum and nearby ambient water revealed that the scum contained more microcystin than the nearby ambient water ($t = 2.08$, $df = 47$, $p = 0.04$; Figure 9).

Table 2. Tukey's honestly significant differences between depths and shoreline development factors among lake types.

Depth				Shoreline development factor		
	Reservoir	Natural with dam			Reservoir	Natural with dam
Natural	0.15	0.56		Natural	**<0.01**	0.6
Natural with dam	**0.03**			Natural with dam	**0.04**	

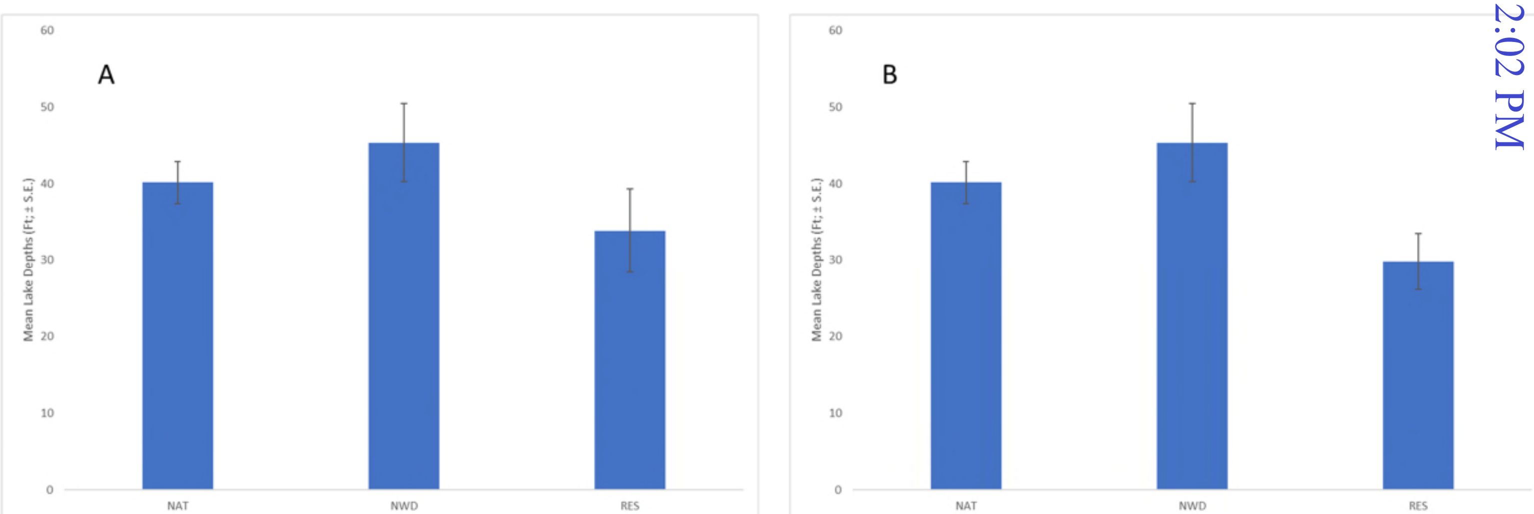


Figure 7. Mean depths (feet ± S.E.) among lake types. Graph A includes Hardy Dam Pond in the reservoir average, and Graph B excludes Hardy Dam Pond.

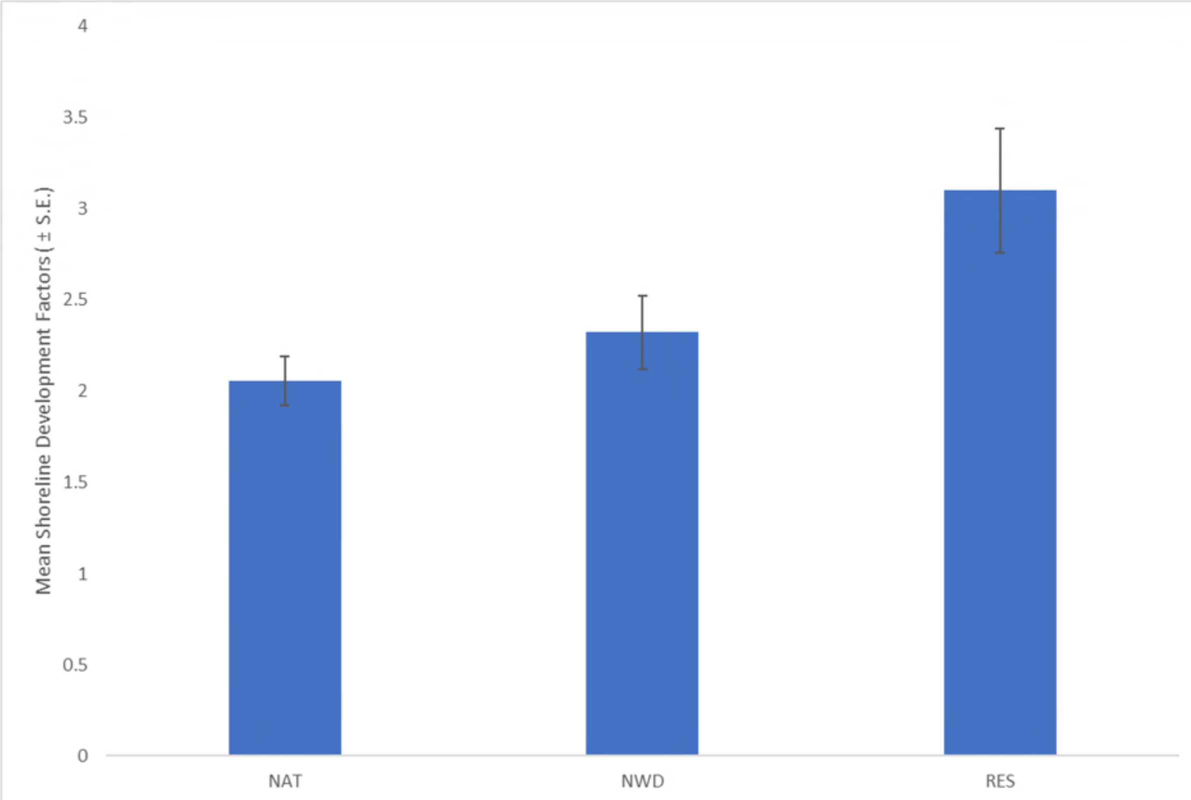


Figure 8. Mean shoreline development factors (± S.E.) among lake types.

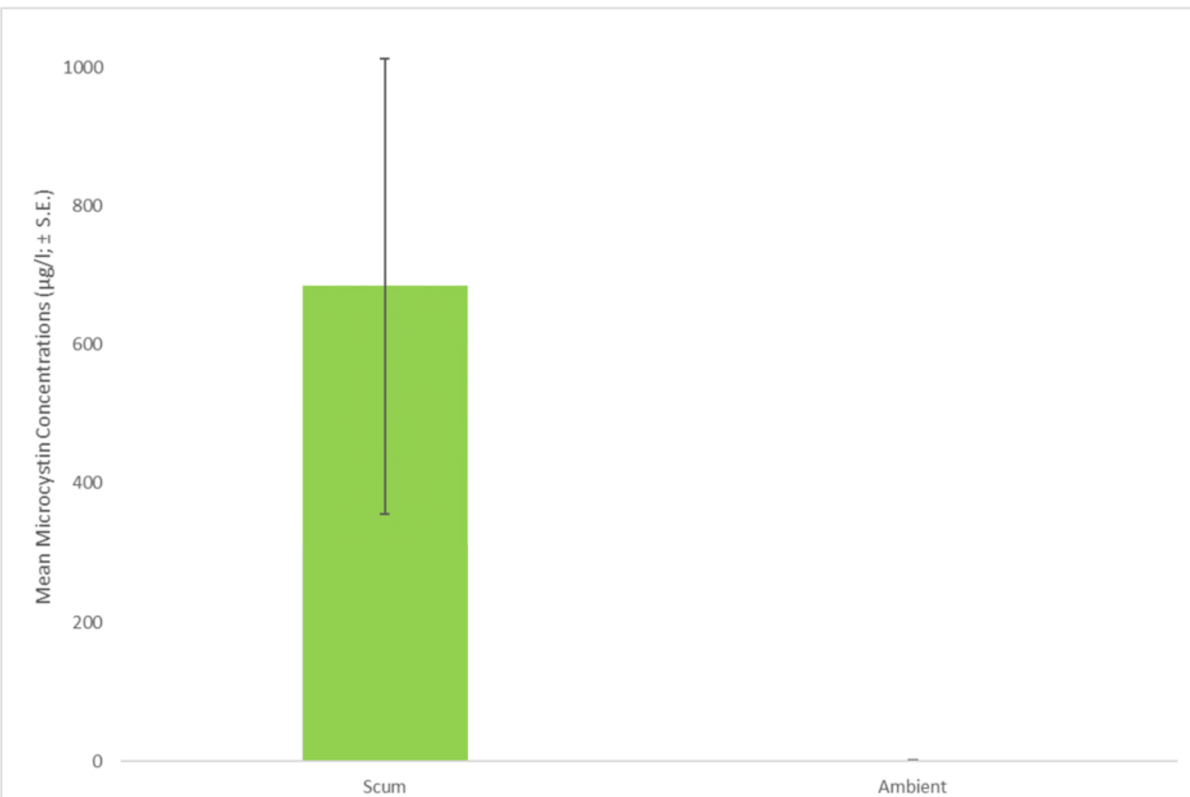


Figure 9. Mean microcystin concentrations (± S.E.) from scum and ambient water samples collected side by side.

Discussion

In the last few years, the number of complaints received by EGLE about nuisance cyanobacteria and algae have increased. EGLE (Parker, 2018b) and others (Cheung et al., 2013) have acknowledged that the increased awareness and attention that HABs have received recently may account for the increased reports. However, Cheung et al. (2013) maintained that the increasing number of reports is unlikely the sole result of increased attention. Recently, Ho et al. (2019) also found that cyanobacteria blooms are increasing globally after reviewing satellite images in 71 lakes over three decades. The consensus amongst most researchers is that the frequency, magnitude, and intensity of HABs is increasing worldwide, and that given future climate scenarios coupled with more intensive agricultural practices worldwide, HABs are only expected to get worse (Kosten et al., 2012; O'Neil et al., 2012; Paerl and Paul, 2012; Michalak et al., 2013; Scavia et al., 2014; Taranu et al., 2015; Scholz et al., 2017).

In the United States, after the 2019 recreational season, disentangling whether the increased number of complaints that year was a result of actual increases or increased media attention was especially difficult. Following canine deaths from cyanobacteria in several southern states, there was intense, nationwide media coverage of the cases. This led to numerous citizen inquiries to EGLE about water bodies throughout the state. In 2019, half of the water bodies that we received complaints about did contain cyanobacteria, as opposed to filamentous green algae or duckweed. In 2019, anatoxin-a was measured at the highest concentrations we have observed since monitoring began, in a private pond where several dogs died after consuming cyanobacteria (Parker, 2020). Finally, cylindrospermopsin was also detected for the first time by EGLE staff in an Oakland County lake in September 2019.

We have consistently found that, statewide, the vast majority of the randomly sampled lakes have not had active cyanobacteria blooms occurring and that typically, the only time we do find active blooms is if we target specific lakes that have had them in the past, or if we are alerted to a bloom by citizens. In general, confirmed cyanobacterial blooms were more prevalent in the southern Lower Peninsula of Michigan, which is the most populated area of the state and contains more agricultural areas. Using remote sensing, Torbick et al. (2013) also found that lakes in the southern Lower Peninsula were more productive and that cropland and urban land use was associated with more eutrophic lakes.

There is widespread consensus that water bodies with greater than 10 percent impervious cover in their watersheds will begin to exhibit water quality degradation (Schueler and Holland, 2000; Brabec et al., 2009; Carey et al., 2013). Urban and residential areas quickly convey nutrients and other pollutants to storm drains that then directly discharge to nearby water bodies (Steinman et al., 2006; Carey et al., 2013; Yang and Toor, 2016; Janke et al., 2017; Yang and Toor, 2017). Unlike streams, which will assimilate some nutrients in the sediment and plant biomass, pipes will direct all nutrients to a receiving water body (Steinman et al., 2006; Brabec et al., 2009). Lakes in more populated areas also tend to be largely developed along their immediate shoreline since lakefront property is highly desired. Residential land use along lake shorelines can contribute nutrients to the lake via lawn fertilizer application (Morton et al., 1988; Bierman et al., 2010; Carey et al., 2012; Steinman et al., 2015) and septic system leachate (Gilliom and Patmont, 1983; Tessier and Lauf, 1992; Swann, 2001; Brennan et al., 2016; Schellenger and Hellweger, 2019).

Agricultural nutrient runoff has been recognized as a contributing factor to cyanobacteria blooms, with much attention being focused on the re-eutrophication of western Lake Erie (Michalak et al., 2013; Scavia et al., 2014; Bullerjahn et al., 2016). However, on a smaller scale, agriculture has also been implicated as contributing to cyanobacteria blooms in inland lakes as well (Torbick et al., 2013; Taranu et al., 2015 and 2017; Clement and Steinman, 2017;

Marion et al., 2017). Increased dissolved reactive phosphorus loading via field tile drainage pipes has been cited as one of the main causes of cyanobacteria blooms in water bodies that are surrounded by agricultural land use (Bullerjahn et al., 2016; Clement and Steinman, 2017).

Similar to other work (Taranu et al. 2017; Gina LaLiberte, Wisconsin Department of Natural Resources, personal communication) we found that the majority of cyanobacteria blooms occurred in lakes with some kind of an impoundment structure. Most of the lakes that had confirmed cyanobacteria blooms in the northern Lower Peninsula were either reservoirs or natural lakes with a lake-level control structure. This is significant since the majority of inland lakes in Michigan are natural. The most recent lake inventory by the Michigan Department of Natural Resources recognizes 10,759 inland lakes throughout the state that are greater than five acres (*The link provided was broken and has been removed*). Based on conservative estimates, it is likely that only around 10 percent of those lakes are impoundments or natural lakes with a dam. However, approximately 53 percent of the lakes with confirmed cyanobacteria blooms from 2016-2019 were impounded in some way.

The reservoirs were the shallowest water bodies, had the highest shoreline development factors, and were the most productive systems that we sampled. In general, reservoir systems tend to age faster and are more productive than natural systems (Ryder, 1978; Kimmel and Groeger, 1986; Whittier et al., 2002; Knoll et al., 2015; Doubek and Carey, 2017). Reservoirs also typically have larger catchment-to-lake-area ratios than natural lakes (Knoll et al., 2015; Taranu et al., 2017). That is, they have larger watersheds draining into them from an upstream tributary than a typical, kettle lake will have. With larger watersheds, more nutrients are likely to flow into the receiving water bodies, thus increasing the chances for cyanobacteria blooms (Toporowska et al., 2018). Reservoir systems also tend to be created in either urban or agriculture-dominated areas (Kimmel and Groeger, 1986), which both contribute nutrients to water bodies as described above. Finally, some reservoirs were created for the sole purpose of developing residential communities around a water body (Nicholls and Crompton, 2018), in which case the majority of the shoreline is going to have residential land use along the immediate shoreline of the lake. Shallow lakes coupled with nutrient-rich sediment are prone to nutrient resuspension into the water column as a result of physical disturbances such as wind (Kristensen et al., 1992; Blottière et al., 2013), fish foraging (Havens, 1991), and boat traffic (Anthony and Downing, 2003).

We found that the shoreline development factors of reservoirs were higher than those of the natural and natural with dam lakes. This is not surprising since impoundments tend to flood historic tributary stream valleys and other low-lying areas. The resultant shoreline features of reservoirs, depending on the extent of impoundment and surrounding landscape features, are often numerous peninsulas, coves, canals, and islands throughout the water body. All of which extend the amount of shoreline. Given the inherent desirability of lakefront property and the fact that some reservoirs are created for the purpose of creating residential lake lots (Nicholls and Crompton, 2018), reservoirs tend to have a disproportionate number of residential dwellings along their entire shoreline compared to lakes of similar size, but with less shoreline. Each residential lake dwelling can then contribute nutrients to the water body via lawn fertilizer (Morton et al., 1988; Bierman et al., 2010; Carey et al., 2012; Steinman et al., 2015), pet waste (Schueller and Holland, 2000), loss of natural shoreline buffers (Woodard and Rock, 1995; Søndergaard and Jeppesen, 2007; Rosenberger et al., 2008), and septic systems (Gilliom and Patmont, 1983; Tessier and Lauf, 1992; Swann, 2001; Brennan et al., 2016; Schellenger and Hellweger, 2019). The shallow embayments that are characteristic of reservoir systems often offer calm areas of warm water that is conducive to cyanobacteria growth (Parker, 2018b).

Although the natural lakes with dams had similar depths and shoreline development factors as the natural lakes with no water level control structures, they were over-represented among the water bodies that experienced cyanobacteria blooms. Lake-level control structures are typically constructed at lake outlets to ensure that consistent water levels are maintained that can accommodate recreational activities. In fact, over half of the dams in Michigan on the National Inventory of Dams list have “recreation” as the primary purpose for the dam structure. Typically, lakes that have water-level control structures for recreational purposes are going to have a high number of residential units along the shoreline, which may contribute nutrients from lawns (Morton et al., 1988; Bierman et al., 2010; Carey et al., 2012; Steinman et al., 2015) and/or be near urban centers that can contribute nutrients (Steinman et al., 2006; Carey et al., 2013; Yang and Toor, 2016; Janke et al., 2017; Yang and Toor, 2017). However, if lake-level control structures are constructed in lake outlets for the purpose of artificially raising water levels, then this will also artificially raise groundwater levels around the immediate riparian shoreline. If septic systems were in place prior to the groundwater level rising, then the amount of non-saturated soil to filter nutrients from the septic leachate will decrease, which then increases the risk of septic pollution entering the lake via groundwater (Gilliom and Patmont, 1983; Swann, 2001; Lusk et al., 2017).

Some broad conclusions can be made about the occurrences of cyanobacteria blooms throughout Michigan and possible causes of them. Similar to other work (Kardinaal and Visser, 2005; Omidi et al., 2018), we found that microcystin production dynamics over a large geographic area are very unpredictable (Parker, 2019). For example, although cyanobacteria blooms are rare in the northern Lower Peninsula, one of the highest recorded total microcystin concentrations that we observed (13,000 µg/l) occurred in a lake in Iosco County. And while cyanobacteria blooms are typically associated with eutrophic and hypereutrophic lakes, we have observed high microcystin concentrations in oligotrophic and mesotrophic lakes, possibly as a result of selective feeding by Dreissenid mussels (Raikow et al., 2004; Sarnelle et al., 2005; Wilson et al., 2005; Knoll et al., 2008; Woller-Skar, 2009; Sarnelle et al., 2010; White et al., 2017; Gaskill and Woller-Skar, 2018). Finally, we have sampled obvious cyanobacteria scums in the southeastern Lower Peninsula that have not had any microcystin in them (Parker, 2019).

Whether a population of cyanobacteria produces microcystin is dependent on whether they possess the toxin-producing genotypes or not (Kardinaal and Visser, 2005). In Michigan, cyanobacterial populations are genetically diverse both between lakes, and within lake populations (Wilson et al., 2005). Even within a single lake, cyanobacteria species and genotypes will change throughout the year, meaning that toxins may only be found in a particular water body for part of the year (Kardinaal et al., 2007; Lehman, 2007; Lehman et al., 2009). Further complicating the understanding of microcystin dynamics is that the exact triggers for microcystin production by cyanobacteria are not fully understood (Sivonen and Jones, 1999; Kardinaal and Visser, 2005).

The factors that determine microcystin production by cyanobacteria are probably dependent on the particular genotypes and environmental conditions within individual water bodies (Kardinaal and Visser, 2005; Omidi et al., 2018). For some well-studied, individual lakes in Michigan, microcystin production can be predicted with some accuracy. For example, in Mona Lake, Muskegon County, microcystin concentrations have consistently been correlated with water column, total phosphorus concentrations (Xie et al., 2012; Parker, 2018b). In Ford Lake, Washtenaw County, and Belleville Lake, Wayne County, the cyanobacterial communities appear to exhibit predictable, seasonal shifts in species composition and toxicity (Lehman, 2007).

Predicting microcystin production from lake to lake can be difficult. When we have found elevated concentrations in a water body, it is consistently in obvious cyanobacteria scum accumulations or obvious sheens on the water surface. Typically, when cyanobacteria are present in a lake, it is in a localized area that is protected from disturbance or along windswept shorelines. Only on rare occasions have we observed extensive, lake-wide blooms. Similar to others (Carmichael and Gorham, 1981; Bartram and Rees, 2000) we have found that microcystin concentrations are often much lower, or nondetectable in clear water that is within 10-15 feet of a cyanobacteria scum.

Conclusion

In general, cyanobacteria blooms do not appear to be a widespread problem in Michigan given how they are rarely observed when lakes are randomly sampled. Rather, we typically only observe cyanobacteria blooms and resultant toxin production in lakes that we either target because they have experienced blooms in the past, or because citizens have alerted us to them. Typically, the blooms that are observed occur in localized areas of a water body and any microcystin that is observed is typically found in obvious scums, whereas adjacent, clear water often has very little/no microcystin. The majority of the cyanobacteria blooms that we have observed in the last four years have been in the southern Lower Peninsula. The southern Lower Peninsula contains the most agricultural and urban areas in Michigan, which are known to contribute nutrients to water bodies. Despite only making up a small percentage of the total number of lakes in Michigan, lakes that were either reservoirs or natural, but with a lake-level control structure, made up the majority of the water bodies that experienced cyanobacteria blooms. These systems may have been over-represented since they are typically situated in populated areas and are usually heavily-developed along the riparian area. Reservoirs, in particular, tend to be shallow and have high shoreline development factors. Most experts agree that given future climate projections coupled with agricultural and urban land use scenarios, cyanobacteria blooms are expected to increase in occurrence and magnitude worldwide.

Report By: Aaron Parker, Aquatic Biologist
Surface Water Assessment Section
Water Resources Division

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Appendix 1: Raw lake data from 2019.

Lake	County	Site	Latitude	Longitude	Waterbody type	Month	Day	Year	Sample type (scum or ambient)	Algal Strip Result (Total MC ug/l)	Total microcystins (lab; ug/l)	Anatoxin (lab; ug/l)	detectrospermopsin (lab; ug/l)	Nodularin (lab; ug/l)	Comments
Geneva	Clinton	SW beach	42.830469	-84.585809	lake	6	18	2019	scum	all non-detect	non-detect	non-detect	non-detect	non-detect	
West Bloomfield	Oakland	lakewide	42.562046	-83.381923	lake	6	27	2019	scum	all non-detects	non-detect	non-detect	non-detect	non-detect	
Peach	Ogemaw	Dave's Beach	44.287347	-84.173707	lake	7	2	2019	scum	~5	16	non-detect	non-detect	non-detect	
.	Cheboygan	.	.	.	lake	7	3	2019	ambient	all non-detects	non-detect	non-detect	non-detect	non-detect	Canine illness complaints
Veteran's Park Pond	Washtenaw	Veteran's Park	42.322957	-84.021909	pond	7	9	2019	ambient	non-detect	.	.	.	.	duckweed bloom
.	Cheboygan	.	.	.	lake	7	10	2019	ambient	all non-detects	non-detect	non-detect	non-detect	non-detect	Canine illness complaints
Castell BLVD pond	Wayne	Castell and Ecorse intersection	42.249415	-83.465117	pond	7	11	2019	scum	2.5-5	non-detect	non-detect	non-detect	non-detect	red algae complaint
.	Osceola	.	.	.	pond	7	11	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	canine death and human illness
.	Allegan	.	.	.	lake	7	12	2019	ambient	all non-detects	non-detect	non-detect	non-detect	non-detect	canine illness, wildlife death
.	Montcalm	.	.	.	lake	8	6	2019	ambient	all non-detects	non-detect	non-detect	non-detect	non-detect	Canine death
Driskels	Cass		41.906343	-85.799748	lake	8	9	2019	ambient	all non-detects	.	.	.	.	
.	Hillsdale	.	.	.	lake	8	9	2019	ambient	both non-detects	non-detect	non-detect	non-detect	non-detect	Human illness
Van Auken	Van Buren	3 sites	42.260111	-86.181335	lake	8	13	2019	ambient	all non-detects	non-detect	non-detect	non-detect	non-detect	
Kent	Oakland/Livingston	6 sites	42.513549	-83.671412	lake	8	14	2019	ambient	all non-detects	non-detect	non-detect	non-detect	non-detect	
Kent	Oakland/Livingston	7 sites	42.513549	-83.671412	lake	8	14	2019	ambient	all non-detects	non-detect	non-detect	non-detect	non-detect	
Millpointe pond	Livingston	Chelsea Circle	42.629076	-83.75817	pond	8	14	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
Squaw	Genesee	4190 Four Lakes Ave., Linden, MI	42.825168	-83.752408	lake	8	14	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
Squaw	Genesee	4190 Four Lakes Ave., Linden, MI	42.825168	-83.752408	lake	8	14	2019	scum	non-detect	0.74	non-detect	non-detect	non-detect	
Big Twin	Kalkaska	private residence	44.827575	-84.971354	lake	8	16	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
Lloyds Bayou	Ottawa	Boat launch	43.07271	-86.17219	lake	8	16	2019	ambient	non-detect	.	.	.	.	
Lloyds Bayou	Ottawa	Leonard RD	43.06953	-86.18414	lake	8	16	2019	ambient	non-detect	.	.	.	.	
Lloyds Bayou	Ottawa	M-104	43.07595	-86.16892	lake	8	16	2019	ambient	non-detect	.	.	.	.	
Lloyds Bayou	Ottawa	Oak Ridge	43.07215	-86.17487	lake	8	16	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
White	Muskegon	Boat launch	43.4114	-86.35706	lake	8	17	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
White	Muskegon	Crosswinds Marina	43.40631	-86.34974	lake	8	17	2019	scum	>10	4000	non-detect	non-detect	non-detect	
White	Muskegon	Dock A	43.40602	-86.35162	lake	8	17	2019	ambient	non-detect	0.58	non-detect	non-detect	non-detect	
White	Muskegon	Goodrich Park	43.40928	-86.35217	lake	8	17	2019	ambient	1-5	1.2	non-detect	non-detect	non-detect	
White	Muskegon	Municipal Marina dock	43.40987	-86.35171	lake	8	17	2019	scum	>10	28	non-detect	non-detect	non-detect	
White	Muskegon	Maple Beach	43.40137	-86.35872	lake	8	17	2019	ambient	5-10	2.7	non-detect	non-detect	non-detect	
White	Muskegon	Svensson Park	43.39697	-86.35485	lake	8	17	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
Hamlin	Mason	Davis RD	44.0794	-86.43624	lake	8	19	2019	ambient	non-detect	.	non-detect	non-detect	non-detect	Gloeotrichia bloom
Bass	Mason	S. Lakeshore DR	43.82897	-86.41901	lake	8	20	2019	ambient	>10	6.6	non-detect	non-detect	non-detect	
Bass	Mason	Bass Lake BLVD	43.8358	-86.41982	lake	8	20	2019	scum	>10	3700	non-detect	non-detect	non-detect	
Bass	Mason	Boat launch	43.83957	-86.418	lake	8	20	2019	scum	>10	610	non-detect	non-detect	non-detect	
.	Osceola	.	.	.	pond	8	20	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
.	Osceola	.	.	.	pond	8	20	2019	scum	non-detect	non-detect	24	non-detect	non-detect	
.	Osceola	.	.	.	pond	8	20	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
.	Osceola	.	.	.	pond	8	20	2019	scum	non-detect	non-detect	43	non-detect	non-detect	
Hamlin	Mason	Davis RD	44.0794	-86.43624	lake	8	20	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	Gloeotrichia bloom
Hamlin	Mason	Duneview DR	44.04251	-86.45816	lake	8	20	2019	scum	5-10	0.98	non-detect	non-detect	non-detect	Gloeotrichia bloom
Hamlin	Mason	Middle Bayou	44.02804	-86.45657	lake	8	20	2019	scum	non-detect	.	non-detect	non-detect	non-detect	Gloeotrichia bloom
Hamlin	Mason	South Bayou	44.01552	-86.4574	lake	8	20	2019	scum	non-detect	.	non-detect	non-detect	non-detect	Gloeotrichia bloom
Hamlin	Mason	South canal	44.00887	-86.45853	lake	8	20	2019	ambient	non-detect	0.57	non-detect	non-detect	non-detect	Gloeotrichia bloom
Hamlin	Mason	South canal	44.00887	-86.45853	lake	8	20	2019	scum	>10	40	non-detect	non-detect	non-detect	Gloeotrichia bloom
Hamlin	Mason	State Park beach	44.03508	-86.49265	lake	8	20	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	clear
Lamberton	Kent		43.020403	-85.628929	lake	8	20	2019		ND	non-detect	non-detect	non-detect	non-detect	
Morrison	Ionia	9136 Ash LN	42.855858	-85.21666	lake	8	20	2019			0.58	non-detect	non-detect	non-detect	
Morrison	Ionia	Boat launch	42.862742	-85.213603	lake	8	20	2019			0.53	non-detect	non-detect	non-detect	

Appendix 1 cont.

Lake	County	Site	Latitude	Longitude	Waterbody type	Month	Day	Year	Sample type (scum or ambient)	Algal Strip Result (Total MC ug/l)	Total microcystins (lab; ug/l)	Anatoxin (lab; ug/l)	Cylinon-detectrospermopsin (lab; ug/l)	Nodularin (lab; ug/l)	Comments
.	Newaygo	.	.	.	pond	8	20	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	canine death
.	Newaygo	.	.	.	pond	8	20	2019	ambient	non-detect	.	.	.	.	canine death
Chemung	Livingston	Red Oaks	42.58765	-83.84095	canal	8	21	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
Chemung	Livingston	Boat launch	42.57849	-83.83517	lake	8	21	2019	ambient	non-detect	.	.	.	.	
Chemung	Livingston	Park	42.57924	-83.85034	lake	8	21	2019	ambient	non-detect	.	.	.	.	
Knoblock	Oakland	Knobby View DR	42.69614	-83.61859	lake	8	21	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
Lake Oakland	Oakland	Rutherford CT	42.69356	-83.36557	lake	8	21	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
Lake Oakland	Oakland	American Legion beach	42.70668	-83.36569	lake	8	21	2019	ambient	non-detect	.	.	.	.	
Lake Oakland	Oakland	Boat launch	42.69862	-83.36316	lake	8	21	2019	ambient	non-detect	.	.	.	.	
Pontiac	Oakland	Boat launch	42.66339	-83.44242	lake	8	21	2019	ambient	non-detect	.	.	.	.	
Pontiac	Oakland	State Park beach	42.66809	-83.44731	lake	8	21	2019	ambient	non-detect	.	.	.	.	
Pontiac	Oakland	Tackles DR boat launch	42.67098	-83.45863	lake	8	21	2019	ambient	non-detect	.	.	.	.	
Pontiac	Oakland	Kingston	42.66475	-83.46125	lake	8	21	2019	ambient	non-detect	.	.	.	.	
Pontiac	Oakland	Bonnie Briar	42.66851	-83.47015	lake	8	21	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
Upper Long	Oakland	Oakway DR	42.60039	-83.32726	canal	8	21	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
West Bloomfield	Oakland	Park	42.56122	-83.38134	lake	8	21	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
West Bloomfield	Oakland	Lake Bluff DR	42.56284	-83.38235	lake	8	21	2019	ambient	non-detect	.	.	.	.	
Bass	Mason	Marrison Park	43.83407	-86.40604	lake	8	22	2019	ambient	5-10	1.6	non-detect	non-detect	non-detect	
Bass	Mason	S. Lakeshore DR	43.82897	-86.41901	lake	8	22	2019	ambient	>10	16	non-detect	non-detect	non-detect	
Bass	Mason	Bass Lake BLVD	43.8358	-86.41982	lake	8	22	2019	scum	>10	21	non-detect	non-detect	non-detect	
Bass	Mason	Boat launch	43.83891	-86.41787	lake	8	22	2019	scum	>10	7900	non-detect	non-detect	non-detect	
Bass	Mason	Boat launch	43.83892	-86.41759	lake	8	22	2019	ambient	1-5	6.6	non-detect	non-detect	non-detect	
Hamlin	Mason	Davis RD	44.0794	-86.43624	lake	8	22	2019	scum	non-detect	non-detect	.	.	.	Thin layer of cyanobacteria
Hamlin	Mason	Upper lake boat launch	44.08539	-86.37343	lake	8	22	2019	ambient	non-detect	.	.	.	.	
Hamlin	Mason	Wilson Park	44.07134	-86.42713	lake	8	22	2019	ambient	non-detect	non-detect	.	.	.	
Hamlin	Mason	Duneview DR	44.04256	-86.45819	lake	8	22	2019	ambient	test fail	non-detect	.	.	.	
Hamlin	Mason	Middle Bayou	44.02804	-86.45657	lake	8	22	2019	ambient	non-detect	.	.	.	.	
Hamlin	Mason	South Bayou	44.01552	-86.4574	lake	8	22	2019	ambient	non-detect	.	.	.	.	
Hamlin	Mason	South canal	44.00887	-86.45853	lake	8	22	2019	ambient	non-detect	non-detect	.	.	.	
Hamlin	Mason	State Park beach	44.03508	-86.49265	lake	8	22	2019	ambient	non-detect	.	.	.	.	
.	Washtenaw	.	.	.	lake	8	22	2019	ambient	ND	non-detect	non-detect	non-detect	non-detect	canine death
.	Washtenaw	.	.	.	lake	8	22	2019	ambient	ND	non-detect	non-detect	non-detect	non-detect	
White	Muskegon	Lau RD boat launch	43.37604	-86.42112	lake	8	22	2019	ambient	non-detect	.	.	.	.	
White	Muskegon	Maple Beach	43.40136	-86.35872	lake	8	22	2019	ambient	1-5	.	.	.	.	
White	Muskegon	Montague boat launch	43.41141	-86.35709	lake	8	22	2019	ambient	non-detect	.	.	.	.	
White	Muskegon	Goodrich Park	43.40929	-86.35223	lake	8	22	2019	ambient	~1	non-detect	non-detect	non-detect	non-detect	
White	Muskegon	Municipal Marina dock	43.40994	-86.35176	lake	8	22	2019	scum	>10	21	non-detect	non-detect	non-detect	
White	Muskegon	Crosswinds Dock A	43.40604	-86.35162	lake	8	22	2019	ambient	~1	non-detect	non-detect	non-detect	non-detect	
White	Muskegon	Crosswinds Marina	43.40606	-86.34996	lake	8	22	2019	scum	>10	130	non-detect	non-detect	non-detect	
White	Muskegon	Svensson Park	43.39678	-86.35487	lake	8	22	2019	ambient	non-detect	.	.	.	.	
White	Muskegon	Mill Pond	43.39014	-86.35513	lake	8	22	2019	ambient	>10	3.5	non-detect	non-detect	non-detect	
White	Muskegon	Scenic DR boat launch	43.36309	-86.41199	lake	8	22	2019	ambient	1-5	.	.	.	.	
White	Muskegon	Sylvan Beach	43.36963	-86.42027	lake	8	22	2019	ambient	non-detect	0.55	non-detect	non-detect	non-detect	
Townsend Pond	Eaton	Townsend on the Park Apartments	42.740243	-84.709384	pond	8	23	2019	ambient	ND	.	.	.	.	
Bass	Mason	Marrison Park	43.83407	-86.40604	lake	8	29	2019	scum	>10	12	non-detect	non-detect	non-detect	
Bass	Mason	S. Lakeshore DR	43.82897	-86.41901	lake	8	29	2019	scum	>10	180	non-detect	non-detect	non-detect	
Bass	Mason	Bass Lake BLVD	43.8358	-86.41982	lake	8	29	2019	scum	>10	190	non-detect	non-detect	non-detect	
Bass	Mason	Boat launch	43.83891	-86.41787	lake	8	29	2019	scum	>10	240	non-detect	non-detect	non-detect	
White	Muskegon	Goodrich Park	43.40929	-86.35223	lake	8	29	2019	ambient	>10	0.5	non-detect	non-detect	non-detect	

Appendix 1 cont.

Lake	County	Site	Latitude	Longitude	Waterbody type	Month	Day	Year	Sample type (scum or ambient)	Algal Strip Result (Total MC ug/l)	Total microcystins (lab; ug/l)	Anatoxin (lab; ug/l)	Cylinon-detectrospermopsin (lab; ug/l)	Nodularin (lab; ug/l)	Comments
White	Muskegon	Municipal Marina dock	43.40994	-86.35176	lake	8	29	2019	ambient	7.5	2.5	non-detect	non-detect	non-detect	
White	Muskegon	Mill Pond	43.39014	-86.35513	lake	8	29	2019	ambient	2.5	non-detect	non-detect	non-detect	non-detect	
White	Muskegon	Crosswinds scum	43.40631	-86.34974	lake	8	29	2019	scum	>10	180	non-detect	non-detect	non-detect	
White	Muskegon	2nd municipal marina	43.40994	-86.35176	lake	8	29	2019	ambient	7.5	10	non-detect	non-detect	non-detect	
Fish	Van Buren		42.323053	-85.807122	lake	9	2	2019		ND	.	.	.	.	
.	Antrim	.	.	.	lake	9	3	2019	ambient	ND	.	.	.	.	itching skin complaint
Belleville	Wayne	Harmony LN cove	42.21731	-83.47219	lake	9	4	2019	scum	>10	13.1	non-detect	non-detect	non-detect	
Belleville	Wayne	Alba CT cove	42.21924	-83.45785	lake	9	4	2019	scum	>10	17.7	non-detect	non-detect	non-detect	
Belleville	Wayne	Dora CT	42.20678	-83.51161	lake	9	4	2019	ambient	ND	.	.	.	.	
Belleville	Wayne	Van Buren Park	42.212731	-83.537278	lake	9	4	2019	ambient	ND	.	.	.	.	
Columbia	Jackson	Cannes Circle	42.085439	-84.293553	lake	9	6	2019	scum	>10	370	non-detect	non-detect	non-detect	
Morrison	Ionia	Boat launch	42.862742	-85.213603	lake	9	6	2019	scum		2.9	non-detect	non-detect	non-detect	
Bass	Mason	Marrison Park	43.83407	-86.40604	lake	9	10	2019	ambient	1	0.94	non-detect	non-detect	non-detect	
Bass	Mason	S. Lakeshore DR	43.82897	-86.41901	lake	9	10	2019	scum	>10	51	non-detect	non-detect	non-detect	
Bass	Mason	Bass Lake BLVD	43.8358	-86.41982	lake	9	10	2019	scum	>10	20	non-detect	non-detect	non-detect	
Bass	Mason	Boat launch	43.83891	-86.41787	lake	9	10	2019	scum	>10	6300	non-detect	non-detect	non-detect	
Bass	Mason	Boat launch	43.83891	-86.41787	lake	9	10	2019	light scum	5-10	9	non-detect	non-detect	non-detect	
Columbia	Jackson	Stud Bay			lake	9	10	2019	scum	>10	260	non-detect	non-detect	non-detect	
Columbia	Jackson	W. Shore Bay			lake	9	10	2019	scum	>10	non-detect	non-detect	non-detect	non-detect	
Columbia	Jackson	Back Bedford			lake	9	10	2019		test fail	36	non-detect	non-detect	non-detect	
Mill Pond	Muskegon	Mill Pond RD	43.388148	-86.353147	pond	9	10	2019	ambient	ND	non-detect	non-detect	non-detect	non-detect	
Morrison	Ionia	Boat launch	42.862742	-85.213603	lake	9	10	2019	scum	>10	6.5	non-detect	non-detect	non-detect	
White	Muskegon	Lau RD boat launch	43.37604	-86.42112	lake	9	10	2019	ambient	ND	.	.	.	.	
White	Muskegon	Maple Beach	43.40136	-86.35872	lake	9	10	2019	ambient	ND	.	.	.	.	
White	Muskegon	Montague boat launch	43.41141	-86.35709	lake	9	10	2019	ambient	ND	.	.	.	.	
White	Muskegon	Goodrich Park	43.40929	-86.35223	lake	9	10	2019	ambient	ND	.	.	.	.	
White	Muskegon	Municipal Marina dock	43.40994	-86.35176	lake	9	10	2019	ambient	ND	0.52	non-detect	non-detect	non-detect	
White	Muskegon	Crosswinds Dock A	43.40604	-86.35162	lake	9	10	2019	ambient	ND	non-detect	non-detect	non-detect	non-detect	
White	Muskegon	Crosswinds Marina	43.40606	-86.34996	lake	9	10	2019	ambient	ND	.	.	.	.	
White	Muskegon	Svensson Park	43.39678	-86.35487	lake	9	10	2019	ambient	ND	.	.	.	.	
White	Muskegon	Mill Pond	43.39014	-86.35513	lake	9	10	2019	ambient	ND	.	.	.	.	
White	Muskegon	Scenic DR boat launch	43.36309	-86.41199	lake	9	10	2019	ambient	ND	.	.	.	.	
White	Muskegon	Sylvan Beach	43.36963	-86.42027	lake	9	10	2019	ambient	ND	.	.	.	.	
Sherwood Forest	Macomb		42.694938	-82.983189	lake	9	11	2019		5-10	non-detect	non-detect	non-detect	non-detect	
Thornapple	Barry	Charleton Park	42.619623	-85.193754	lake	9	11	2019	scum	>10	40	non-detect	non-detect	non-detect	
Belleville	Wayne	West launch	42.20985	-83.53946	lake	9	12	2019	ambient	non-detect	.	.	.	.	
Belleville	Wayne	Van Buren Park	42.21256	-83.52494	lake	9	12	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
Belleville	Wayne	Middle DNR launch	42.21388	-83.4732	lake	9	12	2019	ambient	non-detect	.	.	.	.	
Belleville	Wayne	Edison Lake RD	42.21275	-83.44298	lake	9	12	2019	ambient	5-10	3.4	non-detect	non-detect	non-detect	
Belleville	Wayne	Belleville/Denton RD	42.20978	-83.49347	lake	9	12	2019	ambient	non-detect	.	.	.	.	
Budd	Clare	north				9	12	2019	scum	non-detect	non-detect	non-detect	non-detect	non-detect	
Budd	Clare	north				9	12	2019	scum	non-detect	non-detect	non-detect	non-detect	non-detect	
Budd	Clare	north end	44.031522	-84.80316	lake	9	12	2019	.	non-detect	.	.	.	.	
Ford	Washtenaw	North Bay Park	42.23015	-83.60725	lake	9	12	2019	ambient	non-detect	.	.	.	.	
Ford	Washtenaw	Ford Lake Park	42.21099	-83.57291	lake	9	12	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
Ford	Washtenaw	Lakeside Park	42.2047	-83.56217	lake	9	12	2019	ambient	non-detect	.	.	.	.	
Ausable	Ogemaw	Alcott	44.42667	-83.92129	lake	9	18	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect	
Ausable	Ogemaw	Boat launch	44.42632	-83.91886	lake	9	18	2019	ambient	1-5	1.2	non-detect	non-detect	non-detect	
Ausable	Ogemaw	Canal	44.43116	-83.90782	canal	9	18	2019	ambient	non-detect	.	.	.	.	

Appendix 1 cont.

Lake	County	Site	Latitude	Longitude	Waterbody type	Month	Day	Year	Sample type (scum or ambient)	Algal Strip Result (Total MC ug/l)	Total microcystins (lab; ug/l)	Anatoxin (lab; ug/l)	Cylinon-detectrospermopsin (lab; ug/l)	Nodularin (lab; ug/l)
Bass	Mason	Marrison Park	43.83407	-86.40604	lake	9	18	2019	ambient	non-detect	.	.	.	.
Bass	Mason	S. Lakeshore DR	43.82897	-86.41901	lake	9	18	2019	ambient	~1	non-detect	non-detect	non-detect	non-detect
Bass	Mason	Bass Lake BLVD	43.8358	-86.41982	lake	9	18	2019	ambient	1-5	0.94	non-detect	non-detect	non-detect
Bass	Mason	Boat launch	43.83891	-86.41787	lake	9	18	2019	scum	>10	8.5	non-detect	non-detect	non-detect
Budd	Clare	Wilson State Park beach	44.02818	-84.80171	lake	9	18	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Budd	Clare	Townline Lake RD	44.03175	-84.80379	lake	9	18	2019	scum	non-detect	non-detect	non-detect	non-detect	non-detect
Budd	Clare	Boat launch	44.01608	-84.78818	lake	9	18	2019	ambient	non-detect	.	.	.	.
Budd	Clare	Saxton Park	44.02119	-84.79673	lake	9	18	2019	ambient	non-detect	.	.	.	.
Goodemoot Drain	Ionia	Goodemoot RD	42.85719	-85.20482	County drain	9	18	2019	ambient	non-detect	.	.	.	.
Jackson RD Drain	Ionia	Jackson RD	42.8693	-85.19344	County drain	9	18	2019	ambient	non-detect	.	.	.	.
Morrison	Ionia	Boat launch	42.862742	-85.213603	lake	9	18	2019	ambient	non-detect	0.54	non-detect	non-detect	non-detect
Rush Drain	Ionia	Rush st	42.85306	-85.21984	County drain	9	18	2019	ambient	non-detect	.	.	.	.
Tiffany LN Drain	Ionia	Tiffany Lane	42.86203	-85.19391	County drain	9	18	2019	ambient	non-detect	.	.	.	.
Bass	Mason	Marrison Park	43.83407	-86.40604	lake	9	22	2019	ambient	non-detect	.	.	.	.
Bass	Mason	S. Lakeshore DR	43.82897	-86.41901	lake	9	22	2019	ambient	>10	34	non-detect	non-detect	non-detect
Bass	Mason	Bass Lake BLVD	43.8358	-86.41982	lake	9	22	2019	ambient	1-5	.	.	.	.
Bass	Mason	Boat launch	43.83891	-86.41787	lake	9	22	2019	scum	>10	12	non-detect	non-detect	non-detect
Swan	Allegan	Beach	42.468285	-85.964365	lake	9	23	2019	ambient	1-5	1.5	non-detect	non-detect	non-detect
Swan	Allegan	Pauline	42.463632	-85.965052	lake	9	23	2019	ambient	1-5	1.9	non-detect	non-detect	non-detect
Swan	Allegan	boat launch	42.466349	-85.954209	lake	9	23	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Budd	Clare	Wilson State Park beach	44.02818	-84.80171	lake	9	24	2019	light scum	non-detect	.	.	.	.
Budd	Clare	Townline Lake RD	44.03175	-84.80379	lake	9	24	2019	ambient	non-detect	.	.	.	.
Budd	Clare	Boat launch	44.01608	-84.78818	lake	9	24	2019	light scum	non-detect	.	.	.	.
Budd	Clare	Saxton Park	44.02119	-84.79673	lake	9	24	2019	light scum	non-detect	non-detect	non-detect	non-detect	non-detect
Earl	Livingston	west canal	42.602398	-83.89996	lake	9	24	2019	scum	non-detect	non-detect	non-detect	non-detect	non-detect
Intermediate	Antrim	Campground boat launch	45.06815	-85.25997	lake	9	24	2019	ambient	non-detect	.	.	.	.
Intermediate	Antrim	Thurston Park beach	45.06993	-85.25932	lake	9	24	2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Intermediate	Antrim	E. State ST park	45.07001	-85.25846	lake	9	24	2019	ambient	non-detect	.	.	.	.
Intermediate	Antrim	Center Lake launch	45.05097	-85.25807	lake	9	24	2019	ambient	non-detect	.	.	.	.
Intermediate	Antrim	Gorham launch	45.02114	-85.22559	lake	9	24	2019	ambient	non-detect	.	.	.	.
Intermediate	Antrim	Bellaire park beach	44.97936	-85.20896	river	9	24	2019	ambient	non-detect	.	.	.	.
Intermediate	Antrim	Openo launch	45.01952	-85.20502	lake	9	24	2019	ambient	non-detect	.	.	.	.
Intermediate	Antrim	N. Intermediate Lake RD	45.03893	-85.24207	lake	9	24	2019	ambient	non-detect	.	.	.	.
Thornapple	Barry	Charleton Park	42.619623	-85.193754	lake	9	24	2019	scum	>10	31	non-detect	non-detect	non-detect
Sherwood	Oakland	Ledgewood DR docks	42.59534	-83.53905	lake	9	25	2019	ambient	non-detect	.	.	.	.
Sherwood	Oakland	Winewood LN scum	42.59088	-83.53022	lake	9	25	2019	scum	test fail	19	non-detect	27	non-detect
Sherwood	Oakland	Winewood LN ambient	42.59104	-83.53013	lake	9	25	2019	ambient	non-detect	.	.	.	.
Sherwood	Oakland	Driftwood docks	42.59356	-83.55486	lake	9	25	2019	ambient	non-detect	.	.	.	.
Sherwood	Oakland	Driftwood DR residence	42.59056	-83.55232	lake	9	25	2019	ambient	non-detect	.	.	.	.
Sherwood	Oakland	Trentwood/Surfwood	42.59438	-83.54713	lake	9	25	2019	ambient	non-detect	.	.	.	.
Sherwood	Oakland	Wavewood DR	42.59444	-83.54545	lake	9	25	2019	ambient	non-detect	.	.	.	.
Sherwood	Oakland	Ravinewood DR	42.58704	-83.54657	lake	9	25	2019	ambient	non-detect	.	.	.	.
Sherwood	Oakland	Ravinewood DR E	42.59092	-83.53114	lake	9	25	2019	ambient	non-detect	.	.	.	.
Sherwood	Oakland	Windwood CT	42.59245	-83.53147	lake	9	25	2019	ambient	non-detect	.	.	.	.
Sherwood	Oakland	E Commerce RD	42.5962	-83.53261	lake	9	25	2019	ambient	non-detect	.	.	.	.
Sherwood	Oakland	E Commerce RD/Winewood	42.59632	-83.53149	lake	9	25	2019	ambient	non-detect	.	.	.	.
Sherwood	Oakland	Gulfwood	42.59883	-83.54696	lake	9	25	2019	ambient	non-detect	.	.	.	.
Sherwood	Oakland	Inverrary CT	42.60209	-83.55523	lake	9	25	2019	ambient	non-detect	.	.	.	.
Sherwood	Oakland	Pikewood scum	42.5921	-83.53693	lake	9	25	2019	scum	5-10	2	non-detect	6.1	non-detect

Appendix 1 cont.

Lake	County	Site	Latitude	Longitude	Waterbody type	Month	Day	Year	Sample type (scum or ambient)	Algal Strip Result (Total MC ug/l)	Total microcystins (lab; ug/l)	Anatoxin (lab; ug/l)	Cylinon-detectrospermopsin (lab; ug/l)	Nodularin (lab; ug/l)
Sherwood	Oakland	Pikewood ambient	42.59201	-83.53675	lake	9	25	2019	ambient	non-detect	.	.	.	.
Hamlin	Mason	Davis RD	44.0794	-86.43624	lake	10	2	2019	ambient	non-detect	.	.	.	.
Hamlin	Mason	Upper lake boat launch	44.08539	-86.37343	lake	10	2	2019	ambient	non-detect	.	.	.	.
Hamlin	Mason	Wilson Park	44.07134	-86.42713	lake	10	2	2019	ambient	non-detect	.	.	.	.
Hamlin	Mason	Duneview DR	44.04256	-86.45819	lake	10	2	2019	ambient	non-detect	.	.	.	.
Hamlin	Mason	Middle Bayou	44.02804	-86.45657	lake	10	2	2019	ambient	non-detect	.	.	.	.
Hamlin	Mason	South Bayou	44.01552	-86.4574	lake	10	2	2019	ambient	non-detect	.	.	.	.
Hamlin	Mason	South canal	44.00887	-86.45853	lake	10	2	2019	ambient	non-detect	.	.	.	.
Hamlin	Mason	State Park beach	44.03508	-86.49265	lake	10	2	2019	ambient	non-detect	.	.	.	.
Bass	Mason	Marrison Park	43.83407	-86.40604	lake	10	2	2019	ambient	non-detect	.	.	.	.
Bass	Mason	S. Lakeshore DR	43.82897	-86.41901	lake	10	2	2019	ambient	non-detect	.	.	.	.
Bass	Mason	Bass Lake BLVD	43.8358	-86.41982	lake	10	2	2019	ambient	non-detect	.	.	.	.
Bass	Mason	Boat launch	43.83891	-86.41787	lake	10	2	2019	scum	1-5	.	.	.	.
Bass	Mason	Marrison Park	43.83407	-86.40604	lake	10	7	2019	ambient	non-detect	.	.	.	.
Bass	Mason	S. Lakeshore DR	43.82897	-86.41901	lake	10	7	2019	ambient	non-detect	.	.	.	.
Bass	Mason	Bass Lake BLVD	43.8358	-86.41982	lake	10	7	2019	ambient	non-detect	.	.	.	.
Bass	Mason	Boat launch	43.83891	-86.41787	lake	10	7	2019	scum	>10	.	.	.	.
Sherwood	Oakland	Winewood LN scum	42.59088	-83.53022	lake	10	7	2019	scum	.	5.4	non-detect	2.74	.
LeAnn	Hillsdale					10	7	2019	scum	>10	55	non-detect	non-detect	non-detect
Croton	Newaygo	Croton Township Campground	43.44728	-85.65867	river impoundment	10	7	2019	ambient	non-detect	.	.	.	.
Croton	Newaygo	DuChemine Park	43.43996	-85.6667	river impoundment	10	7	2019	ambient	non-detect	.	.	.	.
Hardy	Mecosta	Pierce RD scum	43.57655	-85.51686	river impoundment	10	7	2019	scum	>10	510	.	.	.
Hardy	Mecosta	Pierce RD ambient	43.57657	-85.51688	river impoundment	10	7	2019	ambient	non-detect	.	.	.	.
Hardy	Mecosta	River Ridge	43.58362	-85.52732	river impoundment	10	7	2019	ambient	non-detect	.	.	.	.
Hardy	Mecosta	Elder/Pierce	43.57628	-85.53178	river impoundment	10	7	2019	scum	>10	5500	.	.	.
Hardy	Newaygo	Big Bend docks	43.52613	-85.58161	river impoundment	10	7	2019	scum	>10	910	.	.	.
Hardy	Newaygo	Breezy Knoll Beach	43.5158	-85.62081	river impoundment	10	7	2019	ambient	non-detect	.	.	.	.
Hardy	Newaygo	Sandy Beach boat launch	43.49518	-85.62982	river impoundment	10	7	2019	ambient	non-detect	.	.	.	.
Hardy	Newaygo	Hardy Dam launch	43.49128	-85.63675	river impoundment	10	7	2019	ambient	non-detect	.	.	.	.
Hardy	Newaygo	Oxbow Park launch	43.5055	-85.61069	river impoundment	10	7	2019	ambient	non-detect	.	.	.	.
Hardy	Newaygo	Newaygo State Park launch	43.50435	-85.58624	river impoundment	10	7	2019	scum	>10	56	.	.	.
Hardy	Mecosta	Brower Park launch	43.55957	-85.54907	river impoundment	10	7	2019	scum	>10	11000	.	.	.
Hardy	Mecosta	Brower Park launch	43.55954	-85.54901	river impoundment	10	7	2019	ambient	non-detect	.	.	.	.
Croton	Newaygo	Croton Township Campground	43.44728	-85.65867	river impoundment	10	16	2019	ambient	non-detect	.	.	.	.
Croton	Newaygo	DuChemine Park	43.43996	-85.6667	river impoundment	10	16	2019	ambient	non-detect	.	.	.	.
Hardy	Mecosta	Pierce RD scum	43.57655	-85.51686	river impoundment	10	16	2019	scum	>10	15000	.	.	.
Hardy	Mecosta	Pierce RD ambient	43.57657	-85.51688	river impoundment	10	16	2019	ambient	non-detect	.	.	.	.
Hardy	Mecosta	River Ridge	43.58362	-85.52732	river impoundment	10	16	2019	ambient	non-detect	.	.	.	.
Hardy	Mecosta	Elder/Pierce	43.57628	-85.53178	river impoundment	10	16	2019	scum	>10	8100	.	.	.
Hardy	Newaygo	Big Bend docks	43.52613	-85.58161	river impoundment	10	16	2019	scum	>10	3800	.	.	.
Hardy	Newaygo	Big Bend docks	43.52613	-85.58161	river impoundment	10	16	2019	ambient	>10	.	.	.	.
Hardy	Newaygo	Breezy Knoll Beach	43.5158	-85.62081	river impoundment	10	16	2019	light scum	>10	39	.	.	.
Hardy	Newaygo	Hardy Dam launch	43.49128	-85.63675	river impoundment	10	16	2019	scum	>10	1500	.	.	.
Hardy	Newaygo	Hardy Dam launch	43.49128	-85.63675	river impoundment	10	16	2019	ambient	non-detect	.	.	.	.
Hardy	Newaygo	Oxbow Park launch	43.5055	-85.61069	river impoundment	10	16	2019	ambient	non-detect	.	.	.	.
Hardy	Newaygo	Newaygo State Park launch	43.50435	-85.58624	river impoundment	10	16	2019	ambient	non-detect	.	.	.	.
Crooked Lake	Emmett	.	45.413963	-84.7980891	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Guthrie Lake	Otsego	.	44.857026	-84.6096769	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Long Lake	Iosco	.	44.420639	-83.834719	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect

Appendix 1 cont.

Lake	County	Site	Latitude	Longitude	Waterbody type	Month	Day	Year	Sample type (scum or ambient)	Algal Strip Result (Total MC ug/l)	Total microcystins (lab; ug/l)	Anatoxin (lab; ug/l)	Cylinon-detectrospermopsin (lab; ug/l)	Nodularin (lab; ug/l)
Sand Lake	Iosco	.	44.31973	-83.681392	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Peach Lake	Ogemaw	.	44.295004	-84.164735	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Hardwood Lake	Ogemaw	.	44.243735	-84.000542	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Bush Lake	Ogemaw		44.192891	-84.037132	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Five Lakes	Clare	.	43.872663	-84.798162	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Bennett Lake	Livingston	.	42.786143	-83.840685	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Wycamp Lake	Emmet	.	45.653211	-84.983139	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
White Cloud Pond	Newaygo	.	43.547107	-85.767489	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Winnewana Impoundment	Washtenaw	.	42.354662	-84.1129996	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Belle Lake 2	Luce	.	46.483349	-85.816124	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Kaks Lake	Luce	.	46.303501	-85.5690655	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Sixteenmile	Alger	.	46.300687	-86.758691	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Fortune, Third	Iron	.	46.089779	-88.4272853	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Fortune, Fourth	Iron	.	46.089779	-88.4272853	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Ford Dam (Kingsford Flowag	Dickinson	.	45.876727	-88.083629	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Rice Lake, Little	Houghton	.	45.653211	-84.983139	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Big Lake	Baraga	.	46.612157	-88.5724222	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Steusser	Ontanagon	.	46.4508	-89.248293	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
McClure Basin	Marquette	.	46.559455	-87.5448666	lake	8		2019	ambient	non-detect	non-detect	non-detect	non-detect	non-detect
Gulliver Lake		3	45.982504	-86.027025	lake	8		2019	.	non-detect	0.86	non-detect	non-detect	non-detect
Gulliver Lake		C	45.982504	-86.027025	lake	8		2019	.	non-detect	0.81	non-detect	non-detect	non-detect

EXHIBIT 7

Testimony Excerpt of
EGLE Senior Aquatic Biologist;
Aaron Parker

STATE OF MICHIGAN

MICHIGAN ADMINISTRATION HEARING SYSTEM

In the matter of:	Docket No.: 20-009773
Petition of Michigan Farm Bureau; Michigan Milk Producers Association; Michigan Allied Poultry Industries; Foremost Farms USA; Michigan Pork Producers Association; Dairy Farmers of America; Select Milk Producers, Inc.; and 126 Identified Livestock Farms /	Permit No.: MIG010000 Part: Part 31, Water Resources Protection Agency: Department of Environment, Great Lakes and Energy Case Type: Water Resources Division

HEARING - VOLUME NO. VI

BEFORE DANIEL PULTER, ADMINISTRATIVE LAW JUDGE

Via Microsoft Teams Meeting

Monday, December 13, 2021, 9:00 a.m.

APPEARANCES:

For the Petitioners:

MR. ZACHARY CHAD LARSEN (P72189)
MR. MICHAEL JOHN PATTWELL (P72419)
Clark Hill, PLC
212 East Cesar E. Chavez Avenue
Lansing, Michigan 48906
(517) 318-3053

For the Respondent:

MS. ELIZABETH ANNE MORRISSEAU (P81899)
MS. JENNIFER A. ROSA (P58226)
Assistant Attorneys General
Department of Attorney General
525 West Ottawa Street
G. Mennen Building, 6th Floor
Lansing, Michigan 48933
(517) 373-7540

A Both the number of reports that we receive each year from citizens about algae and cyanobacteria blooms and the number of confirmed instances of cyanobacteria occurrence have steadily increased since we began keeping track of those data.

Q Do you have an opinion as to why this is?

A Yes, the consensus amongst the scientific literature is that climate change combined with more intensive agricultural practices, which results in increased nutrient run-off, is causing more cyanobacteria blooms. More intensive agricultural practices primarily refer to, but are not limited to, the increased amount of fertilizer being used on agricultural crop fields and the increased number of CAFOs in the United States that are in turn generating increased amounts of manure that are also being applied to agricultural crop fields.

Q Are cyanobacteria blooms really increasing or are citizens just more aware of cyanobacteria blooms because of increased media coverage?

A Recent research looking at historical lake sediment and satellite data from around the world have indicated that the occurrences of cyanobacteria blooms really are occurring more frequently in the last few decades.

Q With reference to Exhibit R-27, can you describe what this is?

A It is a map of CAFO locations in Michigan in relation to cyanobacterial blooms.

Q Can you explain what, if any, relationship exists between algal blooms and CAFOs?

A The map appears to show that, for the most part, watersheds with higher densities of CAFOs also have higher densities of confirmed instances of cyanobacteria blooms in them.

Q Is this consistent with your understanding from literature addressing the subject?

A Yes, there is a relationship between agricultural land use and its associated nutrient run-off to waterbodies causing cyanobacteria blooms both in the Great Lakes and on a smaller scale in inland lakes as well. Increased dissolved reactive phosphorus loading via field tile drainage pipes has been cited as one of the main causes of cyanobacteria blooms in water bodies that are surrounded by agricultural land use.

Q Looking again at the map, there appears to be a high density of CAFOs in the "Thumb" region of the state, yet very few confirmed instances of cyanobacteria blooms in inland lakes in that area, why is that?

A This is most likely because there are very few inland lakes in that region of the state. In the four main watersheds that make up most of that region of the state (Pigeon-Wiscoggin, Birch-Willow, Cass, and St. Clair), only

one inland lake was recorded as having a confirmed cyanobacteria bloom from 2016-2020. This is likely because there are only an estimated 111 waterbodies that are greater than five acres in those watersheds. To put that into perspective, those four watersheds cover a combined area of approximately 3,501 square miles, therefore the likelihood of a bloom occurring would be low, given the low number of lakes throughout that landscape. That said, it is noteworthy to mention that several instances of cyanobacteria blooms have been documented along Saginaw Bay, which is where two of those watersheds drain to.

Q There appears to be a high density of cyanobacteria blooms that have occurred in the Huron River watershed in the southeast part of the state, yet there are no CAFOs in it. Why is that?

A This is likely a result of both the high density of lakes within this watershed and the fact that the Huron River watershed is located in the most densely populated region of the state. The Huron River watershed has had 13 confirmed cyanobacteria blooms in its inland lakes recorded from 2016 through 2020. While 13 blooms seem like a lot, it is noteworthy to mention that there are approximately 462 inland lakes that are greater than 5 acres in that watershed. The Huron River watershed covers 909 square miles, meaning that it has a high density of lakes in it.

Given the high density of lakes and the large population of people living in that watershed, it is not surprising that cyanobacteria blooms have been reported in several of the lakes within it.

Q What is the likely cause of the blooms in that watershed?

A **Most likely it is because of residential fertilizer use, impervious surfaces, and septic systems. In the case of Ford and Belleville Lakes in the Huron River watershed, several municipalities upstream of those lakes are not complying with their wastewater treatment permit limitations based on the total maximum daily load for those waterbodies.**

Q In your opinion, what are the challenges for the Department with respect to CAFOs and water quality, specifically related to prevention of algae and cyanobacteria blooms?

A **Challenges for the Department with regard to CAFOs and water quality include application of manure waste either too close to surface water, or on fields with tile drainage, where the tiles convey run-off to surface water; manure applications onto soils that are already nutrient saturated, or are not well drained, which will result in waste run-off; manure applications onto bare soil with no vegetation to uptake any nutrients; applications onto frozen, or water saturated soils, that cannot absorb waste; and applications of manure onto snow that will neither be taken up by plants or infiltrate into the ground and may run-off the field and**

EXHIBIT 8

2:02 PM

OHIO SEA GRANT AND STONE LABORATORY

Toxic Algae, Undrinkable Water, and Dead Zones in Lake Erie: Understanding the Problems and Solutions

Dr. Jeffrey M. Reutter

Special Advisor, Ohio Sea Grant College Program

Sea Grant
Ohio Sea Grant College Program

The Ohio State University

NOAA

Stone Lab OSU's Island Campus

Blue-green Algae Bloom 1971, But I've Seen Worse (1956)

Photo: Forsythe and Reutter

Lake Erie: The Poster Child for Pollution Problems

- Cuyahoga River burns in 1969
- USEPA, NOAA, and 1st Earth Day in 1970
- Great Lakes Water Quality Agreement 1972
  - Provided P targets
  - Doesn't impact sewage treatment plants outside of Lake Erie watershed
- Clean Water Act in 1972
  - Gave us the tools to attack the problem
  - Concern—HR 861 would terminate USEPA

Impact of GLWQA and CWA

- Binational agreement on targets
- Binational strategy to reach the targets
- Would not have happened without USEPA & ECCC
- First discussion of Ecosystem Based Management
- Recognition that we can't manage Lake Erie from the middle of the Lake
- We have to manage Lake Erie from places like Findlay, Ohio, Fort Wayne, Indiana, and London, Ont.

What brought about the rebirth from dead lake to Walleye Capital?

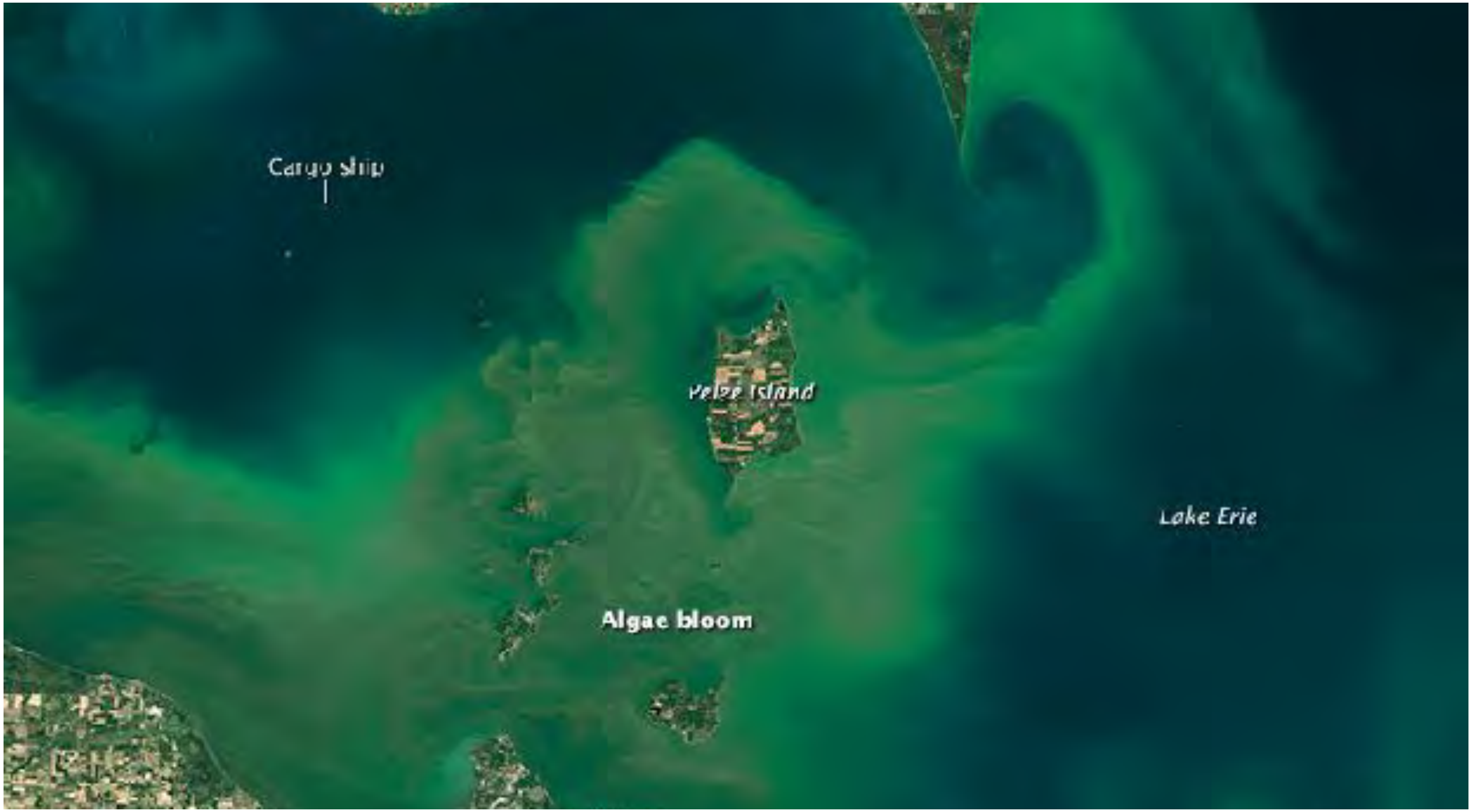
- 62% Phosphorus reduction (29,000 metric tons to 11,000)
  - New TP load for lake = <7,000 MT vs. 11,000
- In those days 2/3 of phosphorus from sewage treatment plants
- Today, more than 2/3 is non-point source loading from agriculture
- HABs are back
- Working on Domestic Action Plans

Photo: NOAA Satellite Image

Microcystis, Stone Lab, 9/20/13

2:02 PM

Western Basin HAB July 28, 2015



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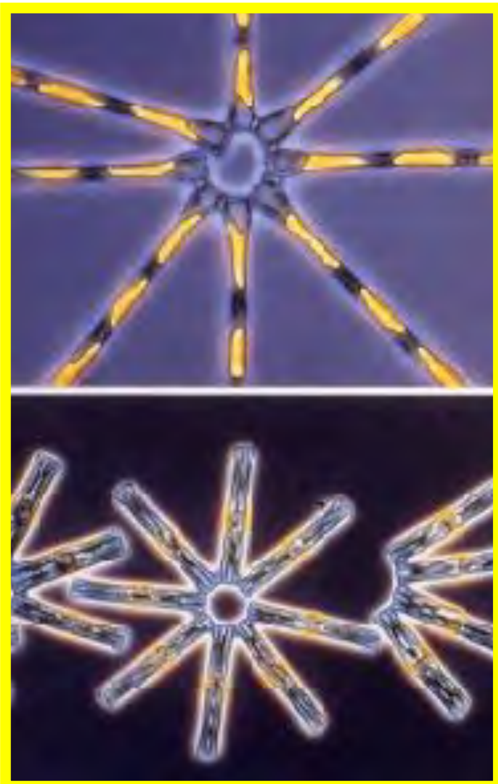
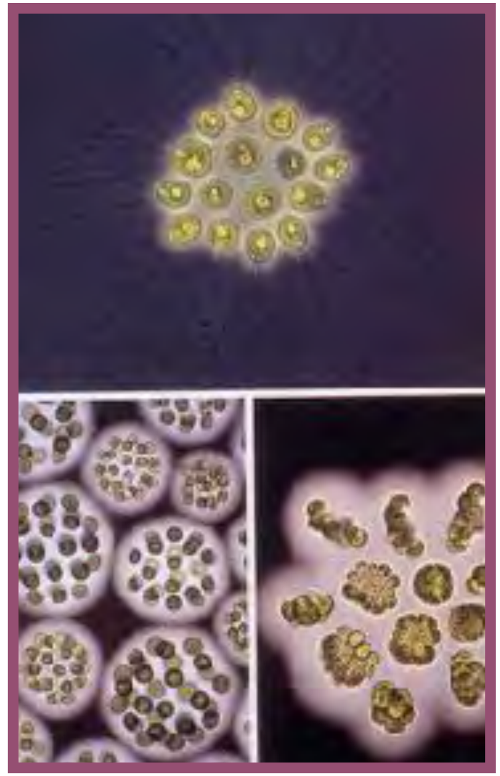
HAB Lake St. Clair July 28, 2015

Major groups/kinds in Lake Erie



Diatoms



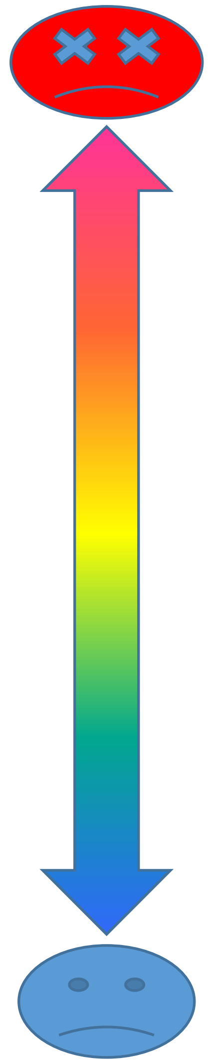
Greens

Source: Tom Bridgeman, UT

Blue-greens
(***Cyanobacteria***)

Toxicity of Algal Toxins Relative to Other Toxic Compounds found in Water

- Reference Dose = amount that can be ingested orally by a person, above which a toxic effect may occur, on a milligram per kilogram body weight per day basis.



Toxin Reference Doses

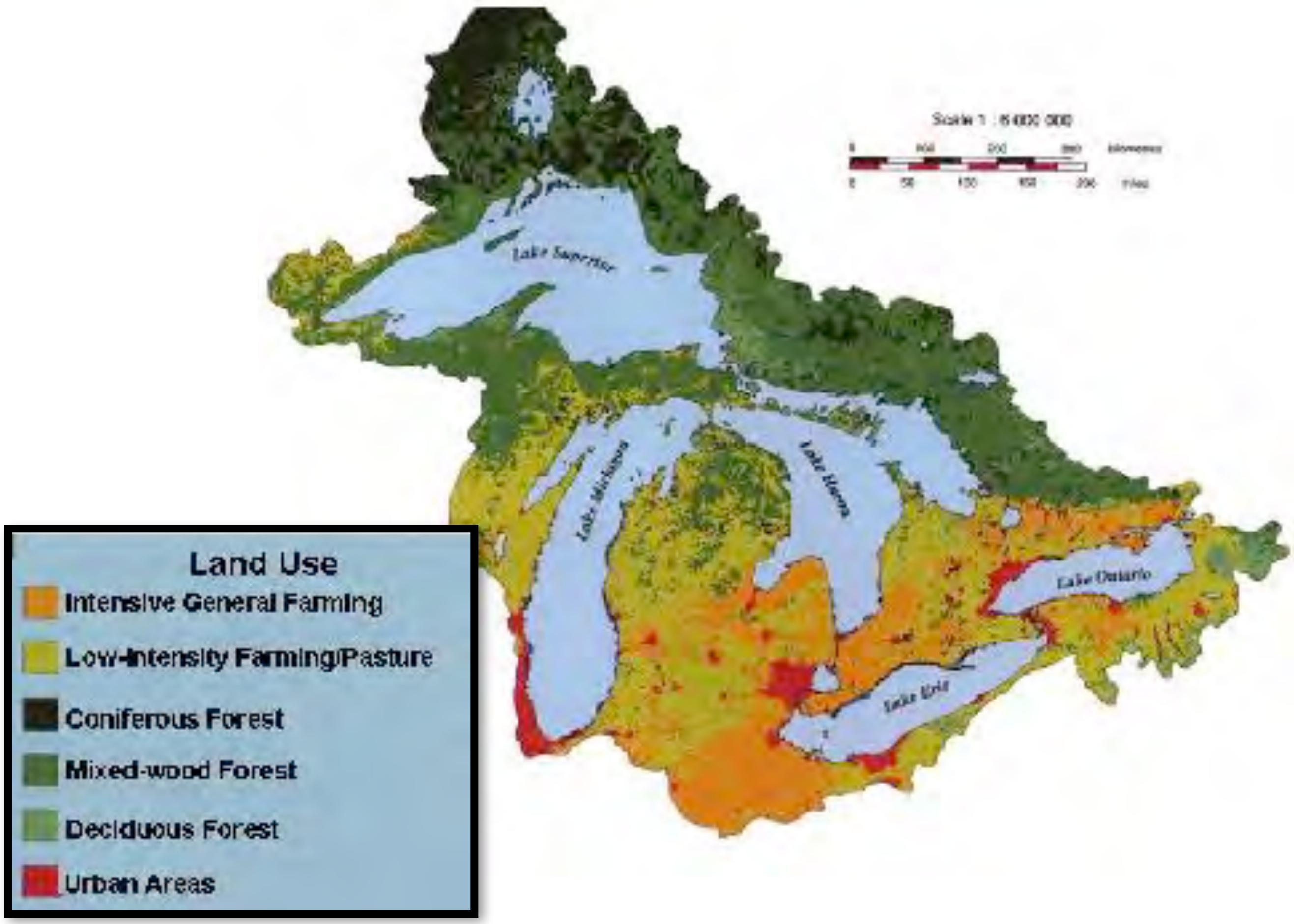
- Dioxin (0.000001 mg/kg-d
- Microcystin LR (0.000003 mg/kg-d)
- Saxitoxin (0.000005 mg/kg-d)
- PCBs (0.00002 mg/kg-d)
- Cylindrospermopsin (0.00003 mg/kg-d)
- Methylmercury (0.0001 mg/kg-d)
- Anatoxin-A (0.0005 mg/kg-d)
- DDT (0.0005 mg/kg-d)
- Selenium (0.005 mg/kg-d)
- Botulinum toxin A (0.001 mg/kg-d)
- Alachlor (0.01 mg/kg-d)
- Cyanide (0.02 mg/kg-d)
- Atrazine (0.04 mg/kg-d)
- Fluoride (0.06 mg/kg-d)
- Chlorine (0.1 mg/kg-d)
- Aluminum (1 mg/kg-d)
- Ethylene Glycol (2 mg/kg-d)

Cyanobacteria “Preferences”

- Warm water—above 60F
- High concentrations of nutrients
  - Particularly phosphorus (P)
  - If nitrogen (N) is low, some cyanos are capable of fixing their own from the air
  - Source of nutrients doesn’t matter
- Preferences tell us where to expect Cyanos anywhere in world
- Cyanos are capable of producing toxins
- 1 March to 31 July load determines size of HAB

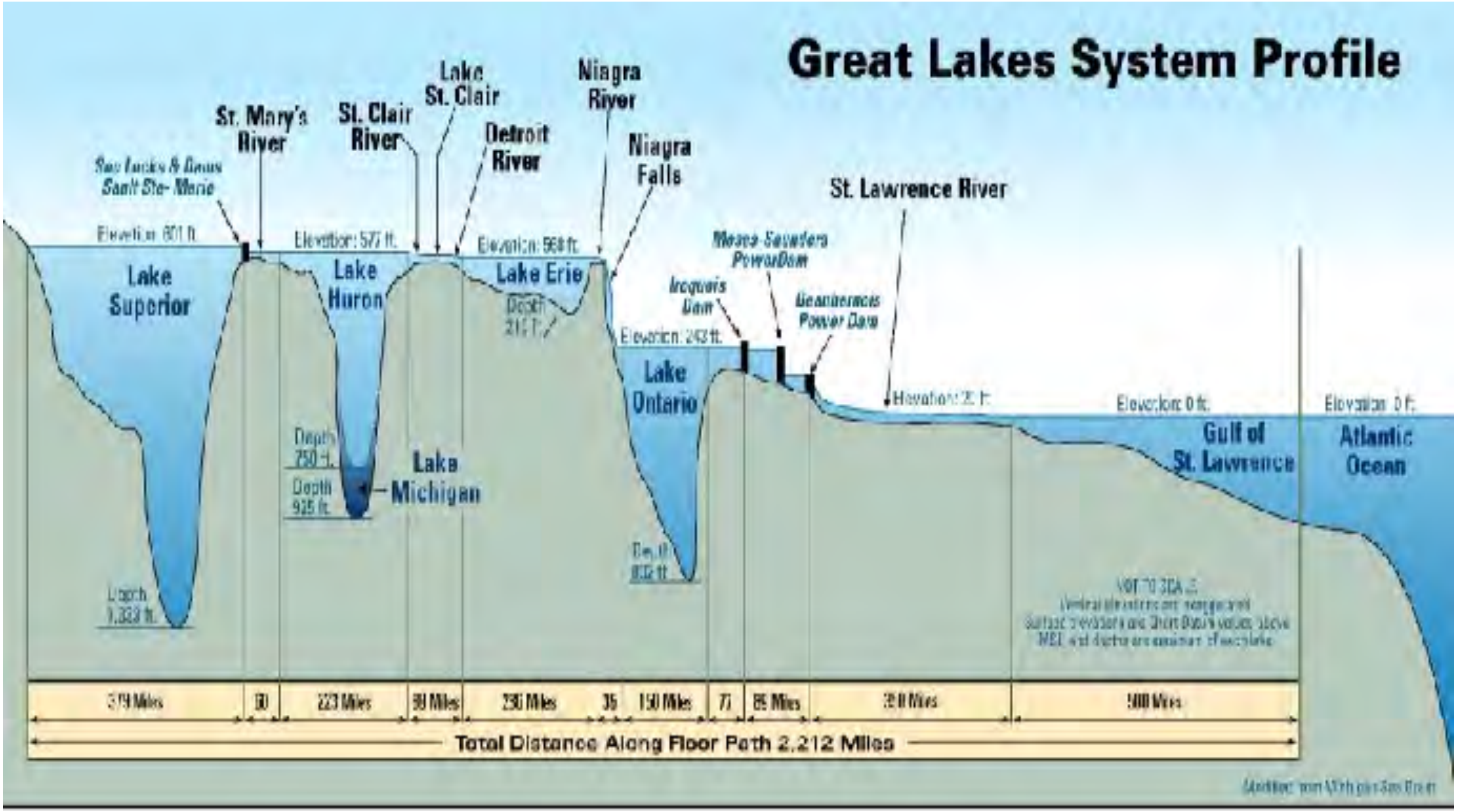
Lake Erie has always been at the forefront of the algae and nutrient problem. Why?

Southernmost



2:02 PM

Shallowest and Warmest



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Great Lakes Land Use Continued

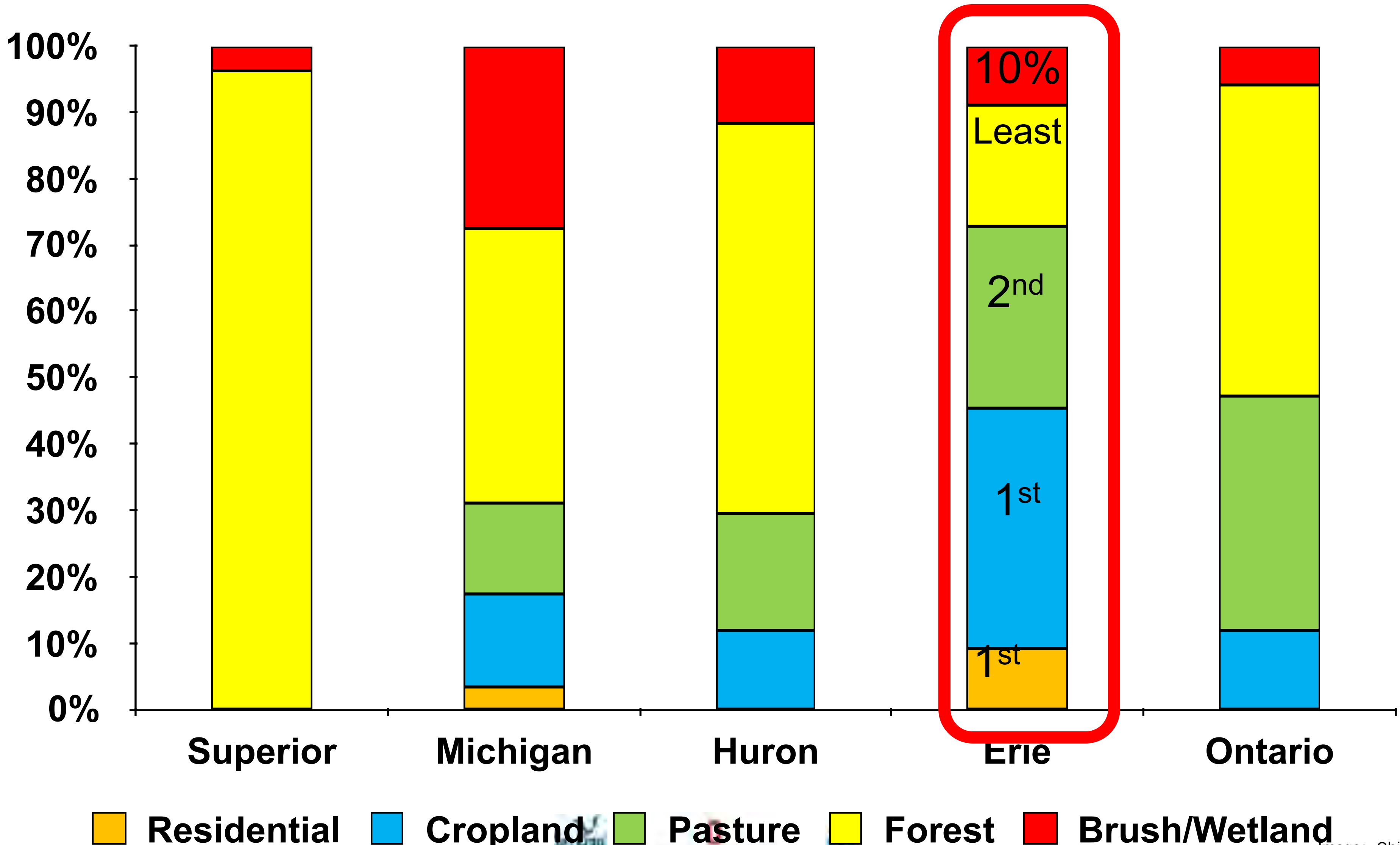


Image: Ohio Sea Grant

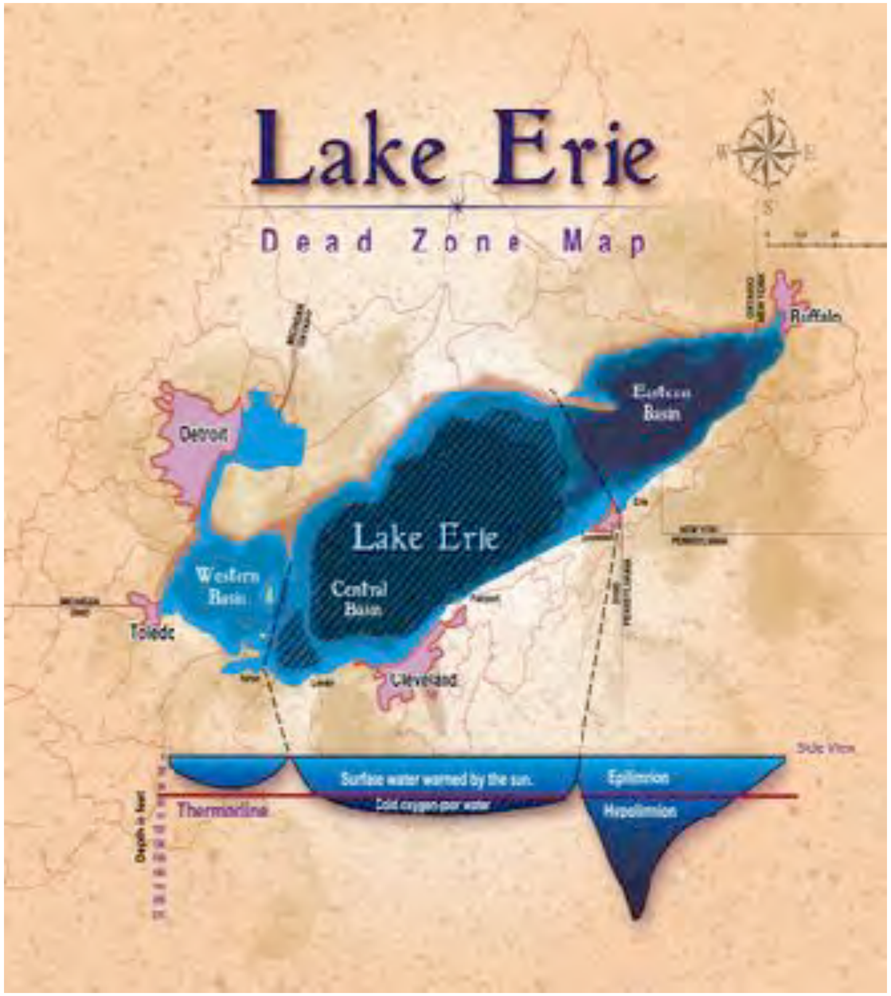
80:10:10 Rule

- 80% of water Detroit River from upper lakes
- 10% direct precipitation
- 10% from Lake Erie tributaries
  - Detroit & Niagara Rivers—connecting channels
  - Maumee
    - Largest tributary to Great Lakes
    - Drains 4.2 million acres of ag land
    - 3-4% of flow into Lake Erie

2:02 PM

Lake Erie Stats

- Lake Erie
  - 9,906 sq. miles
  - 11th in area 17th volume
  - 241 miles long 57 wide
- Western Basin
  - Ave. depth 24 ft.
  - 13% area, 5% volume
- Central Basin
  - Ave. depth 60 ft.
  - 63% area and volume
- Eastern Basin
  - Ave. 80 ft., Max 210 ft.
  - 24% area, 32% volume



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50:2 Rule

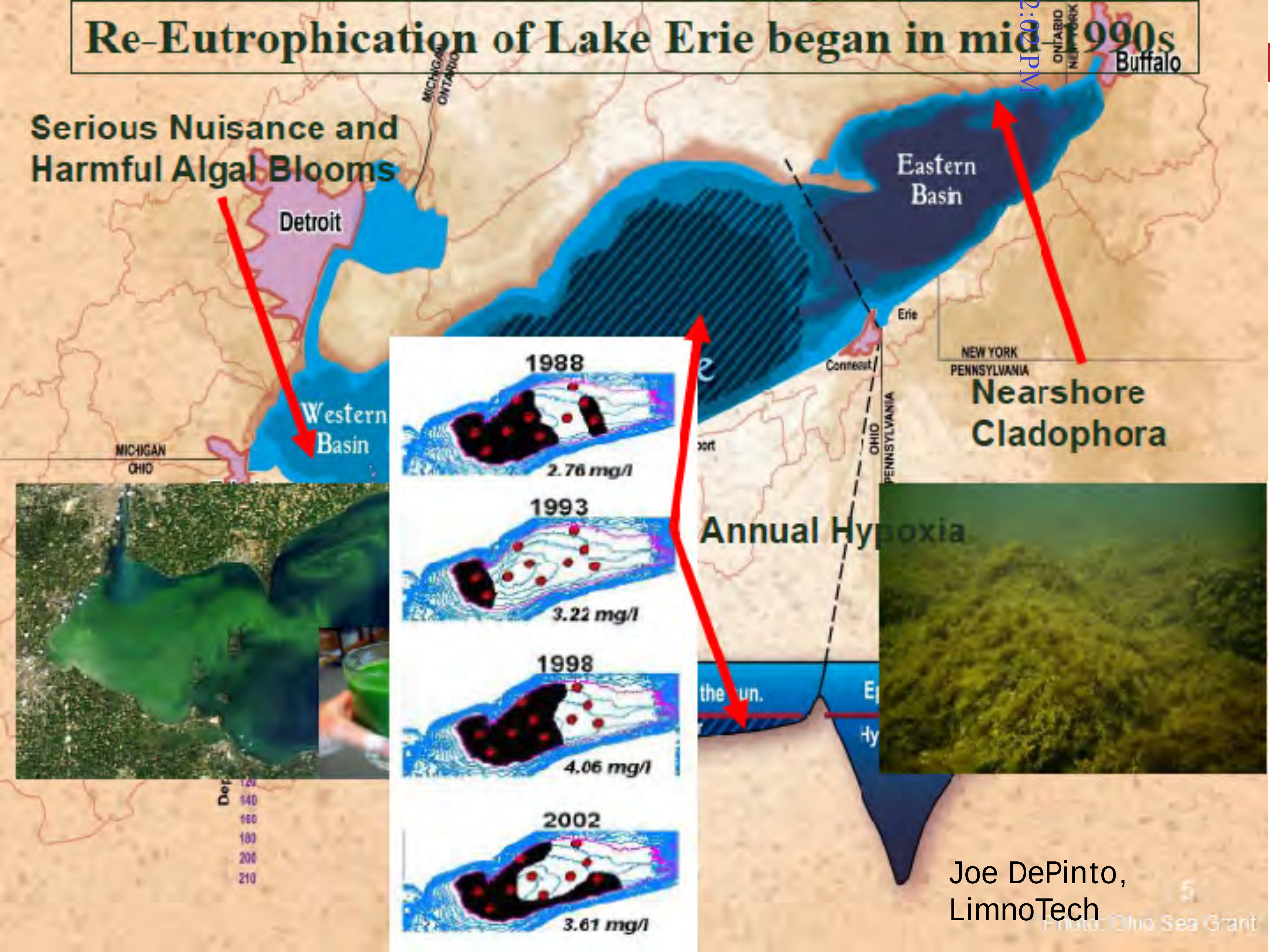
(Not exact, but instructive)

Lake Superior:

50% of the water and 2% of the fish

Lake Erie:

2% of the water and 50% of the fish


Re-Eutrophication of Lake Erie began in mid-1990s
Serious Nuisance and Harmful Algal Blooms
Detroit
Western Basin
MICHIGAN
OHIO
MICHIGAN
ONTARIO
Eastern Basin
Buffalo
ONTARIO
NEW YORK
Erie
Conneaut
NEW YORK
PENNSYLVANIA
OHIO
PENNSYLVANIA
Nearshore Cladophora
Annual Hypoxia
1988
2.76 mg/l
1993
3.22 mg/l
1998
4.06 mg/l
2002
3.61 mg/l
Joe DePinto, LimnoTech
Photo: Ohio Sea Grant
5

Why do we target phosphorus?

- Normally limiting nutrient in freshwater systems
- P reduction is best strategy ecologically and economically
- Reducing both P and N will help the most
  - Can solve problem by reducing only P
  - Nitrogen is more important than originally thought
  - Cannot solve it by reducing only N
  - Best solution is to reduce both

Nutrient Loading

- P discharges from sewage treatment plants vary little from year to year
- P discharges from ag tributaries vary greatly from year to year depending on rainfall
- Vast majority of P loading occurs during storm events

2:02 PM

Maumee River Basin Storm Runoff Statistics (1960-2010)

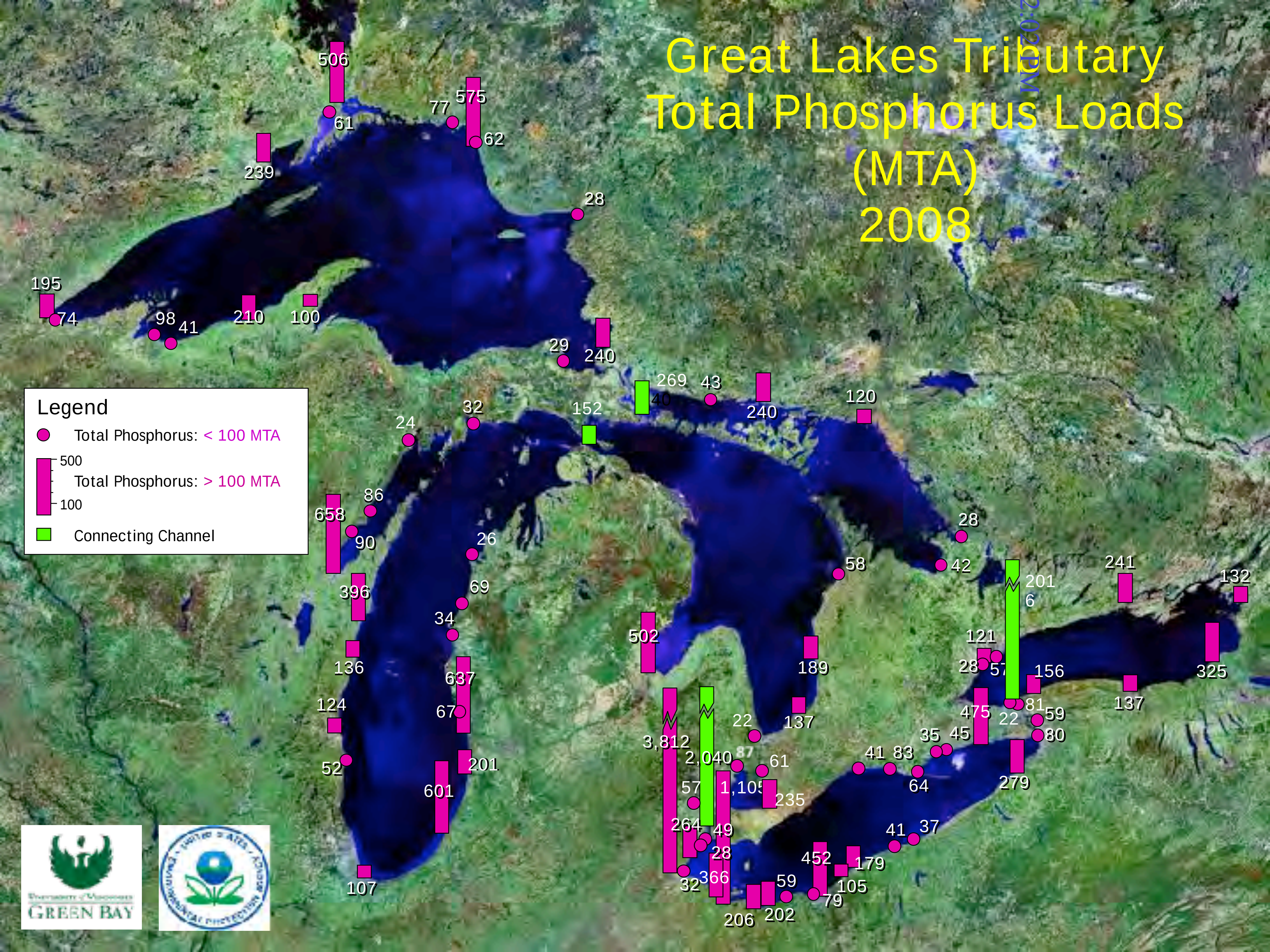
- Statistically significant increases in :
  - Number of storm runoff events per year (up 67%)
  - Number of spring runoff events (up 40%)
  - Number of winter runoff events (up 47%)
  - Annual storm discharge (up 53%)
  - Summer storm discharge (up 27%)

80-90% of loading occurs 10-20% of time

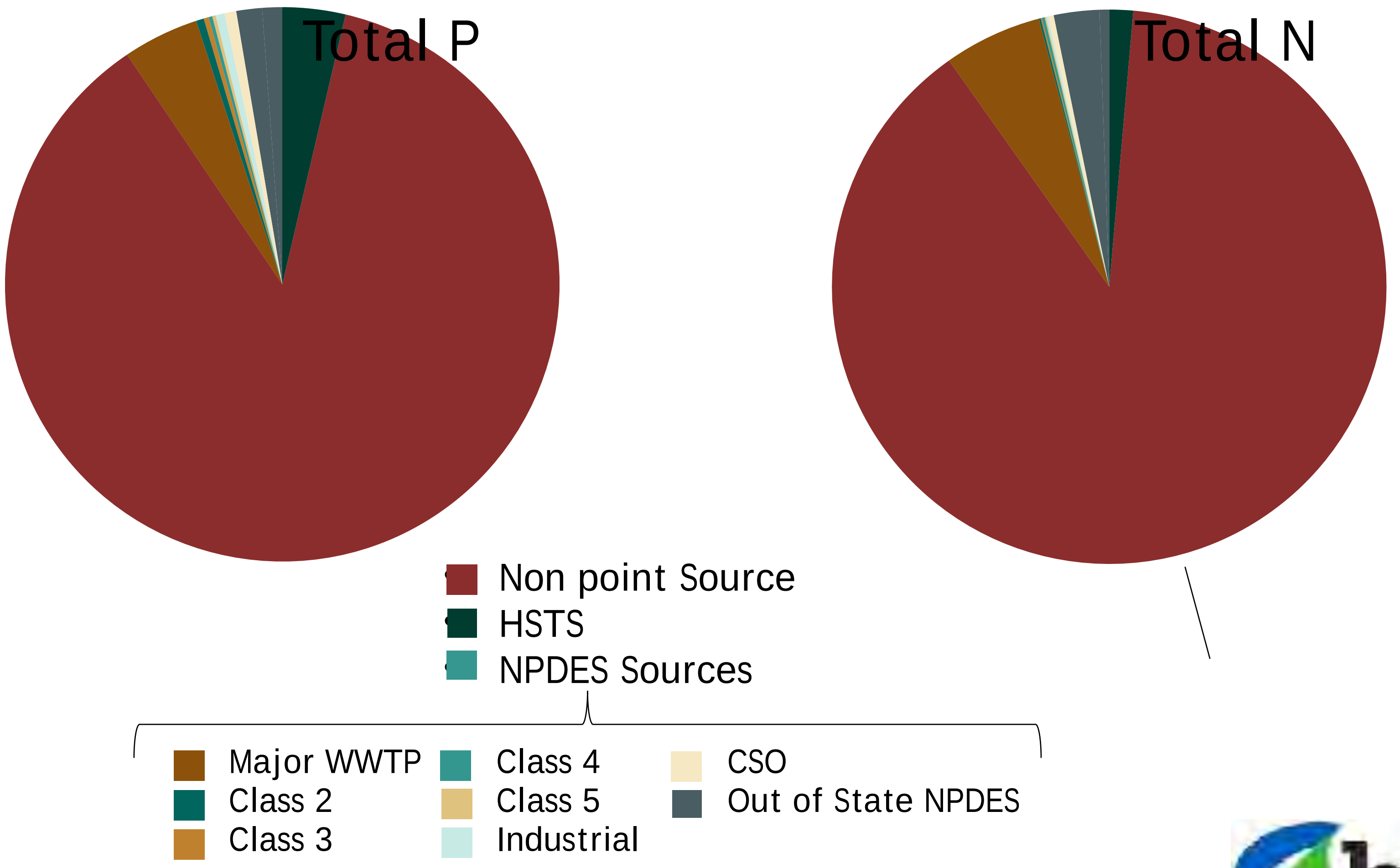
Source: Dr. Peter Richards, Heidelberg University

The Ohio State University

Sea Grant
Ohio Sea Grant College Program


Great Lakes Tributary
Total Phosphorus Loads
(MTA)
2008
Legend
Total Phosphorus: < 100 MTA
500
100
Total Phosphorus: > 100 MTA
Connecting Channel
506
61
77
575
62
239
28
195
74
98
41
210
100
29
240
269
40
43
240
120
152
32
24
86
658
90
26
69
396
34
136
637
67
124
201
52
601
107
502
189
137
22
3,812
2,040
87
61
57
1,105
235
264
49
28
32
366
206
202
59
452
179
105
79
41
37
41
83
64
35
45
475
22
279
28
42
58
201
6
121
28
57
156
81
59
80
241
132
325
137

wy13 Loading Breakdown - Maumee Watershed



Not all P is created equal

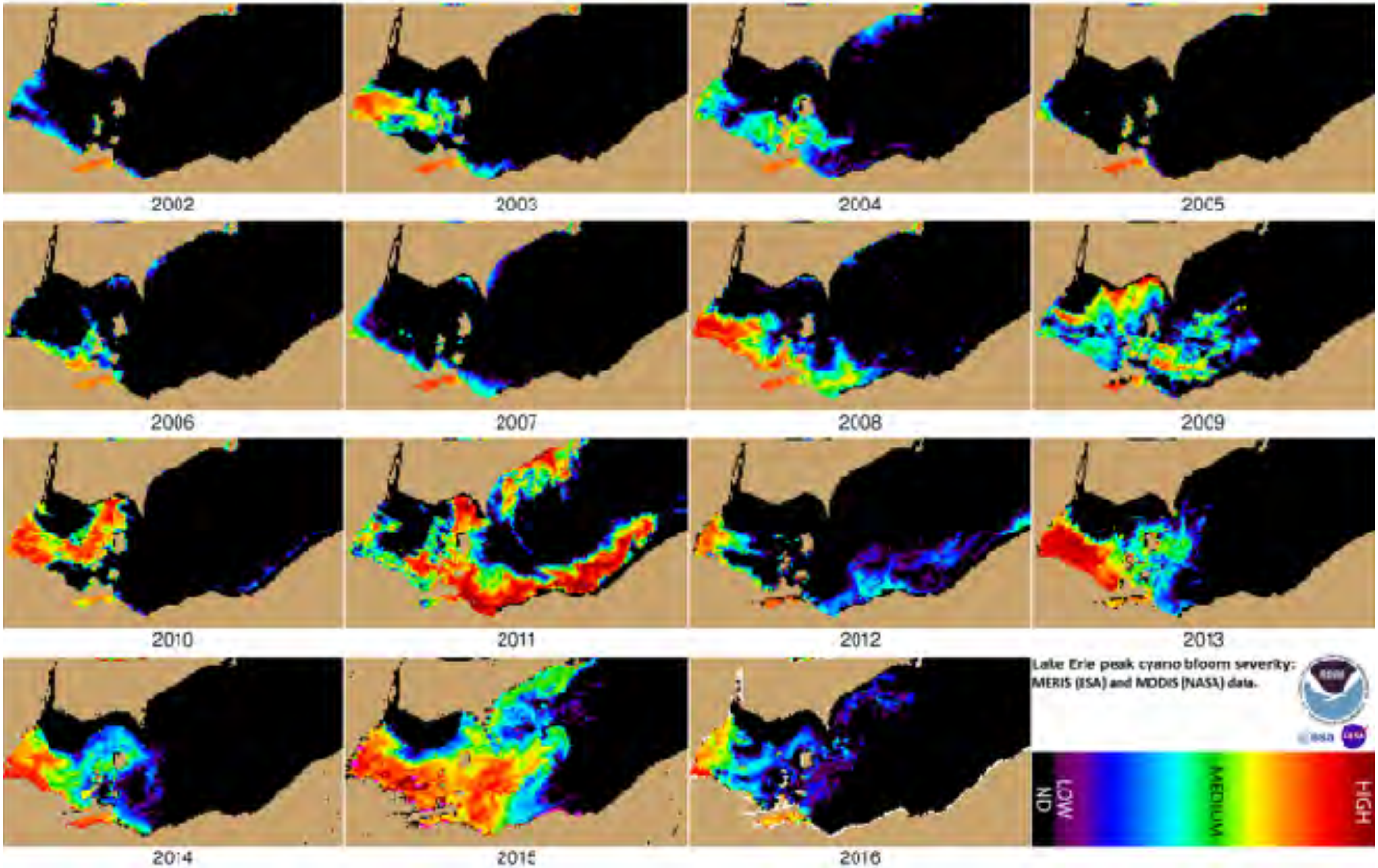
- Total P (TP) = particulate P (PP) and dissolved reactive P (DRP)
- PP is about 25% bioavailable
- DRP is 100% bioavailable
- <u>DRP load up ~150%!</u>
- Most BMPs have focused on PP (stopping erosion)
- Removing 1 ton of DRP = removing 4 tons of PP

2:02 PM

LAKE ERIE AND LAKE ST. CLAIR— 3/8/17

2:02 PM

HABs 2002-16



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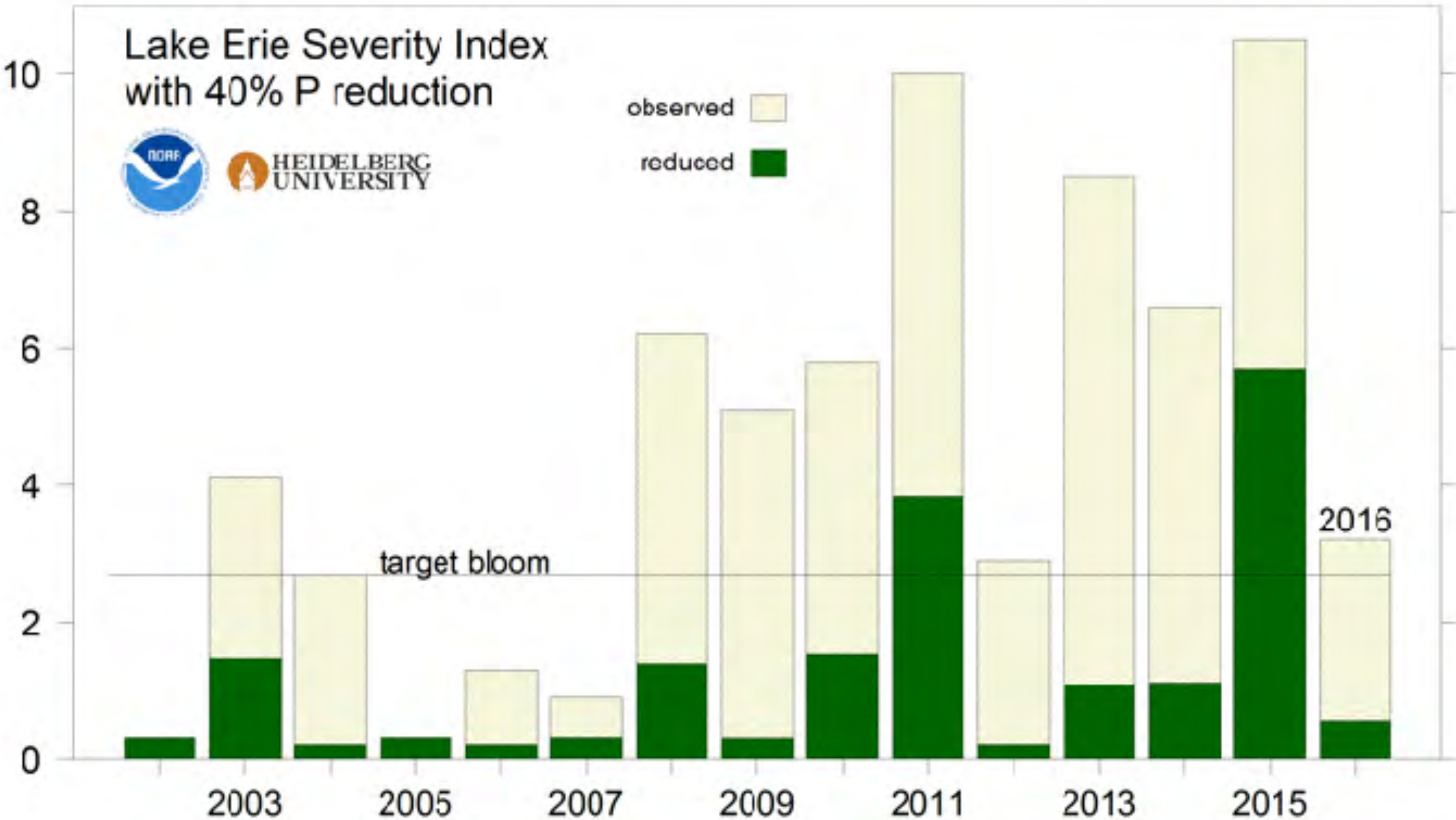
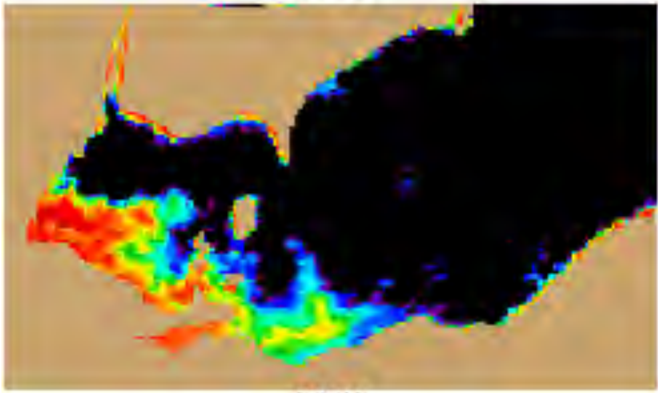
GLWQA Annex 4 (Nutrients) Charge to Objectives and Targets Task Team

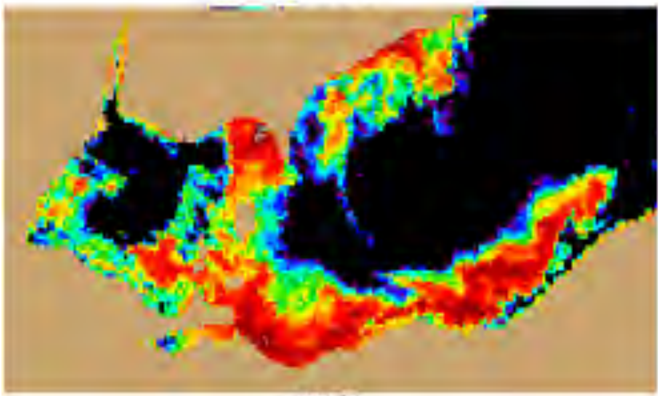
- Provide science-based recommendations to address:
  - HABs—primarily Western Basin problem
  - Hypoxia—Central Basin problem
  - Cladophora—primarily an Eastern Basin north shore problem—NO TARGET YET
- Adaptive management approach
- TT identified 14 Priority tributaries
- 40% spring P reduction for HABs
  - Goal: Blooms like 2012 or smaller 90% of time
- 40% annual reduction for hypoxia
  - Goal: Average hypolimnetic DO above 2.0 mg/l


Lake Erie Severity Index
with 40% P reduction
HEIDELBERG UNIVERSITY
observed
reduced
target bloom
2016
0
2
4
6
8
10
2003
2005
2007
2009
2011
2013
2015



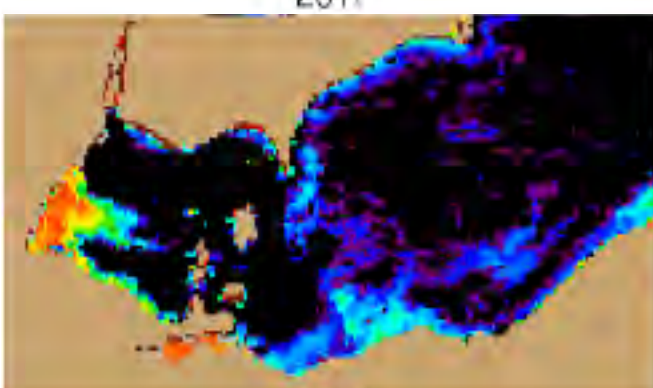
2008

Ann. discharge = 8.0 billion m^3
Spring discharge = 3.4 billion m^3
Ann. P load = 3,800 tonnes
Spring P load = 1,400 tonnes



2011

Ann. discharge = 6.2 billion m^3
Spring discharge = 5.0 billion m^3
Ann. P load = 3,100 tonnes
Spring P load = 2,300 tonnes



2012

Ann. discharge = 6.1 billion m^3
Spring discharge = 1.0 billion m^3
Ann. P load = 2,500 tonnes
Spring P load = 400 tonnes

Understanding Central Basin Issues

- Volume of water in hypolimnion is very important
  - Lake morphometry and water level
  - May be as important and P and C loading
  - Evidence that it has always had episodes of anoxia
- Changes that occur when hypo becomes anoxic
  - Oxidizing to reducing environment
  - Anaerobic bacteria—methane released to atmosphere
  - Sedimented P redissolves in water
  - Internal P loading is more important than in WB
  - Heavy metals dissolve in water
  - Taste and odor problems at water treatment plants
  - HABs now occurring annually
- Understanding material transport between basins
- Less data available than in WB

Conclusions and Recent Findings—1

- Maumee: 55% of farms <50 acres, but represent 3% of acres
- DRP dissolves in water and comes out drain tiles
- P loss directly related to amount of P on field
- P concentration coming out of tiles meets targets when soil test P is not above crop needs
- Can't apply multiple years of P at one time and bank it
- Legacy P from fields with too much P is big part of problem
- Blind inlets & managing flow from tiles will help
- Up to 60% reduction in P loss when incorporated
- 42% of acres responsible for 78% of P & sediment loss
- 42% of acres apply P above removal rates
- 1% of acres account for 40+% of sediment loss
- 1/3 of farmers not likely to take needed action without more aggressive encouragement

Conclusions and Recent Findings—2

- Total elimination of all point sources reduces P load by very small amount
- Ag load from Maumee is about 85% of total
- Manure and commercial fertilizer same when not over applied, but manure is more likely to be over applied
- Models show that it is possible to achieve a 40% reduction
  - Requires extensive changes
  - Not likely to be accomplished voluntarily
  - Will require identification of problem fields
- My opinion of what is needed:
  - More voluntary actions by farmers
  - More targeted incentives for farmers
  - More common sense regulations
    - For example: Ohio Senate Bills 150 and 1
    - Follow the 4R’s for fertilizer and manure: Right time, amount, place, & form—Why optional?

Needs and Opportunities

- Accurate info about what is happening on each ag field
- Accurate loads from connecting channels & atmosphere
- Annual soil test P and nutrients for each field
- Monitoring around animal operations
- BMPs for DRP
- Tributary transport models for 14 priority watersheds
- Ag incentives that create permanent changes
- Phosphorus and toxin probes
- Funding for long-term monitoring
- Daily trib P&N monitoring linked to ag actions
- More info on algal toxins, impacts, and safety levels
- Transfer what we learn on Lake Erie to other Great Lakes, US, and world
- Expand Western Basin Ecosystem Model to CB & Lake

Ideas for Cities and Individuals

- Sewage treatment plants—GLWQA target 0.5 mg/l of P
- Reduce CSO's
- Stormwater management
- Reduce consumption and runoff—Low-flow toilets and shower heads, rain barrels and rain gardens
- No P in lawn fertilizers
- Septic tanks
- Cleaners and detergents—Low P and use recommended amount
- Advocacy, education, and outreach
- Citizen Science, new ideas, out-of-box thinking
- Climate change—Warmer and more frequent storms
  - Solar panels, solar thermal, reduce power consumption

The Battles of Lake Erie

We Should Care!!! Environment vs. Economy

- Lake Erie is living proof that it is not either/or.
- We don't have to make a choice between a clean environment or jobs.
- You can have both!

Impact of the Second Battle of Lake Erie

- Charter Fishing Businesses: 34 to over 1200
- Coastal businesses: 207 to over 425
- Walleye harvest: 112,000 to over 5 million
- Lake Erie becomes the "Walleye Capital of the World" and the best example of ecosystem recovery in the world.
- Tourism in the 8 Ohio Counties bordering Lake Erie currently employs over 120,000 people and is valued at more than $13 billion.

Impact of the Third Battle of Lake Erie

- 2002 HABs observed from satellites
- October 2011, HABs cover the water intakes of 2.8 million people
- 2012: Multiple blooms occur in the Central Basin
- September 2013, 2000+ people in Carroll Township told not to drink their water.
- August 2014: 400,000+ people in Toledo told not to drink their water.
- A number of health impacts reported statewide.
- A number of dogs killed.
- Charter fishing down 25% and many businesses close.
- What are you going to do about it? HB 861?

Thoughts and Challenges for the Future

- Scientists must help public understand science
- Goal: convey truth not impress audience
- You are not important—your message is!
- Style: simplicity, informality, and specificity
- Ecclesiastes 6:11 "The more the words, the less the meaning, and how does that profit anyone."
- Reach people before they have made a decision
- Mark Twain: "It is easier to fool someone than to convince them they have been fooled."
- All can have opinions, but expertise really maters!
- Making fun of people only makes them dig their heels in. Be a good expert!

For more information:
Dr. Jeff Reutter, Special Advisor

Ohio Sea Grant and
Stone Lab
Ohio State Univ.
1314 Kinnear Rd.
Col, OH 43212
614-292-8949
Reutter.1@osu.edu
ohioseagrant.osu.edu

Stone Laboratory
Ohio State Univ.
Box 119
Put-in-Bay, OH
43456
614-247-6500

EXHIBIT 9

January 2022

Molecular Detection Of Cyanobacteria In Local Drinking Water

Andrew Aman James
Wayne State University

MOLECULAR DETECTION OF CYANOBACTERIA IN LOCAL DRINKING WATER

by

ANDREW A. JAMES

THESIS

Submitted to the Graduate School

of Wayne State University,

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____

Advisor Date

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Chapter 1: Introduction

Cyanobacteria is also known as blue-green algae due to its capability of performing plantlike photosynthesis and is a key producer in the phytoplankton community. Conversely, the intracellular makeup of the cyanobacteria cell closely resembles those of bacterial cells such as having no membrane-bound organelles and lacking nucleus. Furthermore, cellular wall structure of cyanobacteria contains peptidoglycans and protein synthesis occurs in the same manner as prokaryotes (Mur et al., 1999; Castenholz, 2001).

Cyanobacteria can be unicellular or multicellular organisms. The cellular compartments are unique as they can perform photosynthesis and respiration. As photosynthetic electron transport occurs within the thylakoids, respiration electron exchange is simultaneously occurring between thylakoids and cytoplasmic membranes system (Fj, 2001). Certain cyanobacteria have specialized cells known as heterocyst. Heterocyst anaerobically converts atmospheric N_2 into a usable form, accomplished by the enzyme complex nitrogenase (nitrogen reductase). Thus, becoming the source of nutrients to neighboring cells in the absence of light or free CO_2 within water bodies (Kumar et al., 2010; Paerl, 1997).

Cyanobacteria are morphologically diverse, oxygenic photosynthetic, gram-negative bacteria that have a significant contribution towards life on earth. Cyanobacterial lineage can be predated to the Precambrian era evident in fossil records and throughout their extensive evolutionary history, these micro-organisms continue to exist as fundamental to global carbon and nitrogen fixation for supplying atmospheric oxygen (Schopf 2000; Shih et al., 2013). The rich phylum diversity of cyanobacteria panoply reveals exceptional adaptive strategy leading to dominance within the phytoplankton community (Soo et al., 2019).

Keen adaptivity to changes influenced by natural and anthropogenic influences allows cyanobacteria to exploit various elemental conditions within terrestrial and aquatic settings and thrive in scarce and abundant nutrient environments throughout the world (Paerl et al., 2001). Moreover, to date cyanobacteria continues to demonstrate adaptability allowing it to proliferate within most ecological niches making them ubiquitous in nature and notably aquatic environments. Cyanobacteria is found inhabiting various aquatic ecological systems, often found attached to sediments, on surface water or freely floating within freshwater, brackish, and marine water bodies (Uyeda et al., 2016; Paerl et al., 2001).

Cyanobacteria can grow in varying temperatures, pH, light exposure and are tolerant to arid conditions. Furthermore, modest survival requirements such as CO_2, H_2O, and inorganic nutrients (N and P) permits cyanobacteria to be thrive in the abundance and scarcity of nutrients. Cyanobacteria tend to dominate over other phytoplankton organisms within the same environmental setting (Whitton and Potts, 2000). In favorable conditions, cyanobacteria can proliferate at an accelerated rate leading to the formation of blooms. Cyanobacterial blooms can also be potentially harmful and concerning due to the negative impact on recreational water bodies, threatening the biodiversity of aquatic ecology and disrupting marine food webs. Moreover, blooms can have an adverse effect on drinking water and recreational water sources (Rastogi et al., 2015).

1.1 Cyanobacteria Blooms

Cyanobacteria can exploit the anthropogenic impact on hydrology resulting in optimal proliferation and rapid aggregation. The accelerated accumulation of biomass results in bloom formation, which is visible spreading across water surfaces due to the varying pigmentation of cyanobacteria (Dittmann & Wiegand, 2006). Changes relating to eutrophication have been

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observed in many ecosystems including temperate, boreal, and both subtropical, and tropical aquatic settings (Auer and Arndt 2004). In recent decades, research has implicated eutrophication, accompanied by elevating CO_2 level and climate changes, as major contributors towards intensifying the frequency and longevity of cyanobacterial bloom (Pearl & Otten, 2013). Moreover, cyanobacterial blooms are of concern as they can be harmful to aquatic ecology and other environments. They also pose a potential threat to freshwater supplies including drinking water and recreational water. Cyanobacterial blooms alter water clarity, thus, impeding the source of light required for aquatic macrophytes and organisms. This negatively impacts invertebrates, fish, and other marine life that are dependent on light for survival. In addition, senescing cyanobacterial blooms can create an oxygen scarce environment ultimately proving fatal for fish and grazers due hypoxic or anoxic conditions (Carmichael et al., 2001,). Most concerning are toxic cyanobacterial blooms that cause spoilage of freshwater ecology and drinking water supplies across the globe (Huisman et al. 2018).

The increase in phytoplankton biomass resulting from eutrophication influences organism diversity and leads to cyanobacteria dominance. Anthropogenic disturbances inducing eutrophication intensifies bloom formation creating a richly diverse cyanobacterial community which consists of toxic and non-toxic cyanobacteria genotypes. Cyanobacterial bloom can consist of only a single genus or an assortment of cyanobacterial species belonging to various genera can coexist within a single bloom. Species belonging to varied cyanobacteria genotypes can reside within a single bloom, with select species producing toxins while others do not. However, not all incidences of cyanobacterial blooms result in toxic blooms. Certain cyanobacteria produce secondary metabolites known as cyanotoxins. Cyanotoxin production by some cyanobacterial species is contingent on meeting several growth and environmental factors that are not well defined. Cyanobacterial species growth and biosynthesis of their cyanotoxin is based upon specific environmental factors such ultraviolet radiation, salinity, pH, nutrients, pollution, and other elemental factors. In addition, toxin production can also occur concurrently with the scarcity of nutrients, light exposure, warmth, and O_2 (Boopathi & Ki, 2014b; Neilan et al., 2013).Toxic cyanobacterial blooms are increasing in prevalence, contaminating drinking water supplies across the globe and have been known to cause illness, injury or death in livestock, wild and domestic animals, and humans (Huisman et al. 2018).

There are several (toxic) genera of cyanobacteria that are recognized as bloom-forming including *Nodularia, Microcystis, Anabaena, Planktothrix (*formally known as *Oscillatoria)*, *Aphanizonmenon* have been previously documented (Huisman et al., 2018). Furthermore, case studies have indicated that due to the rising temperature of freshwater ecosystems brought upon by global warming, the proliferation of harmful blooms belonging to toxic cyanobacterial species far exceed those of the non-harmful algal blooms observed globally (Vepritskii et al., 1991; Berry et al., 2008). For instance, toxic *Microcystis species* blooms caused massive disruption in large lakes and impacting drinking water supplies of large cities in the world (Qin et al. 2010, Steffen et al. 2017). Lake Taihu in China experienced a significant rise in nutrient load due to agriculture run offs, industrial waste, and wastewater treatment facilities depositing into lake tributaries. These conditions precipitated an exponential expansion of cyanobacterial blooms during late spring of 2007 causing the city of Wuxi residents to temporarily lose access to drinking water (Qin et al., 2010). In the USA, the Great Lakes represent approximately 18% of the world's freshwater. Lake Erie's waters are impacted by agriculture, industrial and urban waste, allowing cyanobacterial blooms to proliferate and expand. In 2011, a wet spring resulted in major industrial runoff, followed by warm summer conditions, led to record-breaking cyanobacterial blooms expansion of approximately 3100mi^2 (Michalak et al., 2013). In 2014, the city of Toledo, Ohio issued a 'do not drink' advisory because of elevated levels of microcystin which left over 400 000 residents without access to potable water for approximately two days (Bullerjahn et al. 2016). A fatal event occurred as a result of toxic cyanobacteria bloom in February of 1996 in Caruaru, Brazil. Untreated water from a local reservoir was used for hemodialysis on 131 patients. All patients displayed neurological and hepatic symptoms following treatment. Sadly, half of the patients that received dialysis with the untreated water died shortly afterwards. After a thorough investigation, laboratories determined that serum, dialysis filters, and treatment-water were all contaminated with microcystins leading to severe liver injury and death (Pouria et al. 1998)

1.2 Cyanotoxin

Cyanobacteria secondary toxic compounds known as cyanotoxin that are potentially harmful to humans and wildlife. Studies have demonstrated that biosynthesis of toxins belonging to various cyanobacteria are influenced by multiple factors including pH, light exposure, water temperature, and nutrient loads (Neilan et al., 2013; Häder et al., 2014; Rastogi et al., 2014). Cyanotoxins can be divided chemically into three major categories: cyclic peptides, alkaloids, and lipopolysaccharides. However, biologically, cyanotoxins are classified by their pathophysiological effects and are divided into five major groups including hepatotoxins, neurotoxins, cytotoxins, dermatoxins and irritant toxins (Sivonen and Jones, 1999; Codd et al., 2005).

The most investigated and researched cyanotoxin produced by cyanobacteria is microcystin. Microcystin are bulky, non-ribosomal cyclic heptapeptides biosynthesized by *Microcystis spp.* and other known cyanobacteria including *Oscillatoria, Anabaena and Nostoc, Planktothrix* (Nishizawa et al., 2000; (Hisbergues et al., 2003). Microcystins are known as hepatotoxins as their main target for insult is the liver. Microcystin are powerful inhibitors of protein phosphatases 1 and 2A causing phosphorylated protein to remain within the liver cells. Inhibition of phosphatases dysregulate essential cellular processes, affects cytoskeletal arrangement, impacting cell viability, and ultimately leading to necrosis or cellular death, (Zeng et al., 2015, Komatsu et al., 2007, Kaur, 2019).

Anatoxin-a is a potent and fast-acting neurotoxin produced by numerous cyanobacteria genera such as *Anabaena, Aphanizomenon, Planktothrix, Oscillatoria, Nostoc* and a few others (Buratti et al., 2017). Anatoxin exposure is caused primarily by consuming contaminated water. However, exposure can ensue from exposure to recreational waters (lakes, rivers) as well as contaminated dietary supplements (Osswald et al., 2007). Anatoxin-a is a bicyclic alkaloid amine. Biosynthesis of the toxin involves a cascade of several enzymes encoded by anatoxin-a synthetase genes (Rantala-Ylinen et al., 2011). Anatoxin toxicity stems from interacting with neuronal nicotinic acetylcholine receptors, disrupting signal transmission between neurons and muscles, and acting as a nicotinic agonist (Méjean et al., 2014; Wards et al., 1977). Consequently, excessive neuromuscular stimulus leads to death by respiratory arrest (Méjean et al., 2009).

1.3 Cyanobacteria and Cyanotoxin Detection

The rise of cyanobacterial blooms in freshwater within recent years became a major concern, with their growth attributed to eutrophication, climate change, and nutrient load. The occurrence of harmful blooms harboring species capable of cyanotoxin biosynthesis is increasingly reported. Contamination of freshwater supplies due to cyanotoxins threatens the health of surrounding human, animal, and aquatic communities (Malazarte et al., 2017). Therefore, testing for harmful cyanobacterial bloom and cyanotoxins becomes imperative for detecting and preventing outbreaks.

Microscopy was utilized for many decades to determine cyanobacteria's presence in water. However visual verification of cyanobacteria has some limitations. Microscopy is useful in determining and differentiating cyanobacteria morphologically but falls short in elucidating whether blooms are toxic or nontoxic. Cyanotoxin testing is commercially available employing enzyme-linked immunosorbent assays (ELISA) but there are some concerns due to low sensitivity (Mathys, W., & Surholt, B. 2004). Inconsistent findings due to cross-reactivity of endogenous compounds sharing similarities with target analytes may at rare occasions provide false negatives (Brown et al., 2018). Analytical methodology such as HPLC and/or LC-MS have high accuracy in detecting and quantifying cyanotoxin but are unable to identify the toxin producing cyanobacteria. Although such assays are robust, they require skilled operators, intricate protocols, and expensive instrumentation; thus, making analytical methods less affordable (Robillot et al., 2000; Shamsollahi et al., 2015).

The identification of toxigenic cyanobacteria genera in freshwater bodies is crucial when it comes to monitoring and detecting cyanotoxin contamination. Hisbergues et al. 2003 successfully showed that using molecular approach such as PCR, the identification of different cyanobacteria genera capable of producing microcystin genotypes can be efficiently achieved. Numerous studies have shown the effectiveness of PCR methodology in identifying genetic markers for 16S rRNA bacterial genes conserved for cyanobacteria, detecting cyanotoxins synthetase genes and using genus specific gene primers to differentiate potential toxin producing cyanobacteria (Bukowska et al., 2014; Ostermaier & Kurmayer, 2009; Sipari et al., 2010; Tillett et al., 2001). Previous studies successfully utilized PCR to detect of toxic and nontoxic cyanobacteria and quantify potential toxin gene expression in lakes, rivers, and freshwater ecosystems (Ostermaier & Kurmayer, 2009; Rinta-Kanto et al., 2005; Yuan & Yoon, 2021).

Molecular methodology such as polymerase chain reaction (PCR) and quantitative PCR use DNA and RNA (ribonucleic acid) based techniques to detect the presence of toxin producing cyanobacterial species and the toxin biosynthesis genes (Yuan & Yoon, 2022).

Chapter 2: Aims of the Study

In this study, by utilizing conventional polymerase chain reaction, PCR, tap/drinking water obtained from residential addresses in Adrian, MI was analyzed for the presence of the genus, *Microcystis,* using designated gene primers within the conserved region of bacterial 16S rDNA gene (Rinta-Kanto et al., 2005). Sample collections were also analyzed for the presence of the toxin synthetase genes, microcystin and anatoxin-a. To detect the presence of microcystin biosynthesis gene, conventional PCR was used to amplify the primer pair *mcyA-Cd1* which encodes the condensation region of the microcystin synthetase gene cluster for all microcystin toxin producing cyanobacteria (Hisbergues et al., 2003). For anatoxin-a synthetase gene, primer pair amplifying a section of *anaC-gen*, encoding a gene fragment within the anatoxin gene cluster belonging to all anatoxin producing cyanobacteria (Rantala-Ylinen et al. 2011).

Chapter 3: Methodology

3.1 Sampling site and Collection

Participants for the study were recruited on volunteer bases and had to submitted a signed consent for residential water to be analyzed. A total of 25 water samples and 33 water samples for analysis were collected on June 22, 2019, and September 12, 2019, respectively, from the city of Adrian, Michigan (Figure 1.a). Water samples were obtained from residential addresses of participating homeowners and two field samples were acquired from environmental locations, Turner Drain and Wolfe Creek (Figures 1c-d and 1e-f). Environment sample site were included as they drain from fresh water supply into man-made lake, Adrian Lake, which serve as the source for residential water. Samples were collected in 1.0-liter FDA compliant clear cylinder bottles with caps (ULINE, WI, USA). For residential water samples (figure 1.b, approximately 1 liter of tap water was collected at the start of cold-water flow from sink faucets located in homeowner's kitchen. Field sample collection bottles were submerged 5cm - 10cm surface water until water level reached the neck of the bottle. All samples were capped immediately after each individual collection. Collection bottles containing samples were placed in iced coolers and transported to the laboratory.

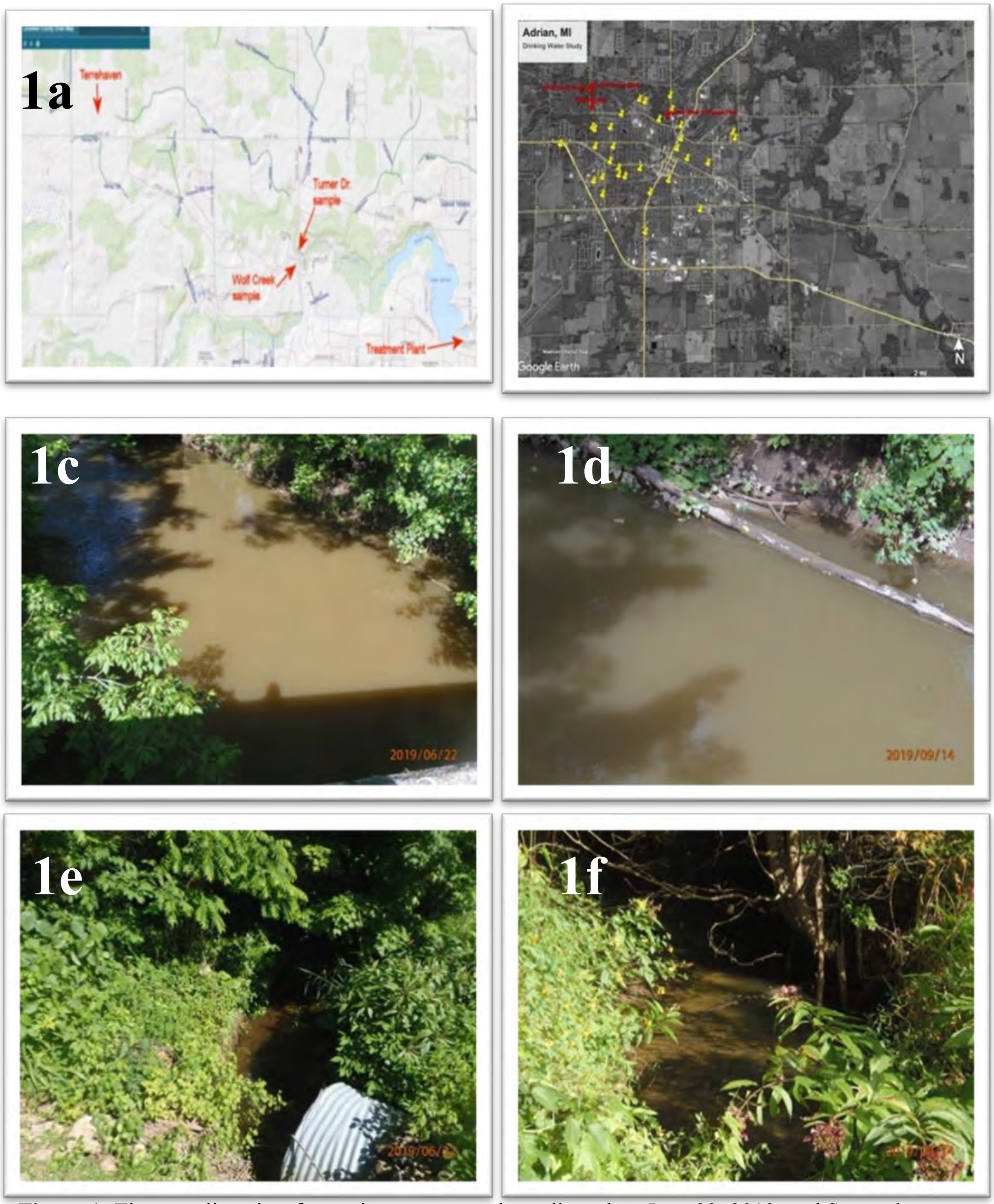


Figure 1: The sampling sites for environment samples collected on June 22, 2019, and September 14, 2019. Figure 1.a; map displaying the location of the Turner Drain and Wolfe Creek and water treatment facility. Figure 1.b; google earth image for all sampling sites on the city of Adrian, MI. Figure 1.c; Wolfe Creek sampling collection site for June 22, 2019. Figure 1.d; Wolfe Creek sampling collection site on September 14, 2019. Figure 1.e; Turner Drain sampling collection site on June 22,2019 and figure 1.f; Turner Drain collection site on September 14, 2019. * Images were acquired and provided to Wayne State University by members of the Environmentally Concerned Citizen of South Central Michigan.

3.2 Sample Collection Filtration and DNA extraction

Water samples volume of approximately 1.0 L were filtered through sterile mixed cellulose ester filters (Whatman MCE; 47 mm diameter; N.J., U.S.A.) using vacuum suction. Each filter was carefully rolled using sterile forceps and placed in a separate 5.0 mL centrifuge tubes (Eppendorf Tube® 5.0 mL, clear, Sterile, CS/200). Tubes containing filters were stored at -20°C until use.

Frozen filters were subjected to bead-bashing technique for the extraction of high molecular bulk microbial community DNA from collection filters through vacuum filtration. Zymobiomics DNA Miniprep Kit was used for DNA extraction and purification according to manufacturer's protocol. In general, 2.0 grams of zirconia/silica beads (ZR Bashing Bead (0.1 & 0.5 mm) were added to each individual tubes containing each separate filters. Volume of 750uL lysis buffers was added to each tube containing filter and shaken for 20 minutes at 2500 rpm using shaker (Vortex Genie). Tubes were centrifuged at 10 000 x g for 2 minutes, supernatant was transferred and filtered through spin column/collection tube via centrifugation at 8 000 x g for 1 minute. DNA binding buffer was added to tube containing filtrate and mixed well by pipetting. Filtrate and binding buffer mixture were transferred to silica collection tube and washed using Wash buffers 1 and 2 (ZymoBiomic DNA miniprep kit, ZymoResearch, CA, USA) DNA was eluted in a final volume of 100uL using elution buffer. Eluted DNA was subjected to inhibitor removal using manufacture supplied filters and solution (ZymoBiomics Research, Ca, USA). DNA was stored at -20°C until further use.

3.3 Culture Strains and Genomic DNA Extraction

Culture strains used as positive and negative controls for PCR were obtained from the Collection of Algae at University of Texas-Austin (Austin, TX, USA). *Microcystis aeruginosa* UTEX LB 2385 was cultured in 15mL of sterile B3N media, *Microcystis sp.* UTEX B 2678 was cultured in J medium (J), *Synechococcus elongatus* UTEX 2973 and *Oscillatoria tenuis* UTEX B 428 were cultured in 1mL of BG-11 medium. All strains were subjected to cool-white, fluorescent light with 12/12-hour light and dark cycles at 23± 2°C for one month in sterile 15mL Eppendorf Tubes (ThermoFisher, MA, USA). 1mL of each cultivated strain was centrifuged at 6000 x g for 5 minutes, the supernatant was removed and discarded, and the cell pellets were utilized for genomic DNA. Genomic DNA extraction was performed using commercially available GeneJet Genomic DNA Purification Kit (ThermoFisher, MA, USA) according to manufacture supplied gram-negative bacteria genomic DNA purification protocol. In brief, harvested cell pellets were resuspended in digestion buffer, with addition of 20uL of Proteinase K and mixed thoroughly. Incubation at 56°C for 2-3 hours or until cell were completely lysed. 20mL of RNase A solution was added to digestion mix for each culture strain, vortexed and incubated at room temperature for 10 mins. After incubation, 200mL of lysis buffer and 400mL of 50% ethanol was added and mixed vigorously for homogeneous mixture. Mixture was transferred to spin column; spin columns were washed twice using supplied Washer buffers I and II. The membrane-bound DNA was eluted at a volume of 50mL using elution buffer. Purified gDNA was used as standard controls for conventional PCR and gel electrophoresis.

3.4 Conventional PCR Amplification of Microcystis Genus

DNA extracts from residential, environmental, and cultures were subjected to conventional polymerase chain reaction using the designated primers (Table 1). The primer pair *MICR 184F* and *MICR431R* was amplified to detect the genera *Microcystis*. Each PCR reaction consisted of 5µL of DNA, 12.5µL of 2X DreamTaq Green Ready Master Mix buffer (ThermoFisher, MA, USA), 2.5 mM $MgCl_2$, 200 nM of each dNTPS, 1.25µL of each forward and reverse primers (10 mM) for a final concentration of 500 nM of each primer and 5µL of nuclease-free H_2O for a final reaction volume of 25µL. PCR reactions were subjected to thermocycling using Mastercycler EP Gradient S (Eppendorf, HH, Germany) and the thermocycling conditions were as follows: initial denaturing at 95°C for 5 mins, followed by 45 cycles of 95°C for 30 sec, annealing temperature according to table 1 for 1 min, extension at 72° C for 30 sec, and a final elongation step at 72°C for 15 mins (Rinta-Kanto et al., 2005). PCR products were subsequently separated using gel electrophoresis to visualize DNA fragments. A total volume of 10µL was loaded onto a 2% agarose TBE gel (2g agarose in 100mL 1XTBE buffer). Sybr Safe DNA stain was added to gel for visualization under UV-illumination using ChemiDoc XRS+ imager (BioRad, CA, USA)

3.5 Conventional PCR and Gel Electrophoresis for Toxin Biosynthesis Gene Detection

PCR reactions for the detection of microcystin and anatoxin-a synthetase genes, the primer pairs *mycA-CD1F/mcyA-Cd1R* (Hisbergues et al., 2003) and *anaC-genF/anaC-genR* (Rantala-Ylinen et al., 2011) were amplified, respectively. Each PCR reaction consisted of 12µL of 2X DreamTaq Green Ready Master Mix buffer (ThermoFisher, MA, USA), 1µL of each primer (10 mM) for a final concentration of 400nM for each primer, 2.5 mM of $MgCl_2$, 200nM of each dNTPS and 5µL of DNA for a final reaction of volume of 25µL PCR reactions were subjected to thermocycling using Mastercycler EP Gradient S (Eppendorf, HH, Germany) and thermocycling conditions were as follows: initial denaturing at 95°C for 3 mins, followed by 35-40 cycles of 94°C for 30 sec, annealing temperature for each primer pair was according to table 1 for 30 sec, extension at 72° C for 30 sec, and a final elongation step for 5 min at 72°C. PCR products for all reactions were separated using agarose gel electrophoresis. A total volume of 6µL of PCR product was loaded on to 1.5% agarose gel in 99.9mL of 1X Tris-Borate-EDTA buffer and 10µL of Sybr Safe DNA Gel Stain (Thermo Fisher, MA, USA) and ran for 1h and 15 min at 80 volts. The gene amplicons were visualized on ChemiDoc XRS+ imager (BioRad, CA, USA) using UV-illumination. A 100bp DNA marker (GoldBio, MO, USA) was added to each gel to determine the correct amplicon size (table 1).

Table 1: List of Primers Used for the Study

Primer	Sequence (5' – 3')	T_m (°C)*	Amplicon Size (bp)	Reference
MICR184F MICR43R	GCCGCRAGGTGAAAMCTAA AATCCAAARACCTTCCTCCC	56	247(bp)	Rinta-Kanto et al. (2005)
mcyA-Cd1F mcyA-Cd1R	AAAATTAAAAGCCGTATCAAA AAAAGTGTTTTATTAGCGGCTCAT	59	297(bp)	Hisbergues et al. (2003)
anaC-genF anaC-genR	TCTGGTATTCAGTCCCCTCTAT CCCAATAGCCTGTCATCAA	58	366	Rantala-Ylinen et al. 2011

*Table 1 - *T_m indicated the specific annealing temperature used for each respective primer.*
(bp) equaling number of nucleotides representative length of the gene fragment within the DNA.

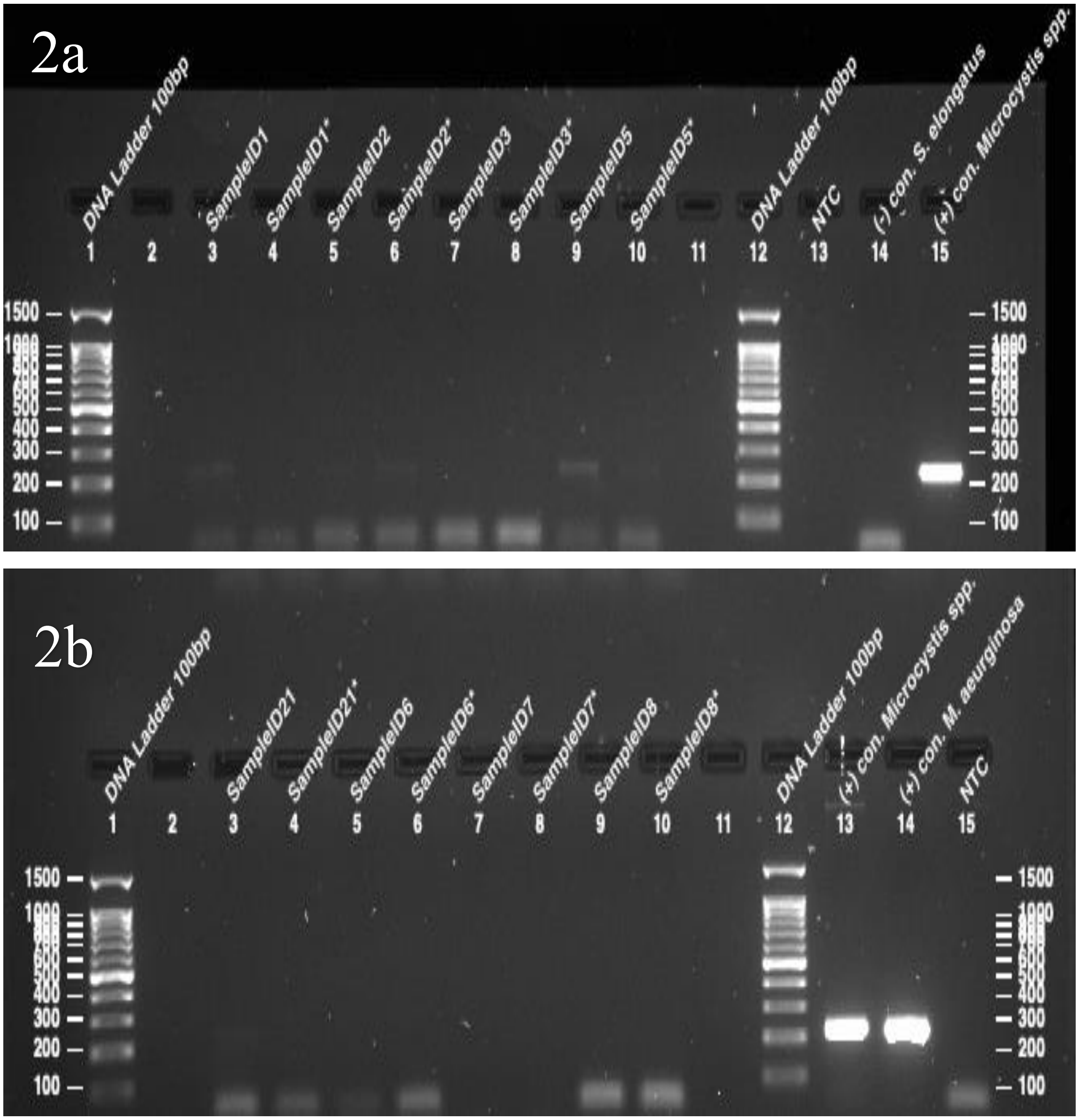
Chapter 4 - Results

4.1. PCR amplification in Detecting Presence of 16S rDNA for Microcystis Genus

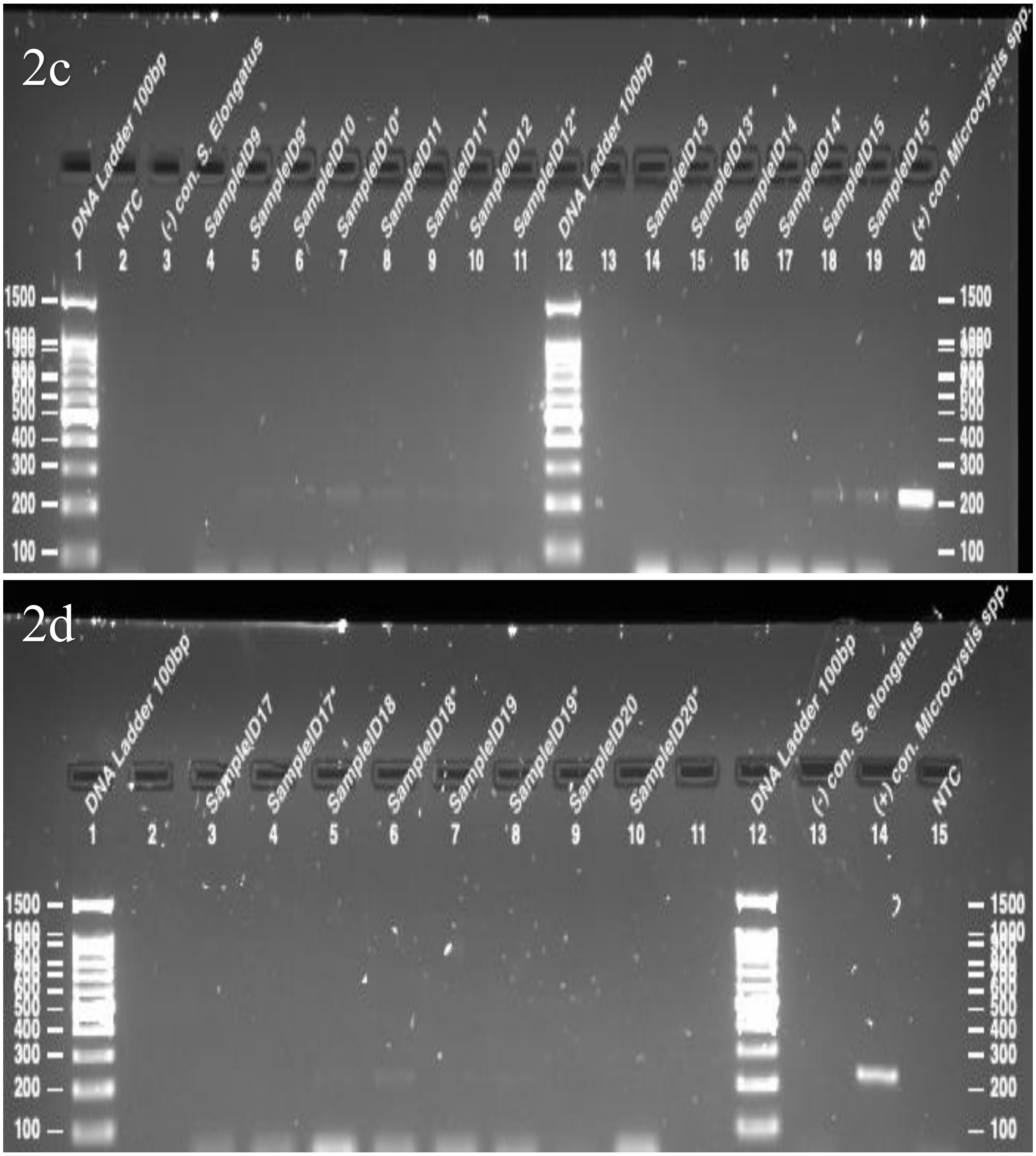
For the presence of *Microcystis* 16S rDNA, PCR resulted in a 247 bp for 12 out of the 25 for DNA extracts from residential samples analyzed for sample collected of June 22, 2019. For the DNA extracts from samples collected on September 14, 2019, the PCR resulted in 15 out of 33 samples analyzed for the detection of *Microcystis*.

For the environmental samples collected from Wolfe Creak and Turner Drain, results were positive for both sites collected on September 14, 2019. To validate the PCR, genomic DNA from the xenic culture strain, *Microcystis spp.* UTEX 438 amplified a 247 bp DNA fragment which served as a positive reference control. *Synechococcus elongatus* did not amplify the target gene, *MICR16S* and served as a negative reference control. PCR products were visualized by agarose gel electrophoresis (figures 2a, c-f).

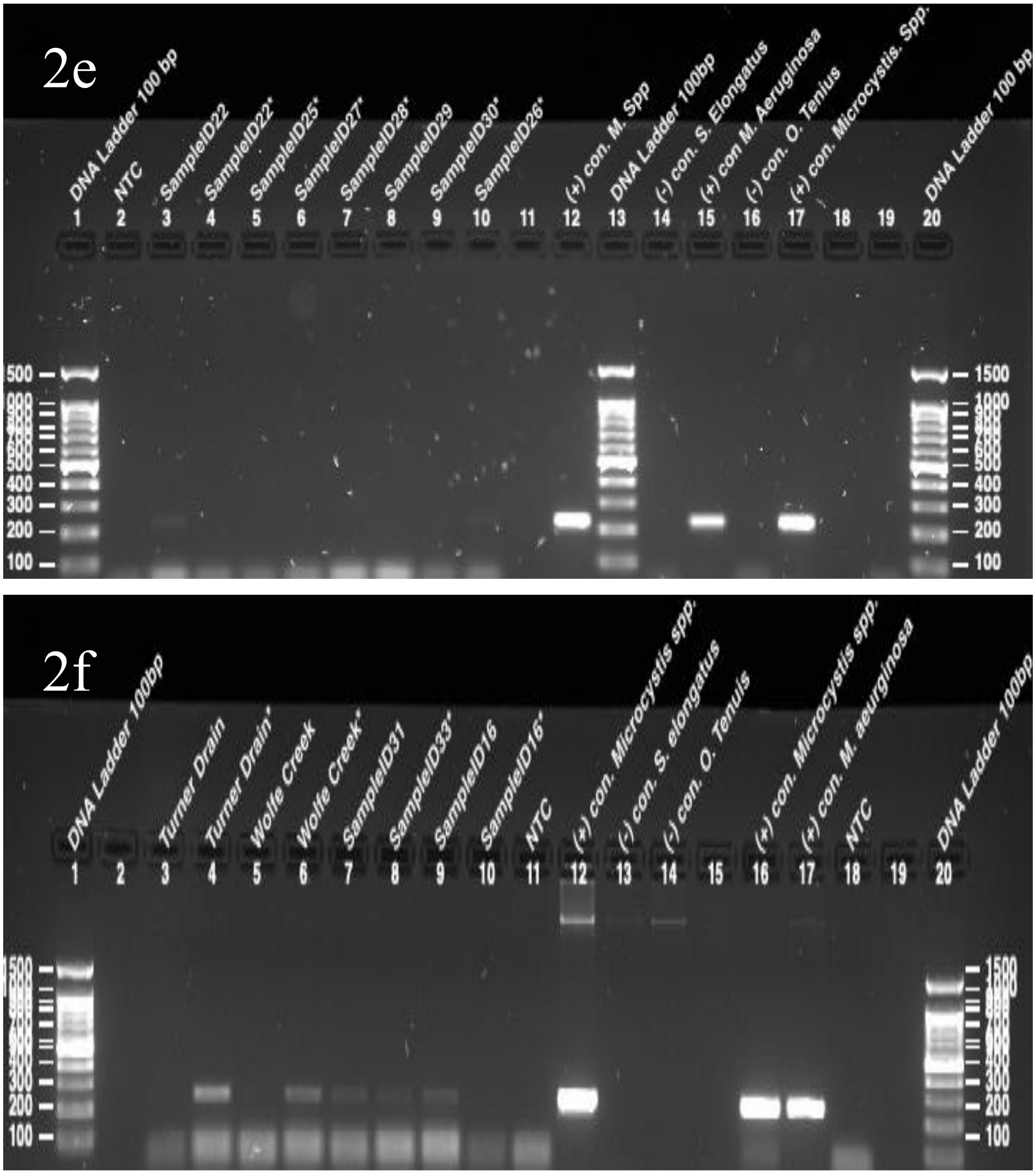
Figure 2a-f: PCR product agarose gel electrophoresis results for *Microcystis* genus using primer pair MICR184F and *MICR428* for water sample obtained Adrian, MI on June 22, 2019, and September 22, 2019. * - indicates water samples collected on 09/14/2019 for the respective sampleID. i.e., sampleID1 sample was obtained on 06/22/2019 and sampleID1* sample was obtained on 09/22/2019 from the same sampling site.



2.a-b on a single gel: Lanes 1 & 12: DNA marker 100bp (Goldbio); Lanes 3, 5, 7 and 9 show results for samples collected on 06/22/209; Lanes 4,6,8 and 10 show results samples collected on 09/14/2019; Lane 13-1a & 15-1b: no template control; Lane 14-1a: negative control *Syenchococcus elongatus* Lane 15-1a & 131b: Positive control, Microcystis. Spp.; Lane 14-1b: positive control *Microcystis aeruginosa*.



2c. Lanes 1 & 12: DNA ladder 100bp (GoldBio); Lane 2: no template control; Lane 3: negative control *Syenchococcus elongatus*; Lanes 4,6,8,10,14,16 and 18 show results for samples collected on June 22, 2019; Lanes 5,7,9,11,15,17 and 19 show results for samples collected on September 22, 2022, for respective SampleIDs; Lane 20: positive control *Microcystis spp.* **2d:** Lanes 1 & 12: DNA ladder 100bp; Lanes 3,5,7,9 show results of sample collection for June 22,2022; Lanes 4,6,8 and 10 show results of samples collected on September 14, 2019; Lane 13: negative control, *Synechococcus elongatus*; Lane 14: positive control *Microcystis spp.*; Lane 15: no template control.



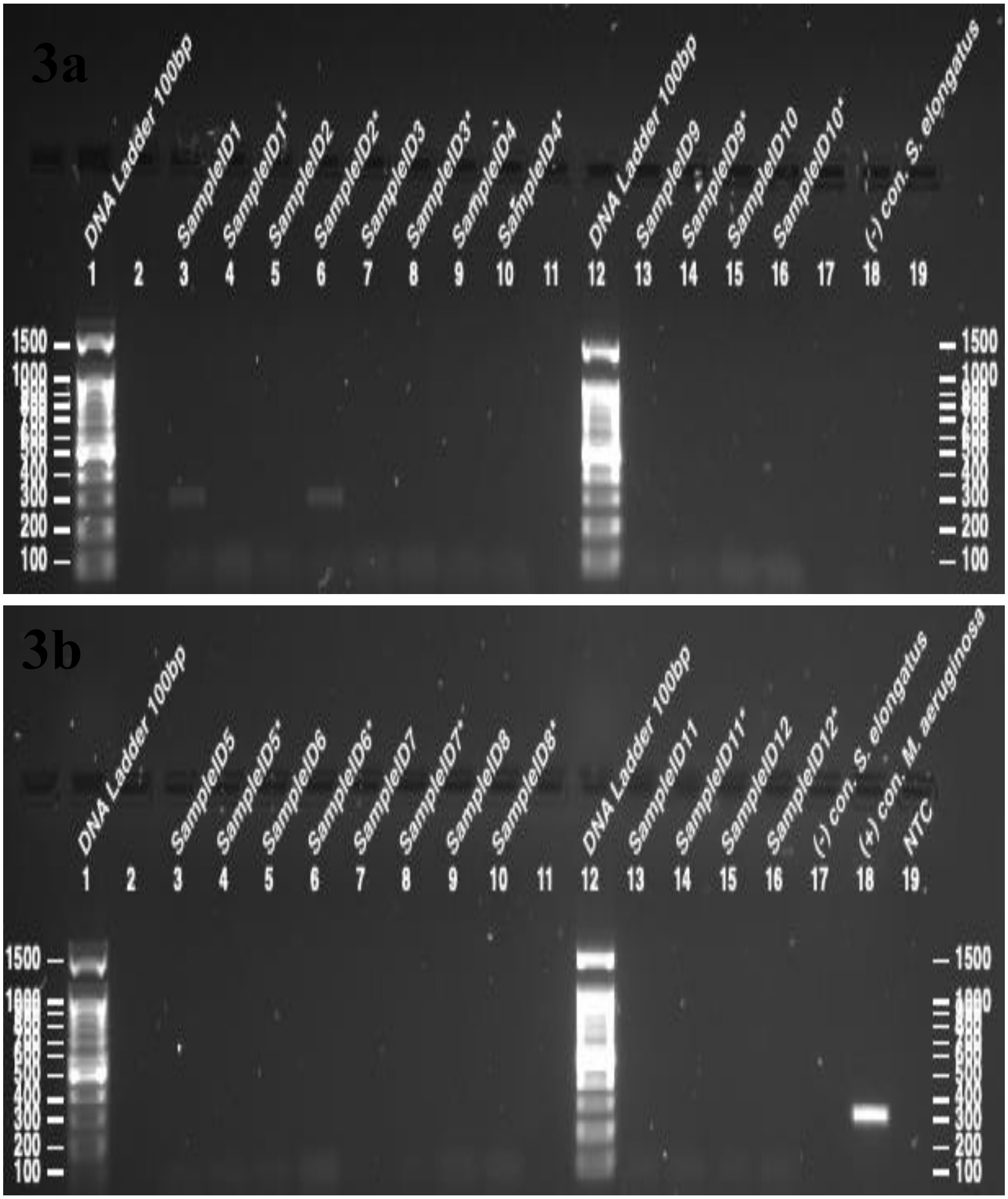
2.e Lanes 1, 13 and 20: DNA ladder 100bp; Lanes 3,5,7,9 show results of sample collection for June 22,2022; Lane 2: not template control; Lanes 4,6,8 and 10 show results of samples collected on September 14, 2019; Lane 12: positive control, *Microcystis spp.;* Lane 14: negative control, *Synechococcus elongatus*; Lane 15: positive control *Microcystis aeruginosa*; Lane 16: negative control, *Oscillatoria Tenuis*; Lane 17: positive control, *Microcystis spp.* **2.f:** Lanes 1 & 20: DNA ladder 100bp, Lanes 3,5,7 and 9 show results for sample collected on June 22, 2019; Lane 4,6,8 and 10 show results for samples collected on September 14, 2019; Lane 11: no template control, Lanes 12 & 16: positive control *Microcystis spp.*; Lanes 13 and 14: negative controls, *Syenchococcus elongatus and Oscillatoria Tenuis;* Lane 18: no template control.

4.2. *PCR amplification in Detection of Toxin Biosynthesis Genes*

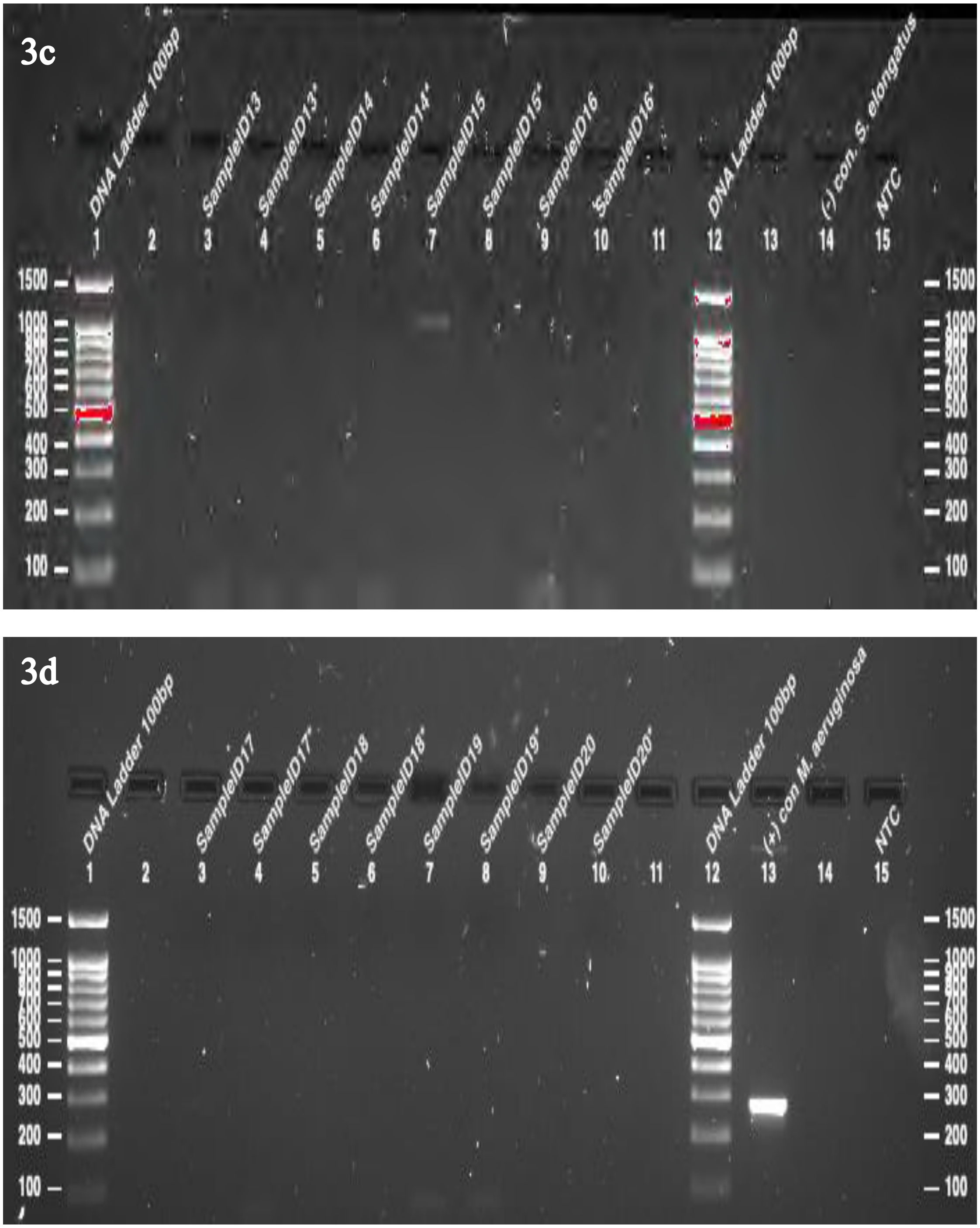
In analyzing the conserved microcystin synthetase, mcyA-Cd1, gene encoding for the biosynthetase gene for microcystin, PCR resulted in a 297 bp fragment for four of the DNA extracts of residential samples collected on June 22, 2019, and one sample collected September 14, 2022. Visualization of PCR products by agarose gel electrophoresis showed that genomic DNA from culture strain, *Microcystis aeruginosa* UTEX 2738 and *Oscillatoria Tenuis* both resulted in 297 bp DNA fragment which served as positive reference control whereas *Synechococcus elongatus* did not amplify the target gene, *mcyA-Cd* and served as negative reference control (Figure 3).

The environmental samples collected on June 22, 2019, and September 14, 2019 from Wolfe Creek and Turner Drain gave a positive result for the presence of *Microcystis* indicated by the formation of 247 bp product. Anatoxin-a provided a positive result in the DNA extracted from the Turner Drain sample collected on June 22, 2019 but was not detected for the DNA extract from September 14, 2019, collection. Microcystin synthetase gene was not detected in the DNA extract of Turner Drain samples for either collection dates. Microcystin synthetase gene was detected in the DNA extract of Wolfe Creek for sample collected on June 22, 2019, but was not detected for sample collection on September 22, 2019 (Figure 3).

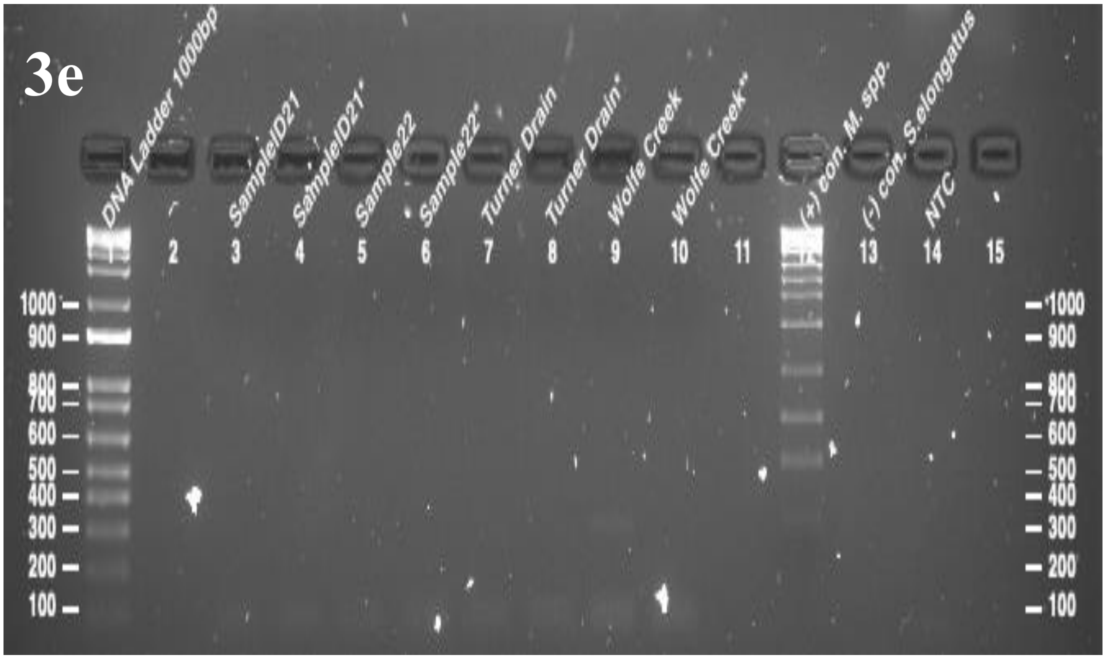
Figure 3a-f: Gel electrophoresis results of PCR products for *microcystin* toxin synthesis gene using primer pair *mcyA-Cd1F* and *mcyA-Cd1R* for sample obtained from Adrian, MI on June 22, 2019, and September 14, 2019, using 2% TBE agarose gel.

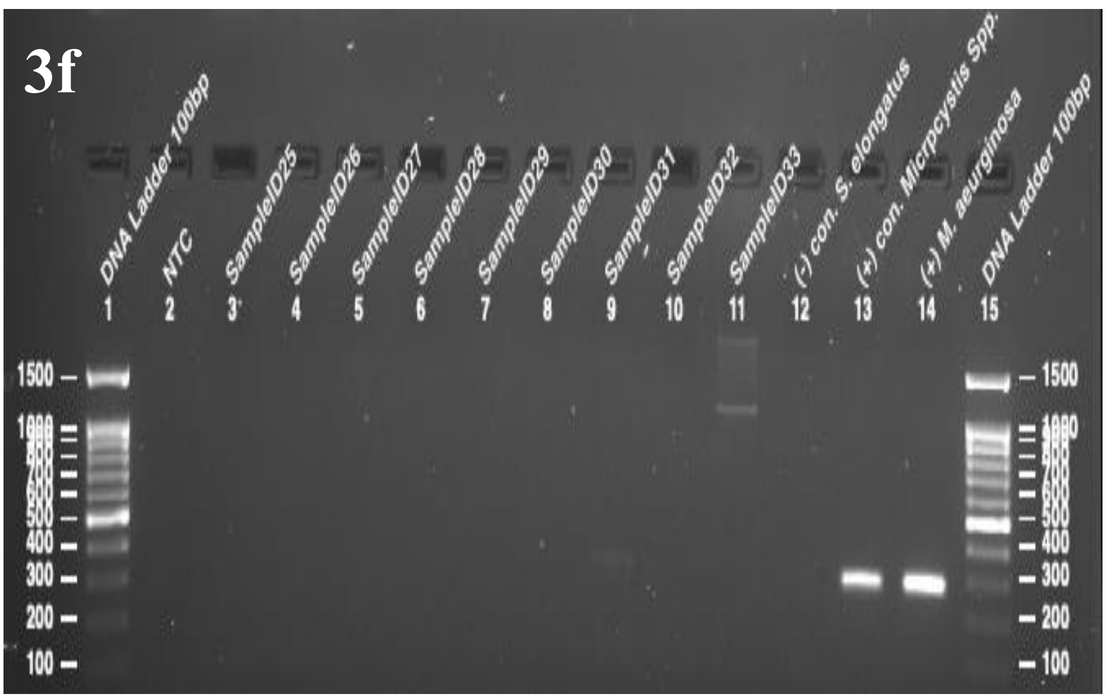


3**a-b** shows samples runs on a single gel: Lane 1: DNA marker 100bp (Goldbio); Lane 2: no reaction sample added to well, empty; Lanes 3, 5, 7,9 and 11 show results for samples collected on 06/22/209; Lanes 4,6,8,10 and 12 show results for samples collected on 09/14/2019 for respective sampled; Lane 17-2a & 19-2b: not template control; Lane 14-2c.: negative control sample, *Synechococcus elongatus*; Lane 18-2b: Positive control, *Microcystis aeruginosa.*



3c-d.: Lane 1 & 12: DNA marker 100bp (Goldbio); Lanes 3, 5, 7 and 9show results for samples collected on 06/22/209; Lanes 4,6,8,10 show results for samples collected on 09/14/2019 for respective sampled; Lane 14-3c: negative control *Synechococcus elongatus*; Lane 13-3d: positive control, *Microcystis aeruginosa*.; Lane 15 no template control.

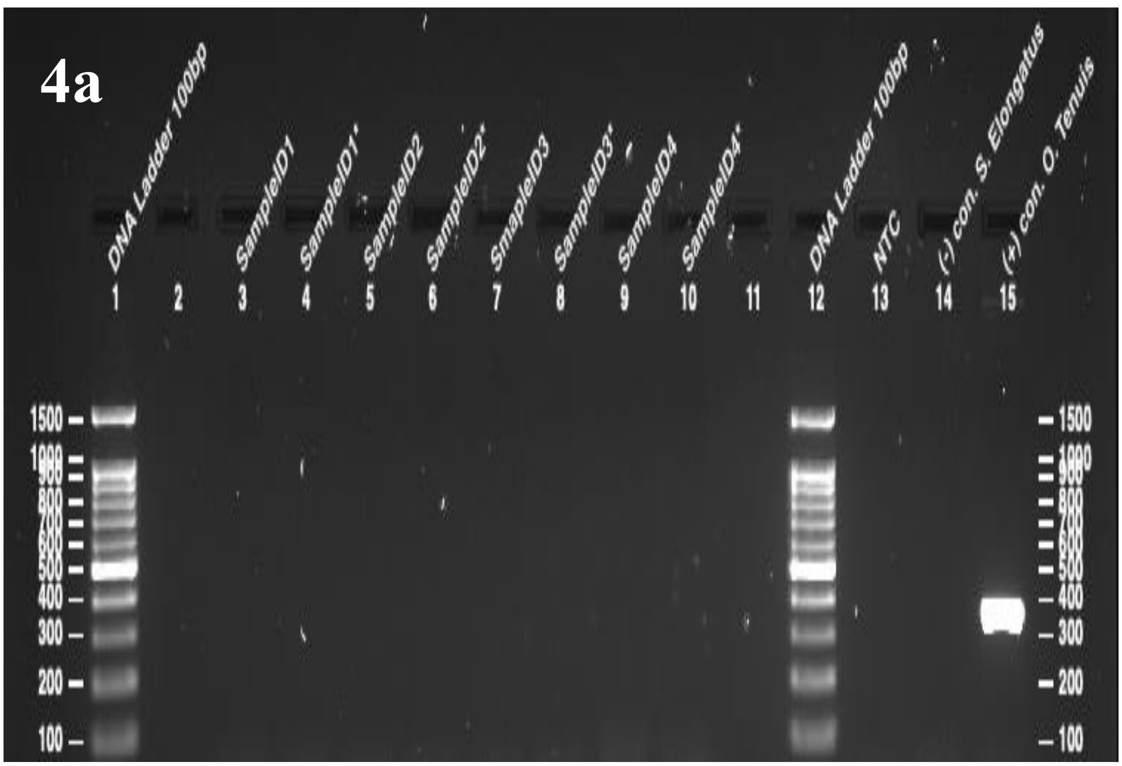




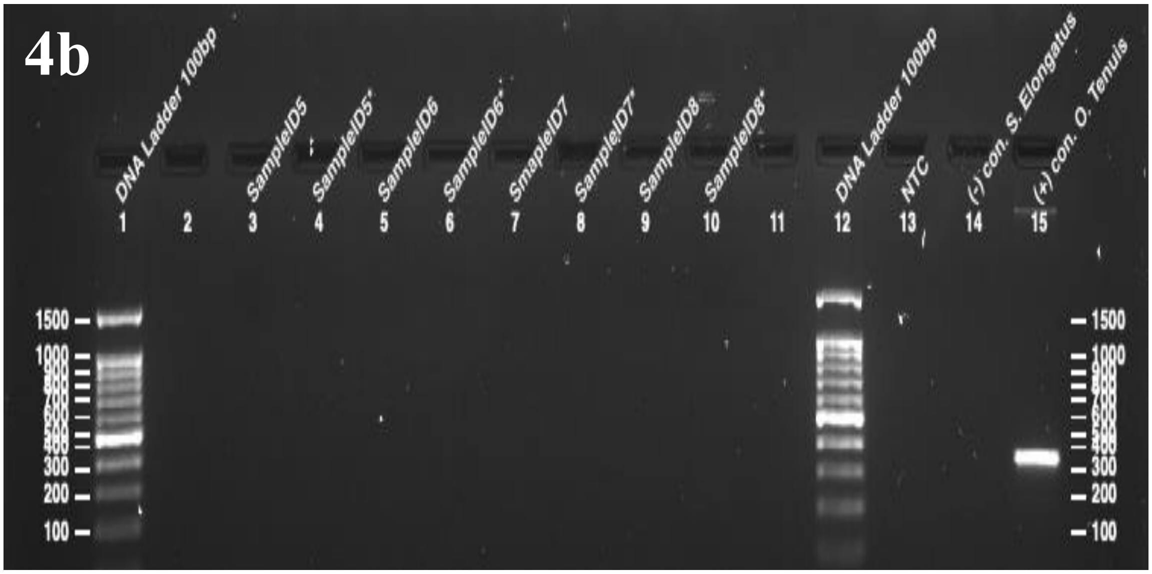
3e-f: Lane 1: DNA marker 100bp (Goldbio); Lanes 3,5,7 and 9 show results for samples collected on 06/22/209; Lanes 4,6,8,10 and 11 show results of PCR product for samples collected on 09/14/2019 for respective sampleIDs; Lane 10: DNA marker 100bp (Goldbio) Lane 11: not template control; Lanes 12-2e & 13,14-2f: positive control sample, *Microcystis spp., Microcystis aeruginosa*, respectively; Lanes 13-2e & 12-2f: negative control *Synechococcus elongatus*; Lane 15-2f: DNA ladder 100bp (Goldbio), 100bp (Goldbio).

Analysis of the PCR for anatoxin biosynthesis gene resulted negative for all DNA extracts from residential collections for June 22, 2022 and September 14, 2019. One positive environmental sample collected from Turner Drain on June 22, 2019. Visualization of PCR product by agarose gel electrophoresis showed that the genomic DNA from culture strains, *Oscillatoria Tenuis* amplified a 366 bp DNA fragment which served as a positive reference control. *Synechococcus elongatus* did not result in the amplification of target gene*, anaC*-gen and served as negative reference control (Figures 4).

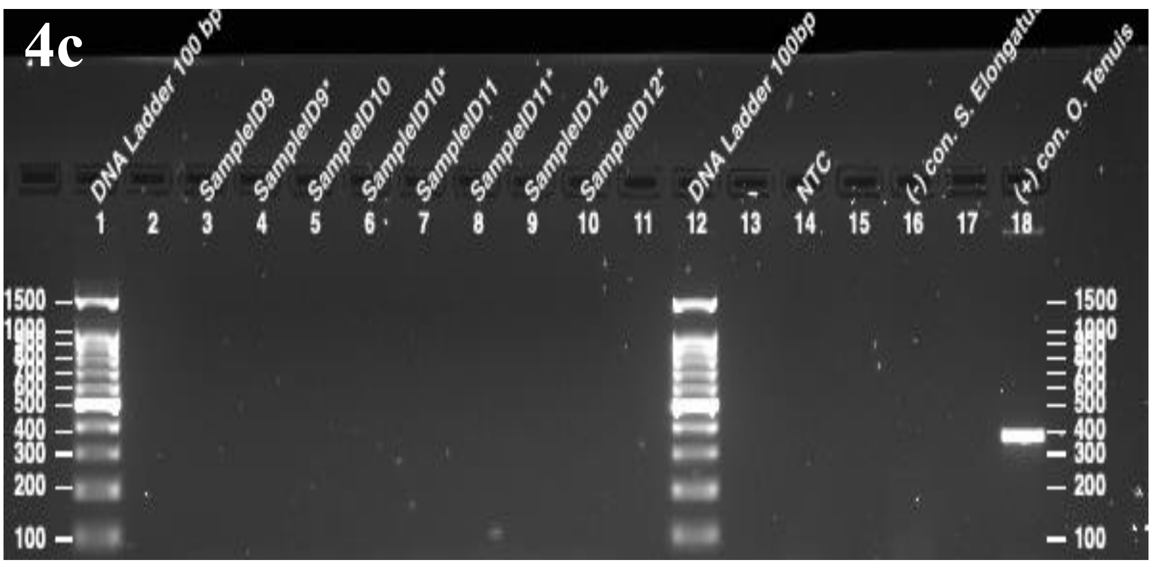
Figures 4a-g.: Gel electrophoresis results for *anatoxin-a* toxin synthesis gene using primer pair *anaC-genF* and *anaC-genR* for sample obtained from Adrian, MI on June 22, 2019, and September 14, 2019



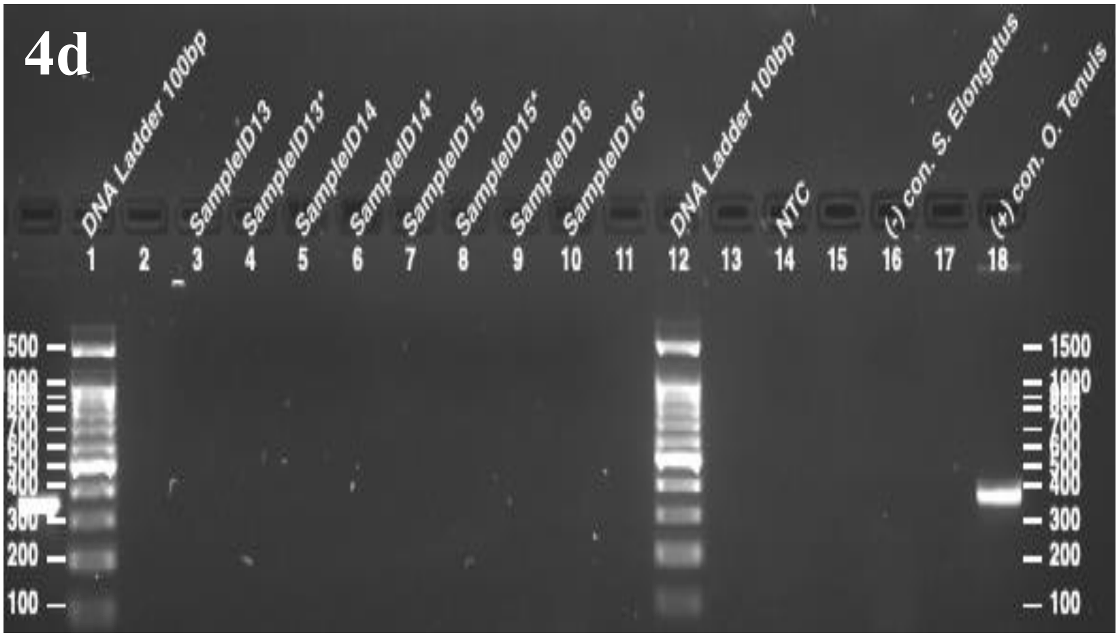
4a: Lane 1: DNA marker 100bp (Goldbio); Lane 2: no reaction sample added to well, empty; Lanes 3, 5, 7 and 9: experimental samples collected on 06/22/209; Lanes 4,6,8,10 show experimental samples collected on 09/14/2019 for respective sampleIDs; Lane 12: DNA marker 100bp; Lane 13: not template control; Lane 14: negative control sample, *Synechococcus elongatus*; Lane 15: Positive control, *Oscillatoria Tenuis.*



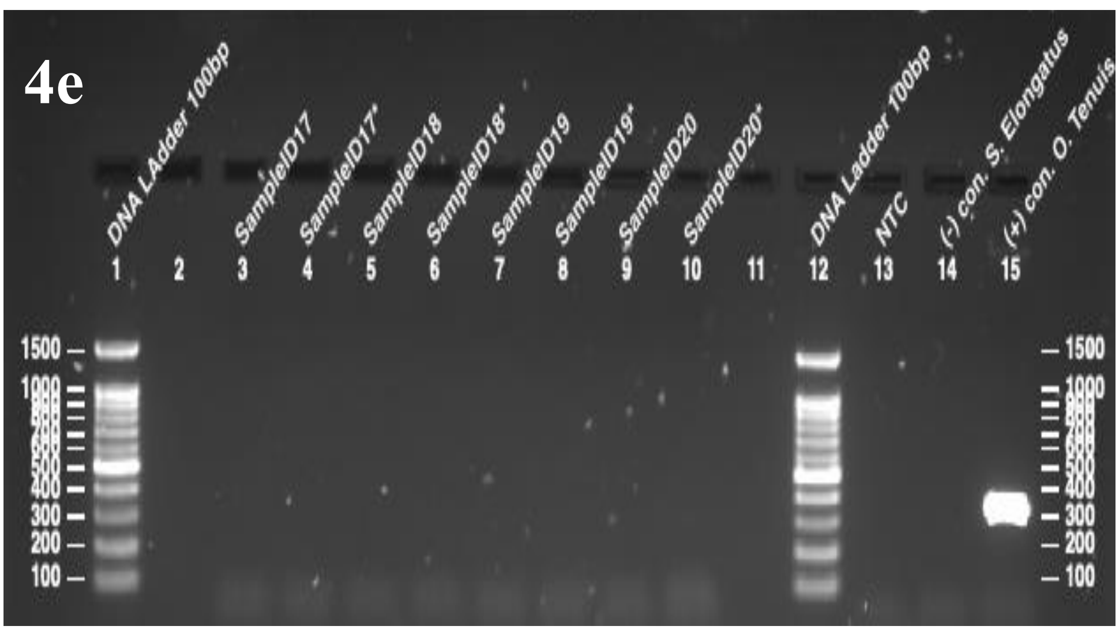
4b. Lane 1: DNA marker 100bp (Goldbio); Lane 2: no reaction sample added to well, empty; Lanes 3, 5, 7 and 9: experimental samples collected on 06/22/209; Lanes 4,6,8,10 show experimental samples collected on 09/14/2019 for respective sampleIDs; Lane 12: DNA marker 100bp; Lane 13: not template control; Lane 14: negative control sample, *Synechococcus elongatus*; Lane 15: Positive control, *Oscillatoria Tenuis.* **4c:**



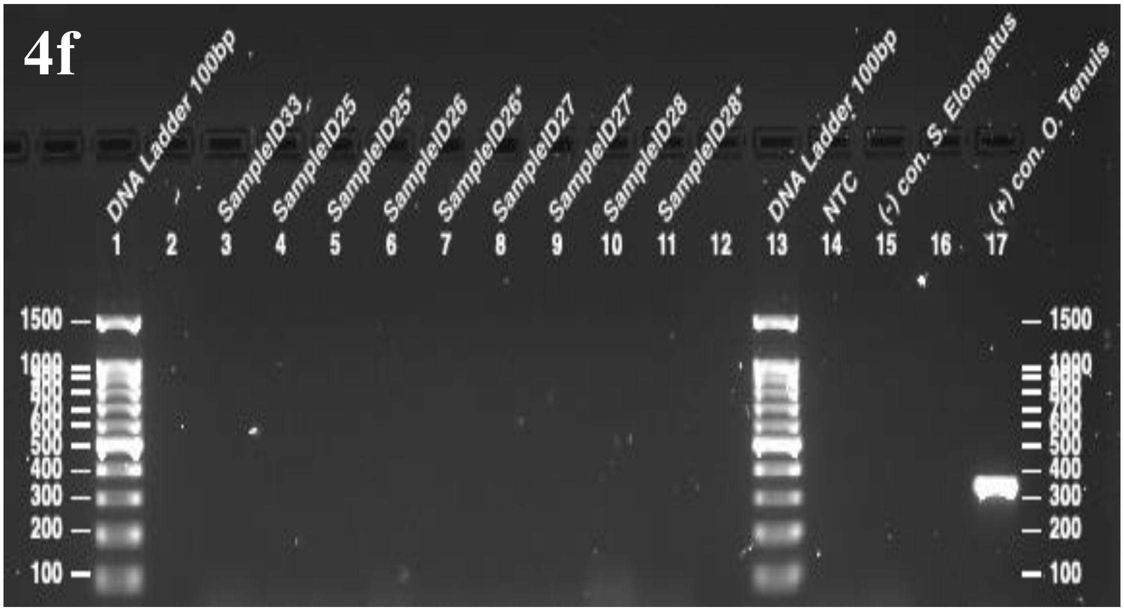
4c. Lane 1: DNA marker 100bp; Lane 2: no reaction sample added to well, empty; Lanes 3, 5, 7 and 9: experimental samples collected on 06/22/209; Lanes 4,6,8,10 show experimental samples collected on 09/14/2019 for respective sampleIDs; Lane 12: DNA marker 100bp (Goldbio); Lane 14: no template control; Lane 16: negative control *Synechococcus elongatus*; Lane 18: positive control, *Oscillatoria Tenuis*.



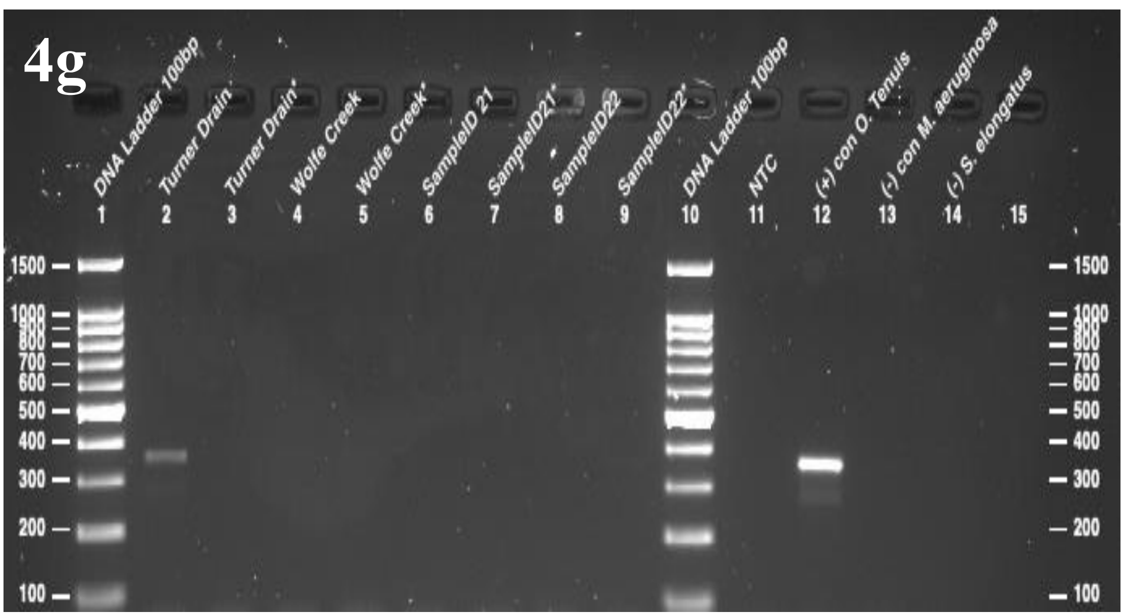
4d. Lane 1: DNA marker 100bp; Lane 2: no reaction sample added to well, empty; Lanes 3, 5, 7 and 9: experimental samples collected on 06/22/209; Lanes 4,6,8,10 show experimental samples collected on 09/14/2019 for respective sampleIDs; Lane 12: DNA marker 100bp (Goldbio); Lane 14: no template control; Lane 16: negative control *Synechococcus elongatus*; Lane 18: positive control, *Oscillatoria Tenuis*.



4e.: Lane 1: DNA marker 100bp (Goldbio); Lane 2: no reaction sample added to well, empty; Lanes 3, 5, 7 and 9: experimental samples collected on 06/22/209; Lanes 4,6,8,10 show experimental samples collected on 09/14/2019 for respective sampleIDs; Lane 12: DNA marker 100bp; Lane 13: not template control; Lane 14: negative control sample, *Synechococcus elongatus*; Lane 15: Positive control, *Oscillatoria Tenuis.*



4f.: Lane 1: DNA marker 100bp (Goldbio); Lanes 2,4,6: experimental samples collected on 06/22/209; Lanes 3,5,7 show results of PCR product for samples collected on 09/14/2019 for respective sampleIDs; Lane 10: DNA marker 100bp (Goldbio) Lane 11: not template control; Lane 12: positive control sample, *Oscillatoria Tenuis;* Lane 13: negative control *Synechococcus elongatus*; Lane 15: empty well, not PCR product add to well.



4g.: Lane 1: DNA marker 100bp (Goldbio); Lane 2: no reaction sample added to well, empty; Lanes 4,6,8, and 10 contain PCR product for collected on 06/22/209; Lanes 5,7,9,11 show results of PCR product for samples collected on 09/14/2019 for respective sampleIDs; Lane 13: DNA marker 100bp (Goldbio); Lane 14: no template control; Lane 15: negative control *Synechococcus elongatus*; Lane 17: positive control, *Oscillatoria Tenuis*

	Saturday, June 22, 2019			Saturday September 14, 2019		
SampleID	**MicR16S**	**mcyA-Cd1**	**anaC-gen**	**MicR16S**	**mcyA-Cd1**	**anaC-gen**
1	+	+	-	+	-	-
2	+	-	-	+	+	-
3	-	-	-	-	-	-
4	+	-	-	+	-	-
5	+	-	-	+	-	-
6	-	-	-	-	-	-
7	-	-	-	+	-	-
8	-	-	-	-	-	-
9	-	-	-	+	-	-
10	+	-	-	+	-	-
11	+	-	-	+	-	-
12	+	-	-	+	-	-
11	+	-	-	+	-	-
12	+	-	-	+	-	-
13	-	-	-	+	-	-
14	+	-	-	-	-	-
15	+	-	-	+	-	-
16	+	-	-	-	-	-
16	+	-	-	-	-	-
17	+	+	-	-	-	-
18	+	-	-	+	-	-
19	+	-	-	+	-	-
20	-	-	-	-	-	-
21	+	-	-	-	-	-
22	+	-	-	-	-	-
Turner Drain	-	-	+	+	-	-
Wolfe Creek	-	+	-	+	-	-
25*	n/a	n/a	n/a	-	-	-
26*	n/a	n/a	n/a	+	-	-
27*	n/a	n/a	n/a	-	-	-
28*	n/a	n/a	n/a	-	-	-
29*	n/a	n/a	n/a	-	-	-
30*	n/a	n/a	n/a	-	-	-
31	+	+	-	n/a	n/a	n/a
32*	n/a	n/a	n/a	-	-	-
33*	n/a	n/a	n/a	+	-	-
Synechococcus elongatus	-	-	-			
Microcystis spp.	+	+	-			
Microcystis aeruginosa	+	+	-			
Oscillatoria tenuis	-	-	+			

Table 2: Results of PCR products of samples collected from Adrian, MI
(+) presence of specific gene (positive result); **(-)** absence of gene (negative result)
MICR16S gene for 16S rDNA conserved region for *Microcystis* genus
mcyA-Cd1 constituting a part of the microcystin synthetase gene cluster present in all microcystin toxin producing Cyanobacteria species.
anaC-gen represents anatoxin C synthetase gene present in all anatoxin producing Cyanobacteria species
n/a indicates no sample collection was obtained and ***** Represents samples collection only on September 14, 2022.

Chapter 5: Discussion

Cyanobacteria's presence in freshwater can potentially be hazardous to human health. The exact mechanism and regulation involving cyanobacterial growth nor toxin production are not entirely understood. It is difficult to appropriately set precise markers defining future predictors and early detection of bloom formation, or cyanotoxin productions (Manganelli et al., 2010). The DNA based PCR detection technique used in this study determines the presence of cyanobacteria genus *Microcystis* and cyanotoxin genes but does not indicate whether the toxin is being actively produced by the bacteria. Samples resulting in a positive signal for the MiCR16S gene indicate the presence of cyanobacteria belonging to the genus *Microcystis* encompassing both toxic and non-toxic strains. On the other hand, a positive signal for mcyA-Cd1 signifies the detection of a *Microcystis* species that harbors the toxin synthetase gene irrespective of whether the bacteria are actively producing toxins (Sipari et al., 2010; Vaitomaa et al., 2003).

Conventional PCR targeting the conserved region of the bacterial gene 16S rDNA specific for the cyanobacteria genus, *Microcystis,* revealed a positivity rate of 48% and 53%, for June and September, respectively. The results of this report are aligned with previously published research revealing that a positive signal for the MiCR16S gene indicate the presence of cyanobacteria belonging to the genus *Microcystis* encompassing both toxic and non-toxic strains (Oh et al., 2013; Ostermaier & Kurmayer, 2009; Rinta-Kanto et al., 2005). The biosynthesis of cyanotoxin is a catalytic reaction involving pertinent enzymes coded by toxin synthetase genes (Christiansen et al., 2003; Dittmann et al., 2013; Mazmouz et al., 2010). Toxin production is unachievable in the absence of biosynthetic genes or a disturbance in the enzymatic cascade involving toxin production. The characterization of *mcy* genes encoding for subunits of microcystin synthetase found specifically in *Microcystis* cells allowed researchers to design specific primers to identify strains containing microcystin synthetase genes (Dittmann & Wiegand, 2006; Tillett et al., 2000). Moreover, next generation DNA sequencing and DNA fingerprinting techniques have confirmed *mcy* gene within other cyanobacteria genera commonly found in freshwater ecology (Hisbergues et al., 2003; Metcalf & Codd, 2012). Thus, making the *mcyA-Cd* gene primers appropriate in detecting microcystin producers among cyanobacteria genotypes. Amplification of the target gene *mcyA-Cd1F*/*mcyA-Cd1R* using conventional PCR is used to confirm the presence of microcystin synthetase gene. Results revealed that 16% of all water samples collected in June and 3% of the water samples collected in September tested positive for microcystin synthetase gene. Others have implicated *Microcystis* as a possible cause of harmful cyanobacteria bloom due to being a known toxin producer (Oh et al., 2013; Rinta-Kanto et al., 2005). Furthermore, Rinta-Kanto et al. showed that in the western basin of Lake Erie, reoccurring toxic blooms are attributed to *Microcystis aeruginosa*, however, species belonging to *Planktothrix* were also found involving the production of microcystin in Sandusky Bay (Lake Erie) (Rinta Kanto et al., 2007). This suggest the potential of cyanobacteria genera are spatially distributed when the conditions are favorable for toxic producing genotypes. Furthermore, the distribution of toxic cyanobacteria is repeatedly observed throughout Lake Erie, whereas *Microcystis aeruginosa* dominated the western basin and Long Point. Noticably the toxic blooms were dominated by *Anabaena* and *Aphanizomenon flos*-aquae species at Sandusky Bay which is located closer to the eastern basin. (Carmichael & Culver, 2000).

Results of this study revealed one sample to be positive for the anatoxin-a synthetase gene. The sample providing a positive signal was detected in the environmental sample collected from Turner Drain on September 14, 2019, (Figure 4g). Interestingly, the environmental sample indicating the presence of the target gene, *anaC-gen*, did not include the presence of genus *Microcystis* nor did it contain the microcystin synthetase gene, *mcyA-Cd*. This could be due to the presence of other genera of cyanobacteria such as *Anabaena* and/or *Aphanizomenon flos*-aquae which were found to cohabitate Lake Erie. Moreover, others have shown that cyanobacteria genera that carry the anatoxin synthetase genes are commonly *Anabaena, Oscillatoria and Aphanizomenon* (Rantala-Ylinen et al., 2011). Rantala-Ylinen et al. designed specific primers constructs targeting anaC genes within *Anabaena and Oscillatoria* species which led to the identification of various cyanobacterial strains harboring the anatoxin biosynthesis genes. In New

York State, anatoxin-a prevalence has been acknowledged and the detection for anatoxin-a biosynthesis genes were shown to be associated with *Anabaena, Plantothrix, Oscillatoria* and *Cylindrospermopsis* found in surface water and treated drinking water (Williams et al., 2001). Anatoxin-a was one of the most common observed by Boyer et. all 2004. Anatoxin-a was also detected at measurable quantities in Lake Ontario which also is affected by reoccurring toxic cyanobacteria blooms belonging to species of *Anabaena* (Perri et al., 2015).

Chapter 6 - Conclusion

A strong correlation has been shown between microcystin production and cyanobacteria growth rate. Experimental evidence suggests a complex association between unique physiochemical considerations and the regulation of toxin biosynthesis (Yuan, 2022). However, such factors do not operate the on-off instruction of actual production of microcystin in any strain but allow for appropriate modification. Indeed, eutrophication inducing higher nitrogen and phosphorus level encourages toxic cyanobacterial blooms. However, there is lack of evidence that higher nutrient load directly impacts the expression of microcystin genes or provides optimal conditions for toxin or non-toxin genotypes. Rather, environmental factors may influence the general community structure which subsequently shelter potentially harmful toxin producing cyanobacteria. Several studies suggest environmental regulatory factors impacting anatoxins biosynthesis, but no conclusive results have been drawn at the molecular level. Conversely, it has been shown that toxin production is not proportional to cell-growth as it relates to microcystin (Long et al. 2001). In addition, it was observed that during nitrogen depletion, anatoxin-a production was increased (Saker and Neilan, 2001).

PCR methods used for analyzing water samples in this study, while extremely sensitive in confirming the presence or absence of Cyanobacteria genes in the water source, suffer from distinct limitations. Most notably, the methods used were not designed to detect the presence of toxins that are potentially produced by harmful blooms. The detection of cyanobacteria genes, specifically from toxic species, does not confirm nor repudiate the possibility of water source contamination with cyanotoxins. Cyanotoxin synthetase genes that are present in the cyanobacteria genome are undoubtedly precursors for toxin production. Nonetheless, toxin biosynthesis involves transcriptions of genes influenced by diverse environmental factors (Gobler et al., 2007; Pimentel & Giani, 2014). Therefore, toxin biosynthesis is not constitutively active. The presence of the genes themselves may not necessarily lead to the expression of toxins. Additionally, suggestive positive correlation between gene copies and levels of toxin should be interpreted with great care (Pacheco et al., 2016). Relatively, transcripts of mRNA from the cyanotoxin synthetase genes may provide a stable association with toxin production. Thus, amplification of cDNA would be advantageous in recognizing current production of toxin in real time. Due to cyanobacteria lacking introns, primer design can be optimized for toxin synthetase genes to detect mRNA/cDNA signal leading to protein synthesis and toxin production. However, interference in transcription and the fate of the toxin itself may not always provide a significant positive correlation between the toxin levels and cDNA copy numbers (Ngwa et al., 2014).

Conventional PCR is an efficient tool for detecting the presence or absence of potential toxic cyanobacteria. It provides a cost-effective method and less complexity in comparison to qPCR (Tillett et al., 2001; Yuan et al., 2020). Cyanobacterial blooms may produce toxins when complex environmental conditions are met and require different assays and detection methods to determine the presence and level of toxins, as well as the safety of the water for human consumption. Furthermore, our methods cannot accurately quantify the amount of bacterial contamination in the water sources, nor can it differentiate between live bacteria, dead bacteria, or bacterial fragments. Further evaluation of the water using independent and specialized sources is required to properly address any quality and safety issues.

APPENDIX

Appendix A: Report of Results Sent to Participating Homeowners of Adrian, MI

PCR Detection of Cyanobacteria in Local Drinking Water

Cyanobacteria, or blue-green algae, are ubiquitous in nature and aquatic environments. These naturally occurring microorganisms thrive in aquatic systems such as fresh, brackish, and marine water bodies. Cyanobacteria are photosynthetic bacteria which utilize sunlight as a source of energy for growth. They favor warm and nutrient dense environments, allowing the bacteria to proliferate at an accelerated rate. The rapid growth causes blooms to occur, spreading across the water surface, and becoming visible due to varying pigmentation (Dittmann & Wiegand, 2006).

Cyanobacteria blooms are concerning due to the potentially harmful effects on drinking water, recreational water, and aquatic ecology. Cyanobacterial blooms have the potential to harbor harmful species. Some species can produce toxins referred to as cyanotoxins. Occurrences of blooms followed by the production of cyanotoxin have been reported in multiple bodies of water throughout the world. Cyanotoxin incidents impacting humans and animals have been previously documented (Carmichael & Boyer, 2016).

Microcystin and anatoxin are known toxins that are produced by some species of cyanobacteria inhabiting freshwater bodies (Rantala-Ylinen,2011). In this report we utilized a polymerase chain reaction (PCR) based technique to detect the presence of toxin producing cyanobacteria in collected environmental and household water samples. Results were validated and verified by comparison to extracts from lab grown cultures of toxin producing cyanobacterium species.

Water samples were collected on June 22, 2019, and September 14, 2019, in FDA compliant cylinder bottles with caps (ULINE, WI, USA). For residential water samples, approximately 1 liter of tap water was collected at the start of cold-water flow obtained from kitchen sink faucet. Field samples collection bottles were submerged 5cm - 10cm below water surface until water level reached the neck of the bottle. All samples were capped immediately after each collection. Collection bottle containing samples were placed in iced coolers and transported to the laboratory. Water samples were vacuum filtered using Whatman sterile mixed cellulose ester filter membranes, 0.45um pore size (Cole-Palmer, IL, USA). Filters were processed using ZYMOBiomics DNA Miniprep Kit for extracting genomic DNA. Resulting DNA was then amplified with PCR using cyanobacteria gene specific primers for the following:

1) *Microcystis*: PCR detection of gene MicR16S present in the Cyanobacteria genus *Microcystis*. This approach detects toxic and nontoxic strains (Rinta-Kanto et al., 2005).

2) *Microcystin* toxin gene: PCR detection of *mcyA-CD1* toxi*n* gene through amplification of a fragment in the microcystin mcyA gene, constituting a part of the microcystin synthetase gene cluster present in all microcystin toxin producing Cyanobacteria species (Hisbergues et al., 2003).

3) *Anatoxin-A* toxin: PCR detection of *anaC-gen* toxin gene through amplification of a fragment in the anatoxin C gene present in all anatoxin producing Cyanobacteria species (Rantala-Ylinen et al., 2011).

PCR products were subjected to agarose gel electrophoresis and the resulting bands were verified by comparison to the appropriate positive and negative controls of lab grown cyanobacteria species listed below detection of a Microcystis species that harbors the toxin gene but does not confirm whether the bacteria are expressing the toxin in the environment. Expression of the cyanotoxins only occurs when certain growth and environmental conditions are met. Similarly, a positive signal for anaC-gen indicates the detection of a cyanobacteria containing the *Anatoxin-A* toxin gene, however it does not allude to the presence of the anatoxin-a in the water.

	Gene of Interest		
Control Species	**MicR16S**	**mcyA-Cd1**	**anaC-gen**
Synechoccus Elongatus	-	-	-
Microcystis Spp.	+	+	-
Microcystis Aeruginosa	+	+	-
Oscillatoria Tenuis	-	-	+

[Home Owner Name]

[Residential Address]

[SampleID]

Collection Date	Gene of Interest		
	MicR16S	mcyA-Cd1	anaC-gen
06-22-2019	[result]	[result]	[result]
09-14-2019	[result]	[result]	[result]

	Gene of Interest		
Control Species	**MicR16S**	**mcyA-Cd1**	**anaC-gen**
Synechoccus Elongatus	-	-	-
Microcystis Spp.	+	+	-
Microcystis Aeruginosa	+	+	-
Oscillatoria Tenuis	-	-	+

Results:

Analysis of the samples collected June 22, 2019, revealed that out of 25 samples, 12 samples tested positive for the presence of *Microcystis* species, and 4 samples tested positive for microcystin toxin gene. The anatoxin-a gene was not detected in any of the 25 samples.

For the collection date of September 14, 2019, a total of 32 samples were evaluated. The analysis revealed that 17 samples were positive for *Microcystis* species and 1 sample was positive for microcystin toxin gene. Anatoxin-a gene was detected in one sample.

The DNA based PCR detection technique used in the analysis of the samples determines the presence of cyanobacteria and cyanotoxin genes but does not indicate whether the toxin is being actively produced by the bacteria. Samples resulting in a positive signal for the MiCR16S gene indicate the presence of cyanobacteria belonging to the genus *Microcystis* encompassing both toxic and non-toxic strains. On the other hand, a positive signal for mcy-CD1 signifies the

The methods used in this analysis, while extremely sensitive in confirming the presence or absence of Cyanobacteria genes in the water source, suffer from distinct limitations. Most notably, our methods were not designed to detect the presence of toxins that are potentially produced by harmful blooms. The detection of cyanobacteria genes, specifically from toxic species, does not confirm nor repudiate the possibility of water source contamination with cyanotoxins. Cyanobacterial blooms may produce toxins when complex environmental conditions are met and require different assays and detection methods to determine the presence, level of toxins, as well as the safety of the water for human consumption. Furthermore, our methods cannot accurately quantify the amount of bacterial contamination in the water sources, nor can it differentiate between live, killed bacteria, or bacterial fragments. Further evaluation of the water using independent and specialized sources is required to properly address any quality and safety issues.

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ABSTRACT

MOLECULAR DETECTION OF CYANOBACTERIA IN LOCAL DRINKING WATER

by

ANDREW A. JAMES

May 2022

Advisor: Dr. Ahmad R. Heydari

Major: Nutrition and Food Science

Degree: Master of Science

Cyanobacteria, also referred to as blue-green algae, are oxygenic photosynthetic, gram-negative bacteria which are ubiquitous in nature and aquatic environments. Cyanobacteria blooms can be potentially harmful, posing a threat drinking water, recreational water, and aquatic ecology as they may contain toxin producing species. Microcystin and anatoxin are known toxins that are produced by some species of cyanobacteria inhabiting freshwater bodies. For this study, we analyzed environmental and household water samples collected from Adrian, MI on June 22, and September 14, 2019, for the presence of cyanobacteria. PCR amplification was used to detect the presence of *Microcystis* using genus specific primers, as well as cyanotoxin synthetase genes for microcystin and anatoxin-a, *mcyA-Cd1* and *anaC*-gen, respectively. Results from the June collection revealed that 48% of the samples contained *Microcystis spp.* , and 4% were positive for microcystin synthetase gene. Results from the September collection revealed that 53% of the samples contained *Microcystis spp.* and 3% were positive for microcystin synthetase genes, while only one environmental sample was positive signal for anatoxin synthetase gene.

AUTOBIOGRAPHICAL STATEMENT

ANDREW A. JAMES

Education:

May 2022: Graduating	Master of Science in Nutrition and Food Science Wayne State University
August 2015	Bachelor of Science in Nutrition and Food Science Wayne State University

EXHIBIT 10

ENVIRONMENTALLY CONCERNED CITIZENS OF SOUTH CENTRAL MICHIGAN

Parameter

Date	Site #	Stream	Location	Watershed	Township	Temperature (deg. F)	Dissolved Oxygen	E coli. /100ml	Nitrate (ppm)	Nitrite (ppm)	Phosphate (PO4) (ppm)	Ammonia (ppm)	Cyanobacteria Microcystis	Cyanobacteria Planktothrix	Cyanobacteria Anabaena	Cyanotoxin Microcystin	Cyanotoxin Anatoxin	DNACattle	DNAHuman	DNASwine
6.22.2019 9:56 a.m.	5	Turner Dr. to Wolf Creek	Tipton Hwy./Hunt & Country Club	Raisin (South Branch - E. coli TMDL)	Adrian	58.7	5.83	--	2	0	**30**	0	--	--	--	--	--	--	--	--
7.25.2019 8:34 a.m.						61.7	5.11	**1000**	1	0	**30**	0	No	Yes	No	Yes	Yes	No	Yes	--
9.14.2019 10:06 a.m.						60.8	5.7	--	5	0	**30**	**0.25**	--	--	--	--	--	--	--	--
6.22.2019 10.10 a.m.	6	Wolf Creek to Lake Adrian	Tipton Hwy./Hunt & Country Club	Raisin (South Branch - E. coli TMDL)	Adrian	63.7	5.99	--	1	0	**30**	**0.25**	--	--	--	--	--	--	--	--
7.25.2019 8:29 a.m.						65.6	**4.3**	**700**	1	0	**30**	**0.25**	Yes	Yes	Yes	Yes	Yes	Yes	Yes	--
9.14.2019 10.46 a.m.						60.5	5.33	**--**	2.5	0	**30**	**0.25**	--	--	--	--	--	--	--	--

Key Sampling Parameters:

Parameter	***In Natural Streams***	***Of Concern***	***MI Water Quality Standards***
Ammonia	0.01-0.10 mg/L	above 0.10 mg/L	------
Total Phosphorus	0.05-0.10 m/L	above .10 mg/L	1 mg/L or less (r (convert PO4 to P: *.3262)
Orthophosphate	.005 mg/L	above .005 mg/L	------
Nitrate	varies	above 10 mg/L	10 mg/L (drinking water/point sources)
BOD5	4-10 mg/L	above 15 mg/L	-----
DO	5-13 mg/L	below 5 mg/L	5.0 mg/L or higher (warmwater streams)
		below 7 mg/L	7.0 mg/L or higher (coldwater streams)
Fecal Coliform	varies	above 2,000 mg/L	----
E. coli	varies	above 1,000/100mL	1,000/100 mg/L or less (partial body contact)
			130/100 mg/L or less (30-day avg.), 300/100 mg/L (daily) (total body contact) (TMDL)
			0 mg/L (drinking water)

adapted from "Key Sampling Parameters" fact sheet, Ohio EPA; Michigan Water Standards (Administrative Rules Part , P. O. 51, Natural Resources and Environmental Protection Act), and from http://www.epa.go/safewater/mcl.html

Note: mg/L is approximately, but not exactly, equivalent to ppm

EXHIBIT 11

Testimony Excerpt of

EGLE Senior Aquatic Biologist;

Molly Rippke

STATE OF MICHIGAN

MICHIGAN ADMINISTRATION HEARING SYSTEM

In the matter of:	Docket No.:	20-009773
Petition of Michigan Farm Bureau; Michigan Milk Producers Association; Michigan Allied Poultry Industries; Foremost Farms USA; Michigan Pork Producers Association; Dairy Farmers of America; Select Milk Producers, Inc.; and 126 Identified Livestock Farms /	Permit No.:	MIG010000
	Part:	Part 31, Water Resources Protection
	Agency:	Department of Environment, Great Lakes and Energy
	Case Type:	Water Resources Division

HEARING - VOLUME NO. V

BEFORE DANIEL PULTER, ADMINISTRATIVE LAW JUDGE

Via Microsoft Teams Meeting

Friday, December 10, 2021, 9:00 a.m.

APPEARANCES:

For the Petitioners:
MR. ZACHARY CHAD LARSEN (P72189)
MR. MICHAEL JOHN PATTWELL (P72419)
Clark Hill, PLC
212 East Cesar E. Chavez Avenue
Lansing, Michigan 48906
(517) 318-3053

For the Respondent:
MS. ELIZABETH ANNE MORRISSEAU (P81899)
MS. JENNIFER A. ROSA (P58226)
Assistant Attorneys General
Department of Attorney General
525 West Ottawa Street
G. Mennen Building, 6th Floor
Lansing, Michigan 48933
(517) 373-7540

the risk that a person will be impacted if they accidentally ingest or contact the water. We have a PBC water quality standard to protect public health during recreation year-round because of the risk during skin contact. During the summer, we have a more conservative TBC E. coli standard to protect people while swimming. The TBC Water Quality Standard applies during May through October and is 300 E. coli/100 milliliters (mL) as a daily maximum and 130 E. coli/100 mL as a 30-day geometric mean. Throughout the rest of the year, the PBC Water Quality Standard of 1000 E. coli/100 mL applies. Partial Body Contact of contaminated water can cause illness by infection of wounds, or indirect entry to the body (e.g., hand to mouth, hand to eyes, etc.). Diseases associated with Total Body Contact in waters contaminated by fecal material (indicated by high E. coli) include gastroenteritis, cryptosporidiosis, cholera, and other intestinal parasites. As a precaution, when E. coli is found to be above a threshold or contamination has occurred, such as a known spill of sewage or manure, local health departments may close beaches, boat launches, or sections of rivers by posting warnings. This has economic repercussions in the form of lost tourism dollars, in addition to the direct health impacts if people contact the water.

A Can you describe how the Department monitors the amount of in E. coli TMDL watersheds?

A **Most definitely if there are CAFOs that are covered by this permit, yes, I would say that is true.**

Q Okay. And there's nothing in the 2015 permit on these issues that would prevent a release of E. coli into an already impaired waterbody because of the issues that you mentioned on page 26; is that right?

A **These issues are out -- I'm sorry. I don't really understand the question. Could you rephrase it?**

Q I'm just wondering if part of your concern here is that these deficiencies in the 2015 permit could allow E. coli to enter already impaired TMDLs?

A **Yes, that is absolutely true. I am concerned that the 2015 permit was not protective enough for water quality. The wheat stubble example to me is a big issue because they are -- the CAFOs are potentially putting manure on top of wheat stubble where it's exposed to rain and typically the wheat harvest is in the middle of the summer when people are swimming. And if you get a heavy, unexpected rainfall and they could have tilled that in because it's a tillable field but they don't because the permit allows them to not till it in, it could expose people recreating in surface waters to high levels of E. coli in the middle of summer. So we have -- I have concerns about the winter and I have concerns about the summer as well.**

noon and that would be fine.
JUDGE PULTER: Okay.

EXAMINATION

BY JUDGE PULTER:

Q I want to talk about statistics first. It's been awhile since I've had statistics. But my recollection of why you need to normalize or use a logarithmic scale or natural log as you called it is because the variability of your numbers it's impossible to chart it on a graph. Is that -- is that a fair statement?

A I wouldn't say impossible, but it does --

Q Wouldn't you have to have a pretty big graph?

A Well, that -- yes, that's true.

Q Okay. So -- so a lot of times -- in my experience we used a logarithmic scale on our graphs and then we didn't have to run the natural log; is that a fair -- is that a fair difference in the two types?

A Oh, there's two different -- there's a lot of different ways you can normalize your data. So you can use a log scale based ten or -- or a natural log transformation, or the -- there's a number of other transformations that you can use, too. But, yeah, the idea is to make the data more manageable and you do equally apply that calculation to every single data point. You don't get to pick and choose which ones you do it to. So really it just makes that

EXHIBIT 12

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April 2010

Ohio Environmental Protection Agency
Division of Surface Water

Ohio Lake Erie Phosphorus Task Force Final Report

Ted Strickland, Governor
Lee Fisher, Lt. Governor
Chris Korleski, Director

Acknowledgements

The Ohio Lake Erie Phosphorus Task Force was comprised of the following members:

- Ohio Farm Bureau Federation – Larry Antosch
- Heidelberg University, National Center for Water Quality Research – Dave Baker, Jack Kramer and R. Peter Richards
- Ohio State University, Environment and Natural Resources – Nick Basta, Libby Dayton
- Ohio State University, College of Biological Sciences – David Culver
- Ohio State University Sea Grant – Jeff Reutter
- Ohio State University Extension – Robert Mullen
- U.S. EPA, Great Lakes National Program Office – Paul Bertram
- University of Toledo – Thomas Bridgeman
- U.S. Geological Survey – Dan Button
- Natural Resource Conservation Service – Steve Davis, Mark Scarpitti
- Ohio Department of Agriculture – Kevin Elder
- U.S. Department of Agriculture, Agriculture Research Service – Norm Fausey
- Conservation Action Project and Henry County SWCD – Todd Hesterman
- Northeast Ohio Regional Sewer District – Seth Hothem
- Ohio Department of Natural Resources, Soil and Water – John Kessler
- Ohio Department of Natural Resources, Wildlife – Roger Knight
- Case Western Reserve University – Gerald Matisoff
- Ohio Lake Erie Office – Chris Riddle
- Ohio Academy of Science/Ohio Fractured Flow Work Group– Julie Weatherington-Rice
- Ohio Environmental Protection Agency, Surface Water – Gail Hesse (Chair), Julie Letterhos and Rick Wilson

Observers

- Eric Partee, Little Miami Inc.
- Joe Logan, Ohio Environmental Council
- Ron Wyss

The Task Force would like to thank all the invited presenters who shared their expertise with the group. Presenters included: Amy Jo Klei, Erin Sherer, Robert Miltner, Randy Bournique and Trinka Mount from Ohio EPA; Dan Mecklenburg and Kirk Hines from ODNR; Kevin King from USDA, Agricultural Research Service; Chris Wible from The Scotts Miracle-Gro Company; Joe DePinto from Limnotech; Robert Bonnett from the Northeast Ohio Regional Sewer District; Jim Stafford and Mike Monnin from NRCS; and John Crumrine from Heidelberg University.

The Task Force would like to thank Bob Heitzman of Ohio EPA for maintaining the Phosphorus Task Force Web site. All presentations, minutes, handouts and other information, including an executive summary of this report, can be found at: *www.epa.ohio.gov/dsw/lakeerie/ptaskforce/index.aspx*.

Finally, the Task Force would like to thank Ohio EPA Director Chris Korleski for sponsoring and supporting the work of the Task Force.

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Acronyms

AGNPS	Agricultural Nonpoint Source Pollution Model
ARS	Agricultural Research Service
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
CAP	Conservation Action Project
CCA	Certified Crop Advisor
CNMP	Comprehensive Nutrient Management Plan
CPPE	Conservation Physical Practice Effects
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CSO	Combined Sewer Overflow
CSP	Conservation Stewardship Program
DAP	Diammonium Phosphate
DRP	Dissolved Reactive Phosphorus
DSWC	Ohio Department of Natural Resources Division of Soil & Water Conservation
EMC	Event Mean Concentration
EQIP	Environmental Quality Incentives Program
FOTG	Field Office Technical Guide of the USDA NRCS
FWMC	Flow-Weighted Mean Concentration
FSA	Farm Service Agency
GLNPO	Great Lakes National Program Office
GLRI	Great Lakes Restoration Initiative
GLWQA	Great Lakes Water Quality Agreement
GPD	Gallons per Day
HABs	Harmful Algal Blooms
HSTS	Home Sewage Treatment System
HUC	Hydrologic Unit Code
IJC	International Joint Commission
LEB	Lake Erie Basin
LEWMS	Lake Erie Wastewater Management Study
MGD	Million Gallons per Day

MMP	Manure Management Plan or Manure Management Planner
MOU	Memorandum of Understanding
MS4	Municipal Separate Storm Sewer System
MT	Metric Tonnes
MTA	Metric Tonnes per Year
NASS	National Agricultural Statistics Service
NLCD	National Land Cover Data
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resource Conservation Service
NURP	National Urban Runoff Program
ODA	Ohio Department of Agriculture
ODNR	Ohio Department of Natural Resources
OEPA	Ohio Environmental Protection Agency
OLICA	Ohio Land Improvement Contractors of America
OSU	The Ohio State University
P	Phosphorus
PCS	Permit Compliance System
PLUARG	Pollution from Land Use Activities Reference Group
PPM	Parts per Million
PWS	Public Water Supply
RDP	Runoff Dissolved Phosphorus (same as DRP)
STP	Soil Test Phosphorus
STRAP	Soil Test Risk Assessment Procedure
SWAT	Soil and Water Assessment Tool (Model)
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSP	Technical Service Provider
USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WQ	Water Quality
WWTP	Wastewater Treatment Plant

Glossary

Agricultural Nonpoint Source Model (AGNPS)
A distributed event-based model that simulates surface runoff and sediment and nutrient transport, primarily used for agricultural watersheds

Buffer Strip
An area that is seeded to grass that can be used for filtering pollutants and provide wildlife habitat. They are also called filter strips, filtered areas, field borders, conservation cover and herbaceous riparian cover (shady habitat)

Conservation Tillage/Mulch Tillage
Tillage that breaks up the soil but leaves at least 30% of crop residue from the previous year on the soil surface

Controlled Traffic
Using the same wheel track for field operations to limit soil compaction

Conventional Tillage
Uses moldboard plowing or other intensive tillage that buries all previous year's residue and destroys the natural soil structure

Cover Crops
Used between crop cycles to reduce compaction, recycle nutrients, reduce erosion, improve soil tilth and structure, and fix nitrogen

Diagenesis
The physical and chemical changes occurring in sediments during and after the period of deposition up until the time of consolidation

Flow-weighted Mean Concentration
The sample concentration weighted by both the time and the flow that accompanied it. The FWMC represents the total load for the time period divided by the total discharge for the time period

Interstadial
A warmer subdivision within a glacial stage marking a temporary retreat of the ice

Lateral splitting
The practice of laying additional drainage tiles parallel to existing tiles to create closer spacing and better drainage. Lateral tiles drain into mains

Macropores
Cavities in the soil created by such agents as plant roots, soil cracks or soil fauna such as earthworms. Macropores increase the hydraulic conductivity of the soil, allowing water to infiltrate faster or for shallow groundwater to flow faster.

Manure brokering
Practice of buying/selling excess manure from livestock operations. In the context of this report, it may lead to manure being removed from the watershed where it was created or imported to a watershed where it was not created.

No-Till/Strip-Till/Direct Seed
Planting in the crop residue of the previous year with no soil disturbance

P Index
Modeling tool to assess the risk for runoff of phosphorus from the landscape to a water body

Producer
Farmer

Ridge-Till
Use of specialized equipment builds a ridge where seeds are planted. The ridge is drier and warmer and promotes earlier germination

Rotational Tillage
Practice that alternates no-till with conventional tillage

RTK auto steer
Uses GPS that is programmed to steer the tractor into a particular traffic pattern

Soil and Water Assessment Tool (SWAT)
A river basin scale model developed to quantify the impact of land management practices in large, complex watersheds

Sub-surface mains
The collector tile of sub-surface drainage systems that may consist of a number of connected underground pipes (tiles)

Tile Drainage
Series of underground tiles that are installed on poorly drained soils to improve soil quality and water infiltration, reduce compaction, improve crop yields, and potentially provide a system to control the amount of surface runoff

Tri-State
This refers to the partnership of the university agricultural research departments that set agricultural standards in the tri-state area of Michigan, Ohio and Indiana. The three schools are Michigan State University, the Ohio State University and Purdue University

Water Year
Covers the period from October to September

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Section 1 — Introduction

Lake Erie in the 1960s and 1970s was highly eutrophic and subject to extensive algal blooms. The widespread adoption of phosphorus control programs reversed the highly eutrophic conditions and eliminated the algal blooms in Lake Erie by the 1980s. However, in the mid 1990s, blue-green algal blooms began to reappear in the western basin. A particularly massive bloom of *Microcystis aeruginosa* occurred in 2003. In 2006, the benthic mat-forming blue-green alga (cyanobacterium) *Lyngbya wollei* began growing profusely in Maumee Bay and washing up along the shoreline. Both *Microcystis* and *Lyngbya* produce toxins that can be potentially harmful to humans, animals and aquatic life via ingestion or contact. They are some of the species associated with harmful algal blooms (HABs) occurring in many areas around the country. Many shoreline areas around Lake Erie are again experiencing nuisance growths of the green filamentous algae *Cladophora*. Hypoxia/anoxia in the central basin hypolimnion is expanding both spatially and temporally. The increasingly eutrophic conditions may also be impacting the fishery. Walleye and yellow perch populations have been showing long term declining trends since the 1990s, and there has not been a good hatch of walleye since 2003. Coincidental to the increasing degradation of the lake, Heidelberg University's tributary monitoring program noted an increasing trend in dissolved reactive phosphorus (DRP) loads, also beginning in the mid 1990s, despite the fact that total phosphorus loads were not increasing. The increasing DRP was of particular concern because it is almost 100% bioavailable to support algal growth.

In January 2007, in consultation with Heidelberg University, Ohio EPA convened the Ohio Lake Erie Phosphorus Task Force. The goals of the Task Force were: to identify and evaluate potential point and nonpoint sources of phosphorus to Ohio tributaries; determine what practices may have changed since 1995 that could increase DRP loads; examine various aspects of agriculture that might influence the increase in DRP loads; review the possible/probable relationships of the increased DRP loads to the eutrophication problems that have returned to Lake Erie (particularly the western basin); consider the impacts of zebra and quagga mussels in altering the internal cycling of phosphorus in the lake itself; determine if these issues were unique to Lake Erie or occurring on a broader basis; identify research and monitoring needs; and recommend management actions that could be implemented to alleviate current conditions. The Task Force included representatives from state and federal agencies, Lake Erie researchers, soil scientists, agricultural program representatives and wastewater treatment plant personnel. Experts in a variety of disciplines were invited to provide presentations and additional insight into issues beyond the expertise of Task Force members.

This report presents the findings of the Task Force along with recommendations for future management actions for Ohio. A lakewide approach to phosphorus management is currently being pursued as a priority under the Lake Erie Lakewide Management Plan (LaMP). The Task Force has had input into identifying research and monitoring programs currently being funded by the Ohio Lake Erie Protection Fund and U.S. EPA Great Lakes National Program Office to better understand the reasons for the increasing trend in DRP and the connection to the return of blue-green algal blooms and the degradation of the lake.

An executive summary for this report
is available online at
www.epa.ohio.gov/dsw/lakeerie/ptaskforce/index.aspx.

Section 2 — Background

2.1 — An Overview of Historical Phosphorus Control Programs for Lake Erie

In the 1960s excessive growth of the blue-green algae (cyanobacteria) A*nabaena* and *Aphanizomenon,* along with *Microcystis aeruginosa* covered the western basin in late summer and early fall. These blooms caused taste and odor problems in drinking water supplies, stressed the aquatic community and fouled beaches. Extensive growth of the filamentous green alga *Cladophora glomerata* covered shorelines and hard substrates in shallower waters. The decomposition of this excessive algal growth contributed to widespread oxygen depletion in the deeper waters of the central basin. Total phosphorus loads in excess of 25,000 metric tonnes/year were identified as the major cause of the excessive algal growth. The United States and Canada signed the Great Lakes Water Quality Agreement (GLWQA) in 1972 to begin a bi-national effort to reduce phosphorus loads and the degradation of the Great Lakes.

The Federal Clean Water Act of 1972 authorized the U.S. Army Corps of Engineers to conduct the Lake Erie Wastewater Management Study (LEWMS) to set the course for the restoration of the lake (U.S. Army Corps of Engineers 1975). The Corps initiated detailed monitoring programs to accurately determine the total amounts of phosphorus entering the lake, as well as the relative importance of wastewater treatment plant (WWTP) effluents (point sources) versus land runoff (nonpoint sources). Similar monitoring programs were initiated throughout the Great Lakes as part of the International Joint Commission's Pollution from Land Use Activities Reference Group (PLUARG) studies (International Joint Commission 1978, 1980). Initial programs to reduce phosphorus loading focused on limiting the discharge from WWTPs and eliminating phosphorus in laundry detergents. These sources produced dissolved phosphorus that was nearly 100% bioavailable.

The LEWMS and PLUARG programs used the general approach for quantifying nonpoint source phosphorus contributions that is summarized in Figure 1. The total watershed phosphorus export is measured at the most downstream gauging/monitoring station. The point source inputs upstream of this station are subtracted from the total watershed measurement to get an estimate of the nonpoint source component of the total load. This approach assumes that 100% of the point source phosphorus load entering streams is delivered to the monitoring station, while in reality, this phosphorus is largely assimilated by stream bed materials and biota before it reaches the monitoring station. During subsequent flood events, portions of this material may be re-suspended and deposited on flood plains or washed out into the lake. The procedure shown in Figure 1 thus results in over-estimation of point source contributions to total watershed export and under-estimation of the nonpoint source contributions, but by largely unknown amounts.

In the late 1970s, modeling studies of the relationships among total phosphorus (TP) loading to the lake, concentrations in the lake, algal population densities, and oxygen depletion rates in the central basin led to the establishment of a TP target load for Lake Erie of 11,000 metric tonnes per year (MTA). The models predicted the achievement of this goal would alleviate the problems associated with excessive algal growth. This target was incorporated in the GLWQA. To meet these targets, the GLWQA set a TP limit of 1 mg/L in the effluent from major WWTPs discharging more than 1 million gallons per day (MGD). Further, although not included in the GLWQA, corresponding TP concentration targets were set at 15 µg/L for the western basin and 10 µg/L for the central and eastern basins.

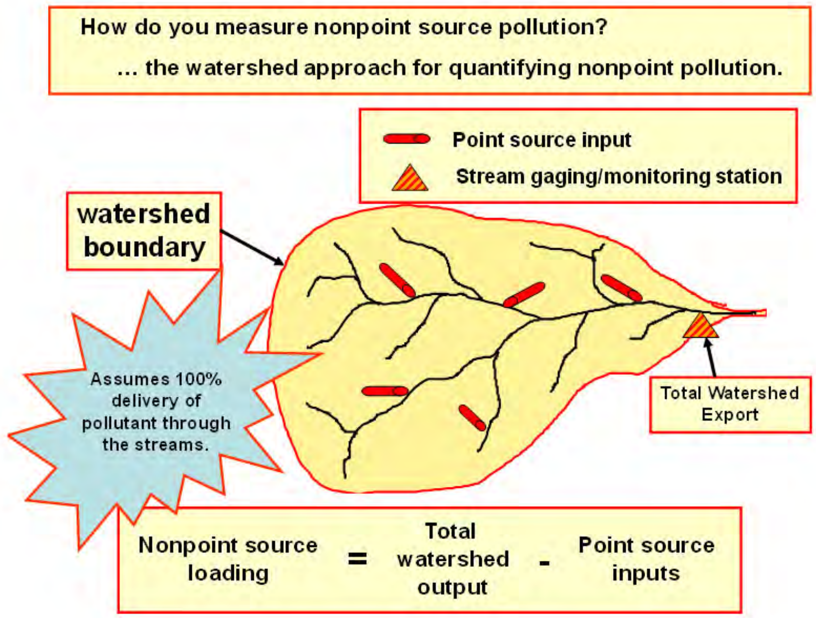


Figure 1 — Conceptual diagram for the procedures used by the IJC to calculate the contributions of phosphorus to the Great Lakes from nonpoint sources. (Graphic produced by David Baker, Heidelberg University)

By 1980, with many of the major WWTPs meeting the 1 mg/L TP limit, agricultural nonpoint sources became the major contributor of phosphorus to Lake Erie (Figure 2). To consistently reach the target load, agricultural nonpoint source loads to the Lake would need to be reduced. Since 75 to 90% of the agricultural phosphorus load was attached to sediment particles, the use of no-till and reduced till conservation practices were promoted (US Army Corps of Engineers, 1979). These measures became the dominant cropping practices in Northwest Ohio through the late 1980s and early 1990s, especially for soybean and wheat production. Increasing use of streamside buffers and set-aside programs for highly erodible land under the Ohio Lake Erie Conservation Reserve Enhancement Program also contributed to reductions in the sediment and associated particulate phosphorus load.

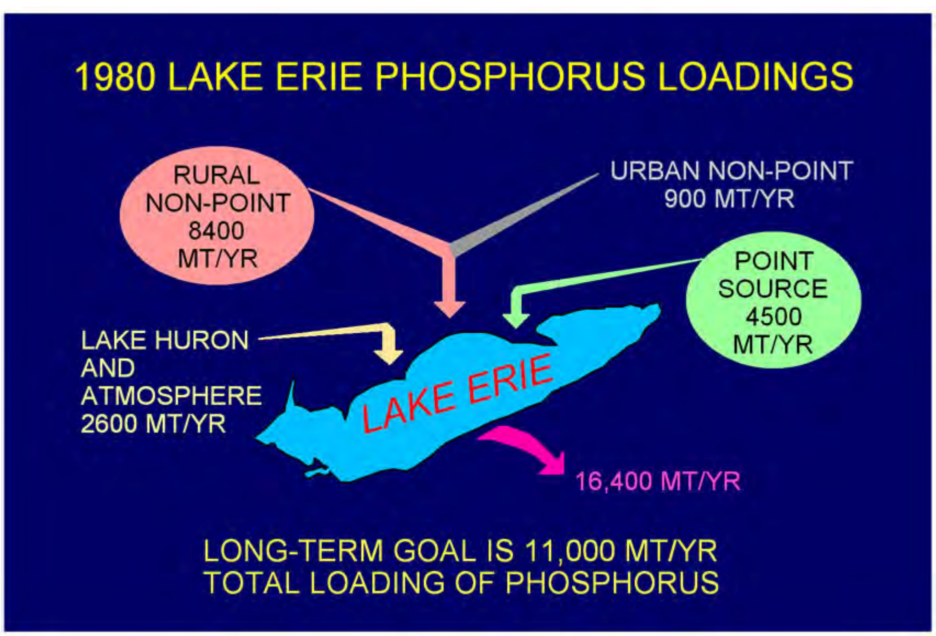


Figure 2 — 1980 mass balance of phosphorus loading to Lake Erie. (U. S. Army Corps of Engineers, 1983)

Figures 3, 4 and 5 show the trends in annual phosphorus loads to Lake Erie. Figure 3 represents the contributions from all sources. Figure 4 depicts the large and rapid reductions in point source loads that occurred in the 1970s as major WWTPs in both the United States and Canada came into compliance with phosphorus effluent limitations of 1 mg/L. Figure 5 shows the large year-to-year variability in the nonpoint source contributions to Lake Erie, reflecting weather-induced (precipitation) influence on river discharges and associated sediment and nutrient loads.

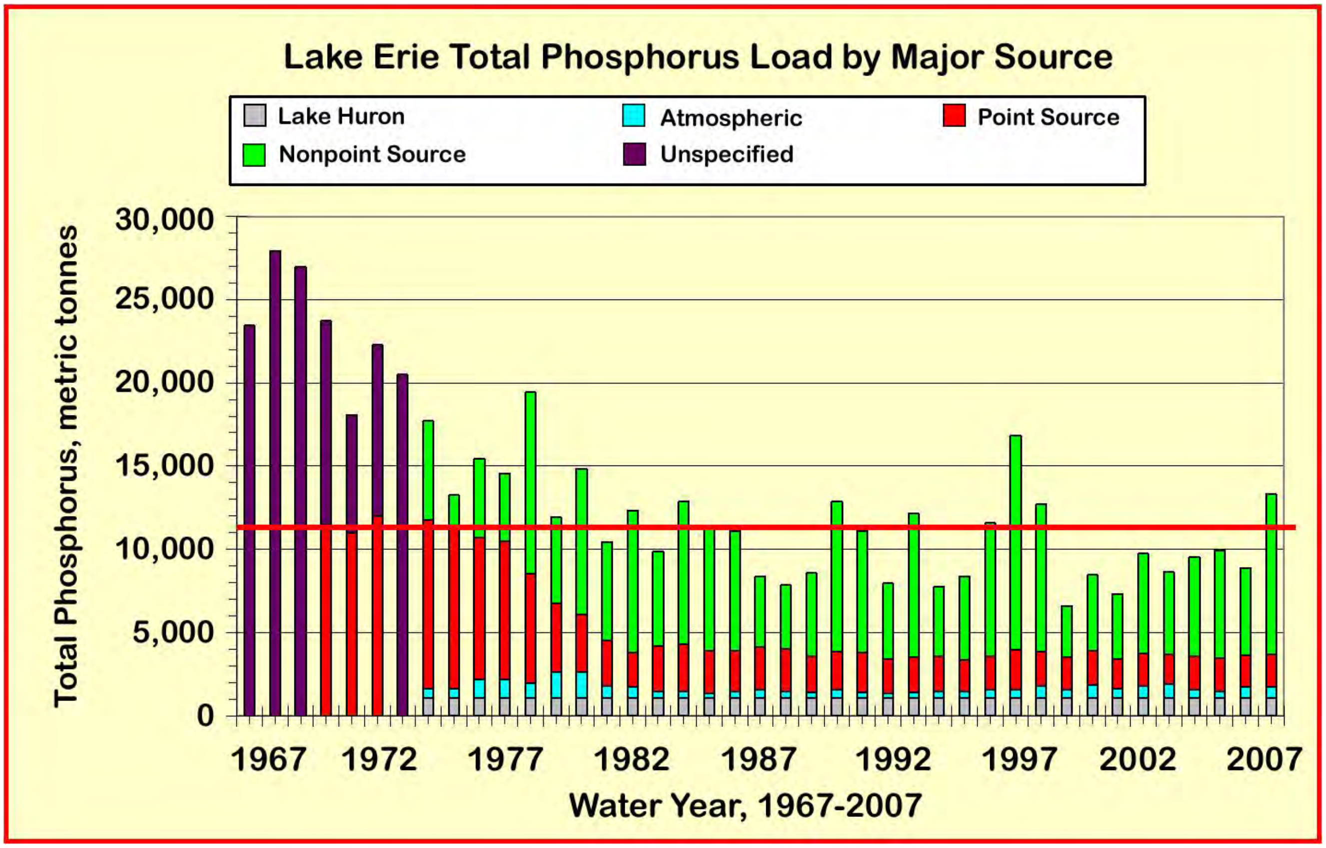


Figure 3— Annual loading of total phosphorus to Lake Erie, 1967 – 2007.
(Historical data from David Rockwell, U.S.EPA and David Dolan, University of Wisconsin Green Bay. Data from 2002-2007 are based on personal communication from David Dolan to David Baker, Heidelberg University. Graph prepared by David Baker)

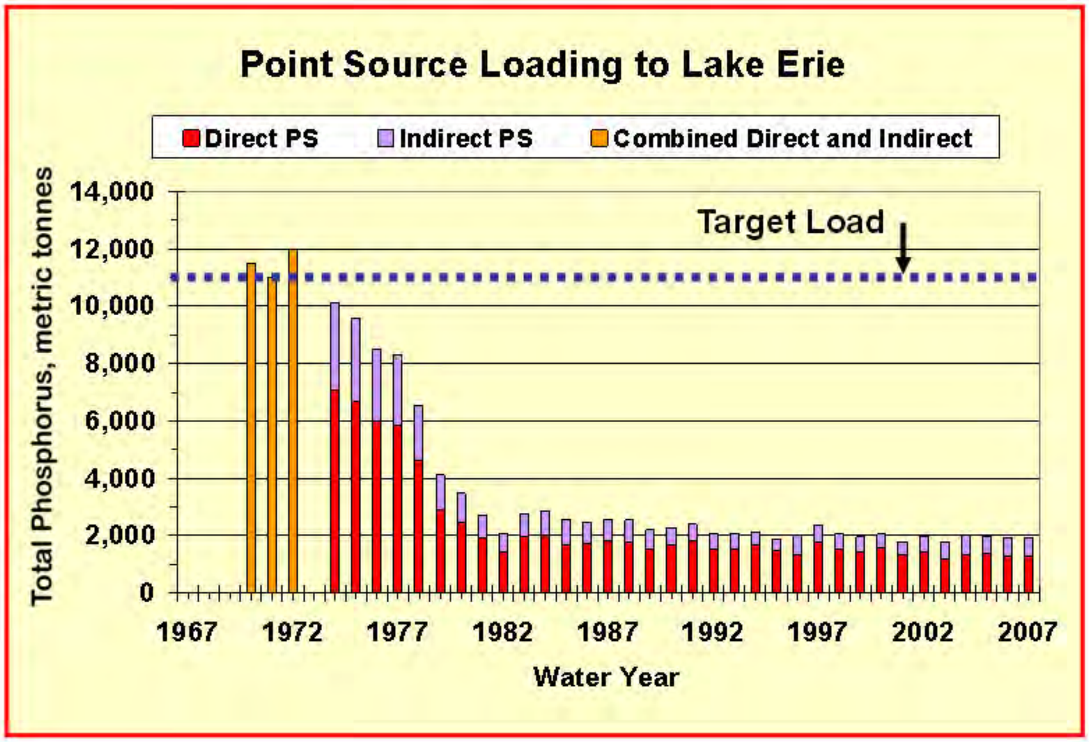


Figure 4— Point source loads to Lake Erie highlighting the large and rapid reductions from wastewater treatment plants in the 1970s. (Subset of data from Figure 3 prepared by David Baker, Heidelberg University)

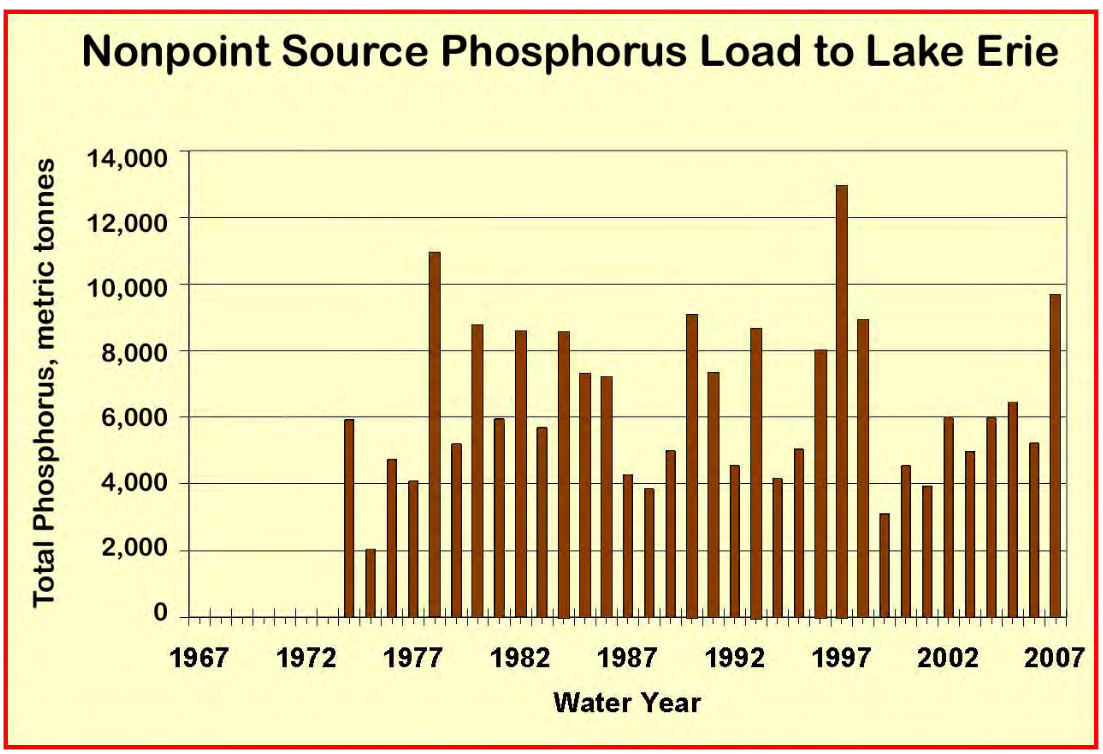


Figure 5— Nonpoint source loads of TP to Lake Erie reflecting weather-induced variability. (Subset of data from Figure 3, Prepared by David Baker, Heidelberg University)

The data shown in Figure 3 reveal that the target load of 11,000 metric tonnes was first reached in 1981. Since that time, the target load has been achieved in most years, with the exceptions limited to years of high precipitation. Conditions in Lake Erie improved dramatically up until the mid 1990s, when problems associated with eutrophication began to reappear.

In 1995, *Microcystis aeruginosa* blooms began to occur in the western basin and recurred with varying intensity through 2002. In August 2003, a massive bloom of *Microcystis* formed in the western basin and persisted for nearly a month. Blooms also occurred in 2004, 2005, and 2006, with particularly extensive blooms in 2007 and 2008. The 2009 bloom extended into the central basin. Not only did surface scums impair recreation and aesthetics, they caused taste and odor problems at water supplies. Elevated concentrations of the toxin microcystin threatened water supplies and at times created potentially harmful exposures to animals, wildlife, fish and humans (NOAA, 2009). In 2006, a benthic mat-forming blue-green alga tentatively identified as the cyanobacterium *Lyngbya wollei* emerged in Maumee Bay and began coating the shoreline in thick foul-smelling mats. The filamentous green alga *Cladophora* once again grew profusely along shorelines and the lake bottom where there was hard substrate. Oxygen depletion rates in the central basin were also increasing.

It is important to note that shoreline algal problems are now more localized and there is a different assemblage of blue-green and green algae than in the past. This may suggest that different mechanisms are now in place and the phosphorus control measures needed may differ from controls used previously. This “re-eutrophication” of Lake Erie has occurred during a time in which total phosphorus loading has remained relatively constant (Figure 3). A variety of potential causes have been proposed, including: 1) increased internal loading of phosphorus (release of phosphorus from bottom sediments to the water column possibly mediated by zebra and/or quagga mussels); 2) underestimation of phosphorus inputs from sources such as urban storm water; 3) changes in overall nutrient balances in the lake and related adaptations of nutrient uptake mechanisms by algae and bacteria (including changes in dominant species); 4) changes in bioavailable phosphorus loading that do not parallel changes in total phosphorus loading; and 5) changes in weather/climate conditions affecting physical conditions in the lake (lake levels, temperatures, wind events, etc.).

Several large scale studies have been mounted to address these questions. These include the Lake Erie Trophic Status (LETS) collaborative study (Matisoff and Ciborowski, 2005) and the Ecological Forecasting Hypoxia Assessment in Lake Erie (ECOFORE 2006). Additional studies were initiated in 2009 as part of the joint Canadian–U.S. Lake Erie Intensive Monitoring Year and a set of related studies being funded by the U.S. EPA’s Great Lakes National Program Office and the Ohio Lake Erie Protection Fund.

2.2 — Current Phosphorus Loading Patterns to Lake Erie

For purposes of this analysis, the Lake Erie watershed is divided into three areas: 1) the connecting channel consisting of the St. Clair River, Lake St. Clair and the Detroit River; 2) the western basin from the mouth of the Detroit River to a line drawn from Point Pelee to Cedar Point; and 3) the combined central and eastern basins. The drainage area going into each of these components of the Lake Erie system is shown in Figure 6. Since the western basin receives the land drainage from both the connecting channel and its own watersheds, about 65% of the total drainage from the Lake Erie watershed enters the western basin. According to Bolsenga and Herdendorf (1993), the shoreline along the central and eastern basins make up 68% of the total Lake Erie shoreline, while the western basin contains 32% of the shoreline. Thus the amount of land area contributing pollutants to nearshore waters per mile of shoreline is much greater in the western basin than in the central and eastern basins.

Estimates of the distribution of external phosphorus load into each area are shown in Table 1 and Figure 6. The nonpoint source loads included in these estimates are based on extrapolation from the tributary loading program conducted by Heidelberg University. Comparable data are not available for Canadian tributaries. Nonpoint sources are responsible for about 60.8% of the total phosphorus load in comparison to about 20.7% for point sources (Table 1). The majority of the point source load to Lake Erie is derived from watersheds draining into the connecting channels while the majority of the nonpoint source load comes from watersheds draining into the western basin (Figure 6).

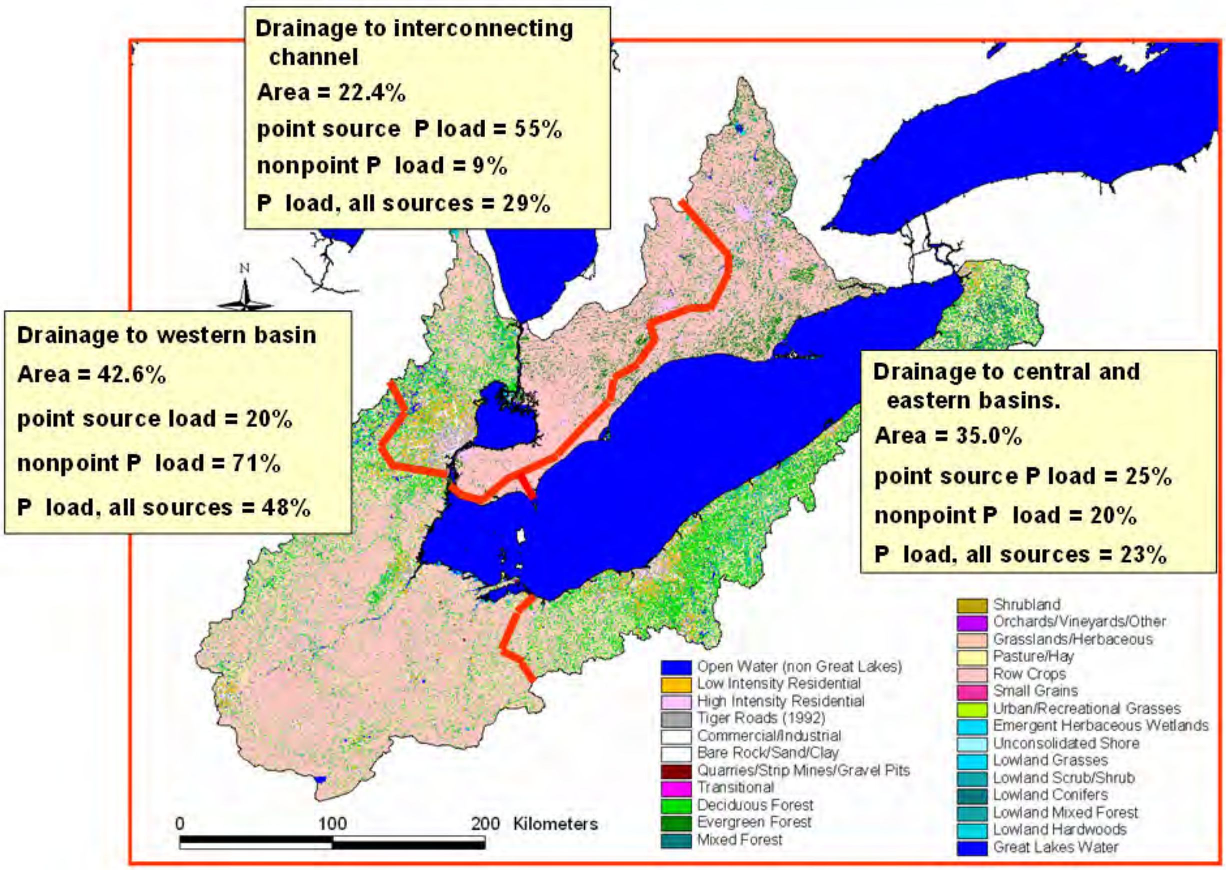


Figure 6— Land areas draining into the three major sub-basins of Lake Erie, along with the corresponding contributions of total phosphorus. (Base map provided by Thomas Hollenhorst, University of Minnesota, Duluth, with phosphorus load allocations calculated by David Baker using data provided by David Dolan, University of Wisconsin, Green Bay and Heidelberg University)

Ohio contributes about 34% of the point source load to Lake Erie (Figure 7), most of which is discharged to the central basin. Ohio is the major contributor to the nonpoint source phosphorus load entering the western basin. Ohio contains 80% of the land area of the watersheds draining directly into the western basin-Sandusky Bay area, excluding the watersheds draining into the connecting channels. While about 27% of the Maumee River watershed lies outside of Ohio in either Michigan or Indiana, these states provide only about 19% of the combined Maumee to Sandusky drainage area. Ontario has minimal land area that drains directly into the western basin (Figure 6). Since the unit area phosphorus load from the Ohio tributaries to the western basin is about twice as high as those of the Michigan tributaries, it is clear that Ohio is responsible for a large proportion of the total nonpoint source load into the western basin, and hence into all of Lake Erie. Overall, Ohio's land area makes up about 55% of the US drainage to the lake and about 39% of the total US-Canadian drainage to the lake.

Table 1— Approximate distribution of phosphorus entering each component of the Lake Erie system from various external phosphorus sources, 1998 - 2005. (MTA – Metric tonnes/year)

External Phosphorus Source	Connecting Channel MTA	Western Basin MTA	Central/Eastern Basin MTA	Total Loads MTA	Percent of Total
Nonpoint	522	3,987	1,094	5,604	60.8%
Point	1,051	388	469	1,908	20.7%
Upper Lakes	1,080	0	0	1,080	11.7%
Atmospheric		80	548	628	6.8%
Total	2,653	4,455	2,111	9,220	100%
Percent of total	**29%**	**48%**	**23%**	**100%**	

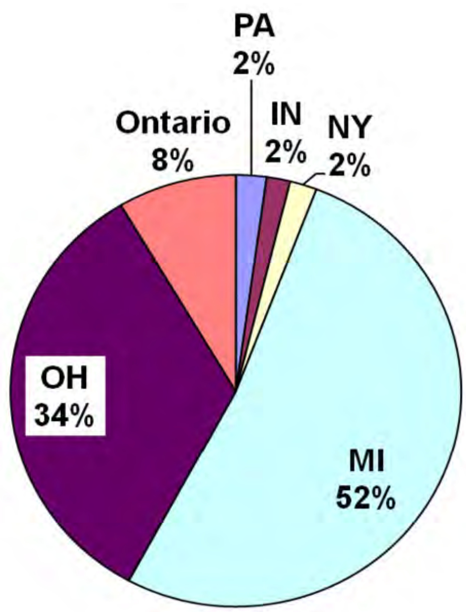


Figure 7 — Percent of total phosphorus point source load to Lake Erie by political jurisdiction, 2004. (Graph by David Baker, Heidelberg University based on data provided by David Dolan, University of Wisconsin, Green Bay)

The phosphorus concentrations in the tributaries entering Lake Erie also vary. The flow-weighted mean concentrations of TP and, where available, DRP are shown in Figure 8 for the mouth of the Detroit River, as well as for five Lake Erie tributaries monitored by Heidelberg University. Flow-weighted concentrations largely reflect the concentrations during high flow periods when the majority of the phosphorus enters the Lake. Although 29% of the TP load to Lake Erie enters from the connecting channels, the TP concentration at the mouth of the Detroit River is very low (13 µg/L). The large volume of water entering the St. Clair River from Lake Huron with very low TP concentrations simply dilutes both the point and nonpoint source inputs into the connecting channels. The highest concentrations for both TP and DRP occur in the Maumee and Sandusky rivers, while the lowest concentrations occur in the Grand River (Ohio). The Grand River watershed has similar land use to that of much of the United States drainage to the central and eastern basins of the Lake east of Cleveland. The concentrations of phosphorus entering the western basin from the Michigan tributaries (River Raisin) are also lower than those of the Maumee and Sandusky rivers.

The elevated sediment and nutrient concentrations of the Maumee and Sandusky rivers likely contribute to the sediment and algal plumes frequently observed from satellite images and aerial photography. These plumes often appear to be emanating from these rivers into the western basin and Sandusky Bay. Comparable algal and sediment plumes are not seen in the flows from the Detroit River. Since the Maumee and Sandusky have the highest DRP loads by far, this study will focus on those areas for further investigation and implementation of recommendations.

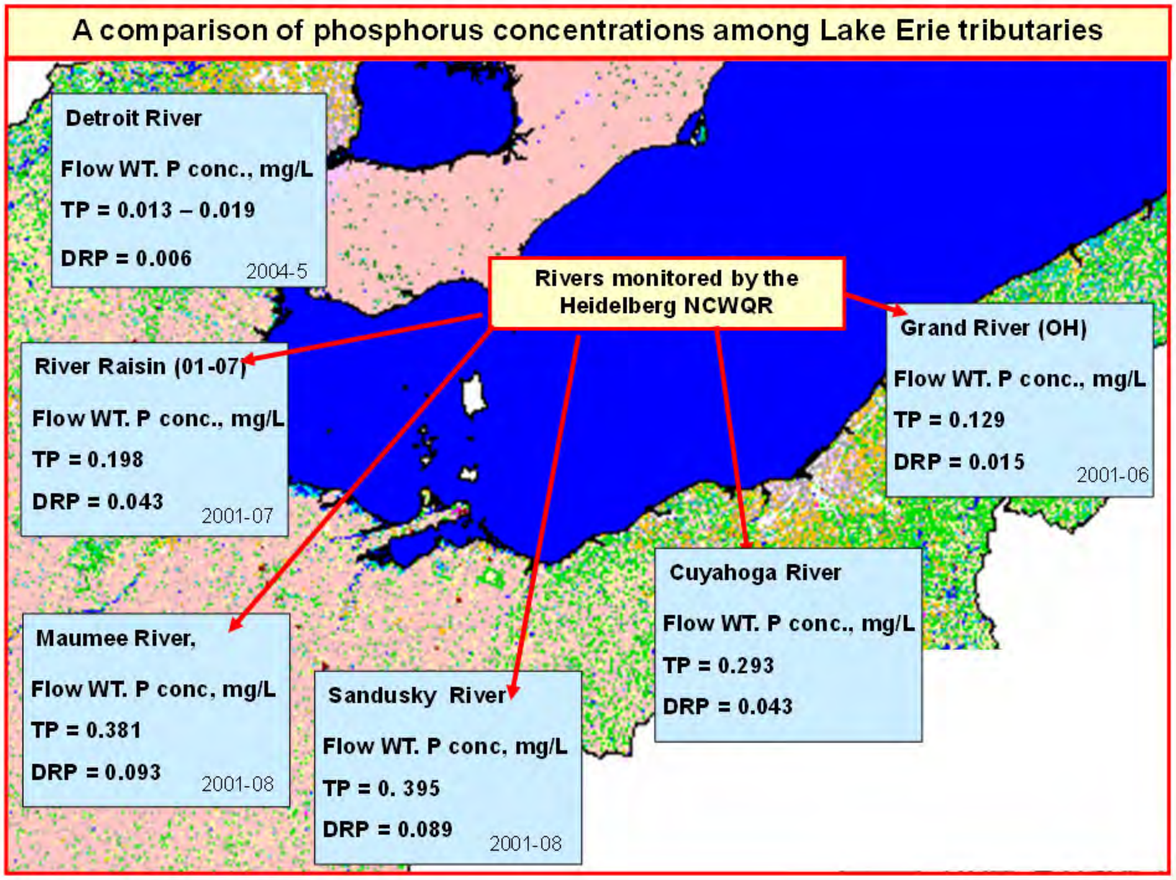


Figure 8 — Flow-weighted concentrations of TP and DRP in tributaries entering Lake Erie. (Based on data from the Heidelberg University Tributary Monitoring Program as supported by the Ohio Department of Natural Resources and the Michigan Department of Environmental Quality. Detroit River data is from Joe DePinto of LimnoTech and the Detroit River Interconnecting Channel Study. Data assembled and analyzed by David Baker, Heidelberg University)

2.3 — Trends in Bioavailable Phosphorus in Western Basin Tributaries

The target phosphorus load for Lake Erie set in the GLWQA was based on TP. The TP discharged from point sources was greater than 85% DRP and considered to be 100% bioavailable. When it became evident that agricultural land uses were a major source of TP entering the lake, and that most of that phosphorus was attached to suspended sediment particles, questions were raised regarding the bioavailability of that particulate phosphorus relative to the bioavailability of phosphorus derived from point sources. On average, DRP comprised 16% to 19% of the total phosphorus loads from the Maumee and Sandusky watersheds during the mid-1970s to mid-1980s. Studies of particulate phosphorus from northwestern Ohio rivers showed that about 30% of that phosphorus was readily bioavailable, as measured by NaOH extraction procedures (DePinto et al., 1981).

The records for the annual load of DRP from 1975 through the 2008 water year are shown in Figure 9 for the Maumee River and Figure 10 for the Sandusky River. These figures include the annual discharge, the annual flow-weighted mean concentration (FWMC) of DRP and the annual load. For both the Maumee and Sandusky rivers, the flow-weighted mean concentrations and loads decreased from the beginning of the sampling program through the mid-1990s. Since that time the flow-weighted concentrations have increased by large amounts. These increases coupled with increases in annual discharge, have led to very large increases in the loading of DRP.

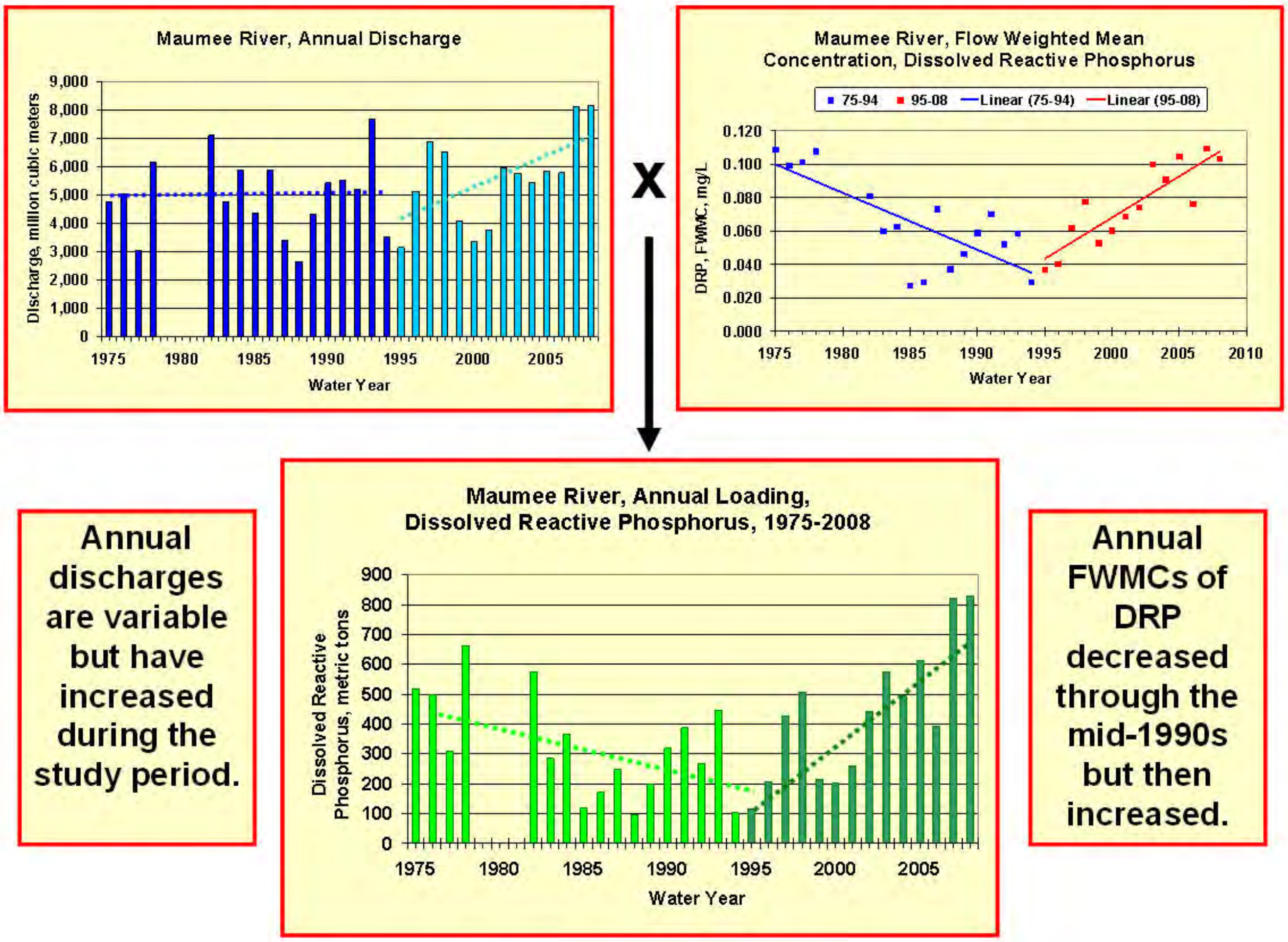


Figure 9 — Annual discharges, flow-weighted mean concentrations and loads of DRP for the Maumee River at Waterville, 1975-2008. (Data from the Heidelberg University Ohio Tributary Loading Program as supported by the Ohio Department of Natural Resources. Graphs prepared by David Baker)

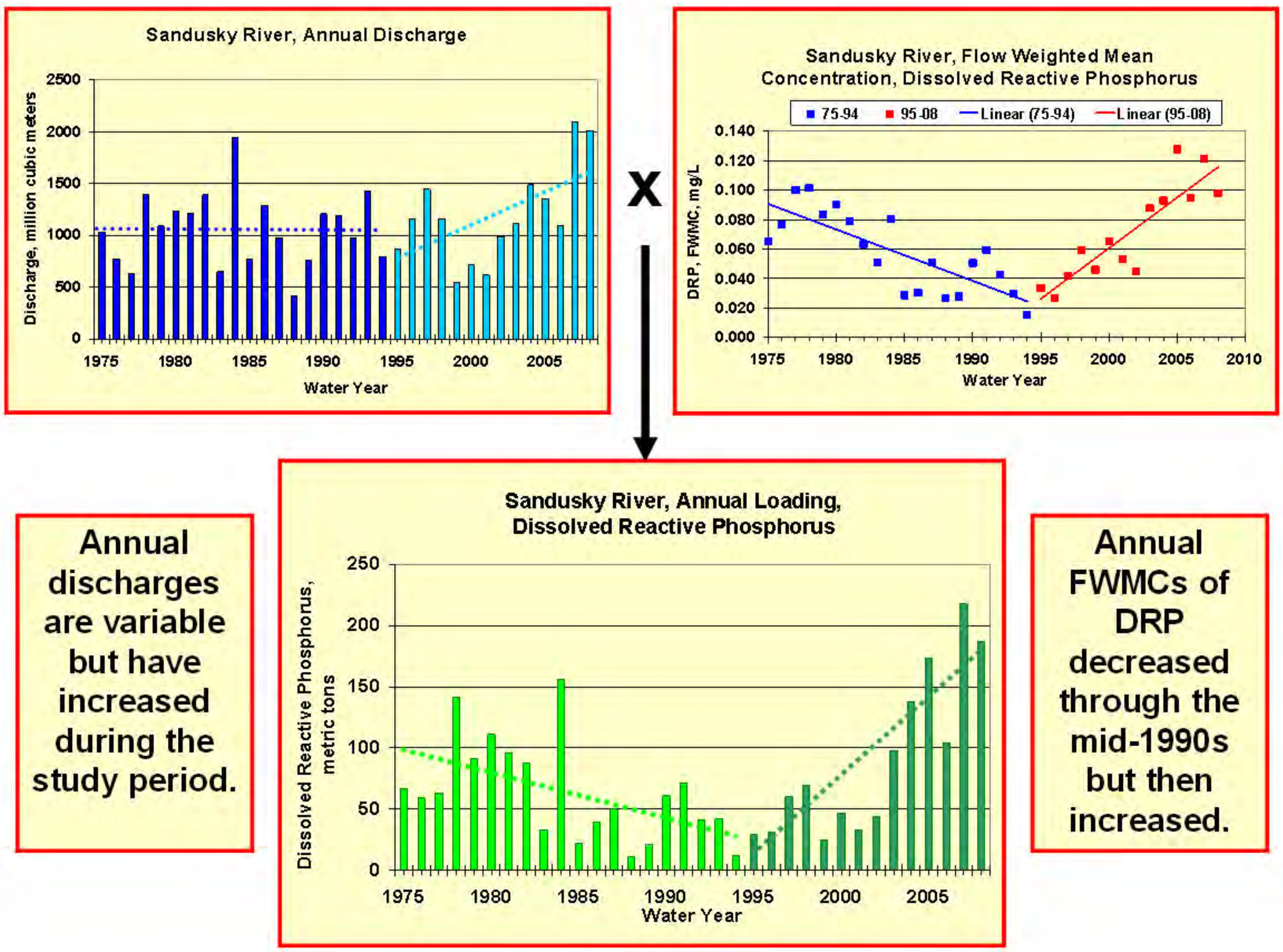


Figure 10 — Annual discharges and flow-weighted mean concentrations and loads of DRP for the Sandusky River near Fremont, 1975-2008. (Data from the Heidelberg University Ohio Tributary Loading Program as supported by the Ohio Department of Natural Resources. Graphs prepared by David Baker)

The annual mean phytoplankton biomass variation in the western and central basins (Figure 11) shows a similar pattern to the DRP values. The increase in cyanobacterial biomass (primarily *Microcystis*) in the western basin also suggests a connection to the increase in soluble P loads from the Maumee River (Figure 12).

Although there is not a direct correlation, it also appears that the increasing loads of DRP from the Maumee and Sandusky Rivers are affecting walleye fisheries in Lake Erie. When combined DRP loads from the Maumee and Sandusky Rivers have exceeded 400 metric tonnes during the years 1975 through 2008, the combined U.S. - Canada walleye catch averaged only 3.877 million fish (range: 0.098-6.800 million, SD: 2.088 million, N=16), as compared to 5.741 million fish (range: 2.645-10.026 million, SD: 2.160 million, N=15) during years when loads were less than 400 metric tonnes. Walleye catches vary directly with walleye abundance, in large part because the fishery is managed. Walleye abundance is driven by natural reproduction success. While a direct relationship between DRP loads from Ohio tributaries to walleye hatch strength is not discernable at present, periods of highly eutrophic conditions in the western basin have been historically detrimental to walleye (Knight, 1997; Ludsin et al., 2001). There has not been an above-average walleye hatch in Lake Erie since 2003 (Personal communication, Roger Knight, Division of Wildlife, ODNR 2010). Additional research is needed to understand the linkages among DRP, biological production of lower trophic level organisms (algae and zooplankton), and fish.

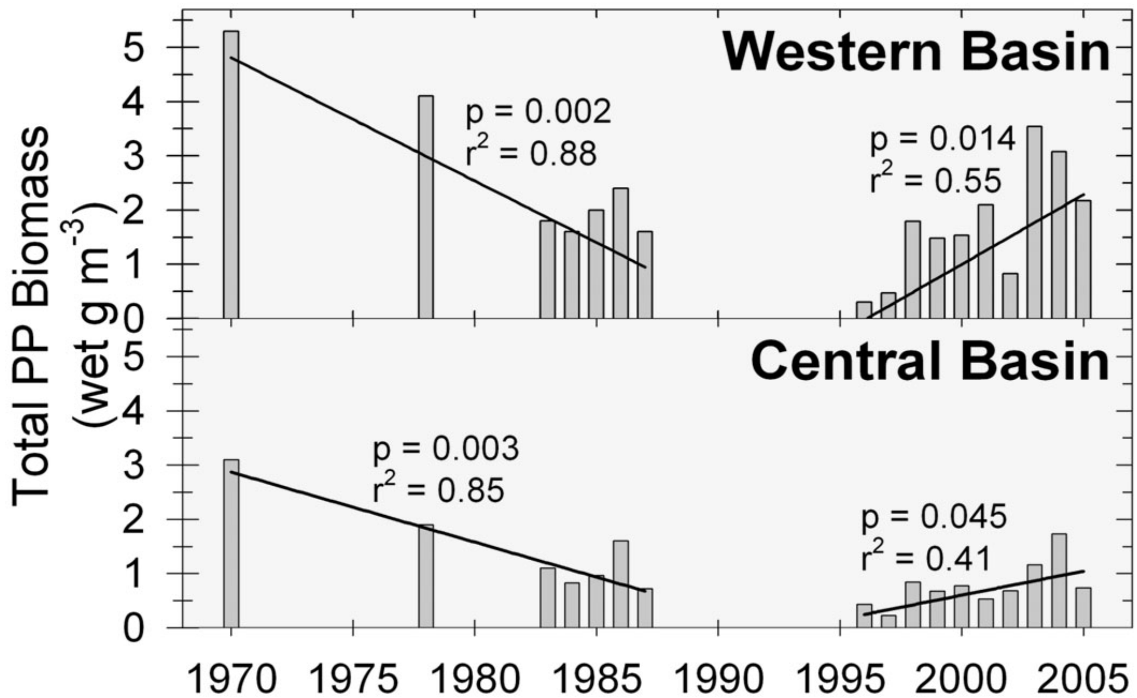


Figure 11 — Annual mean phytoplankton biomass in Lake Erie's western and central basins, 1970-2005. 1970-1986 bars are arithmetic means, whereas those from 1996-2005 are geometric means. Probability (p) and r^2 are for the regressions of biomass vs. time for the periods shown. (Analysis by Joe Conroy, The Ohio State University)

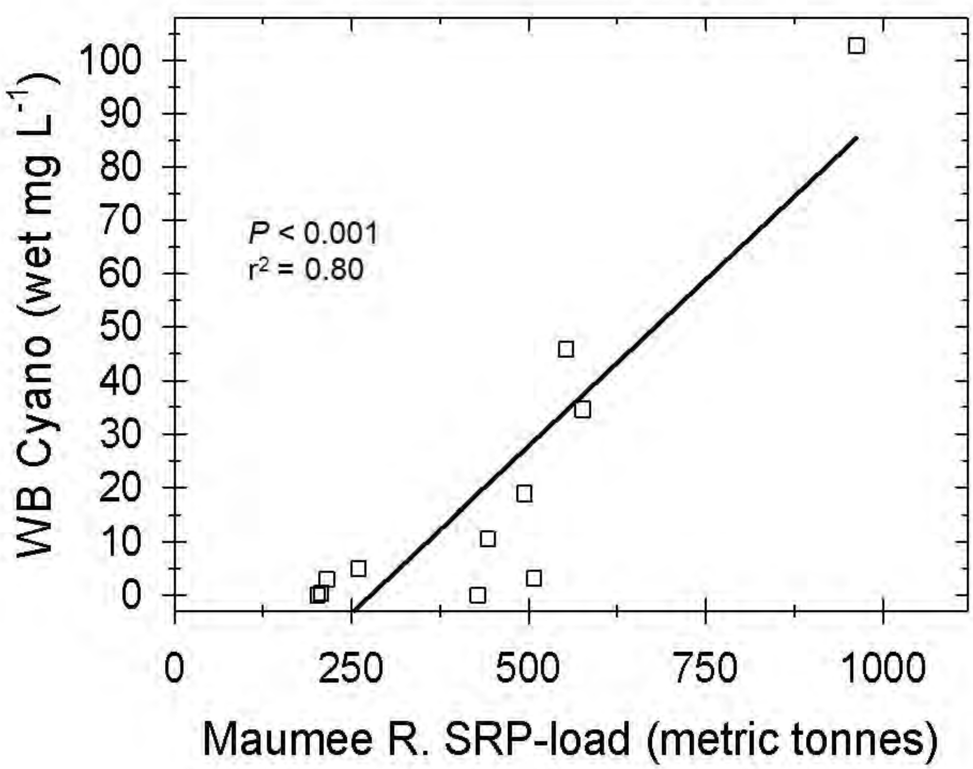


Figure 12 — Median cyanobacterial biomass in the Lake Erie western basin relative to SRP loading from the Maumee River, 1996-2007. Data are from ODNR's Lake Erie monitoring program. (Analysis by D. Kane, Defiance College)

The loading of both particulate P and DRP has changed during the long-term monitoring period. Particulate phosphorus has decreased in response to the various erosion control practices such as no-till and reduced tillage. After rapid decreases in DRP loading through the mid-1990s, DRP loading has rapidly increased. The net effects of these changes on total bioavailable phosphorus loading are shown for the Maumee River in Figure 13 and for the Sandusky River in Figure 14. For both rivers, the bioavailable phosphorus transport at the loading stations is now higher than at any other time during the 34-year monitoring period. These estimates assume that the proportion of particulate P that is bioavailable is still 30% (as measured in the 1980s) and that DRP still represents about 91% of the total dissolved bioavailable phosphorus (i.e., total dissolved bioavailable phosphorus equals 110% of the DRP). Research is now underway to determine if these proportions have remained unchanged since the 1980s.

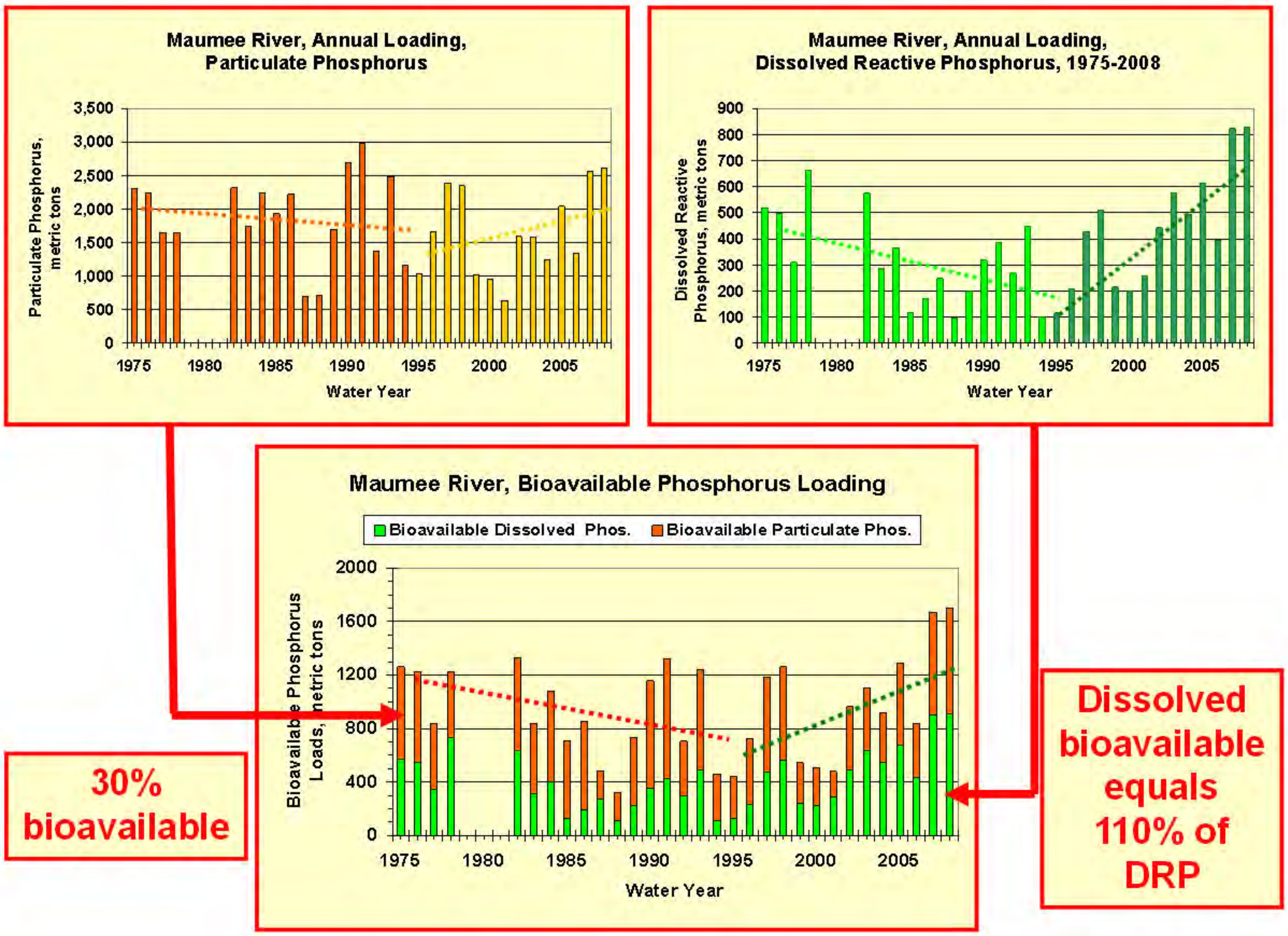


Figure 13 — Estimates of the export of bioavailable phosphorus from the Maumee River at Waterville, 1975-2008. Percentages of bioavailability based on unpublished research by the National Center for Water Quality Research at Heidelberg University (Graphs prepared by David Baker)

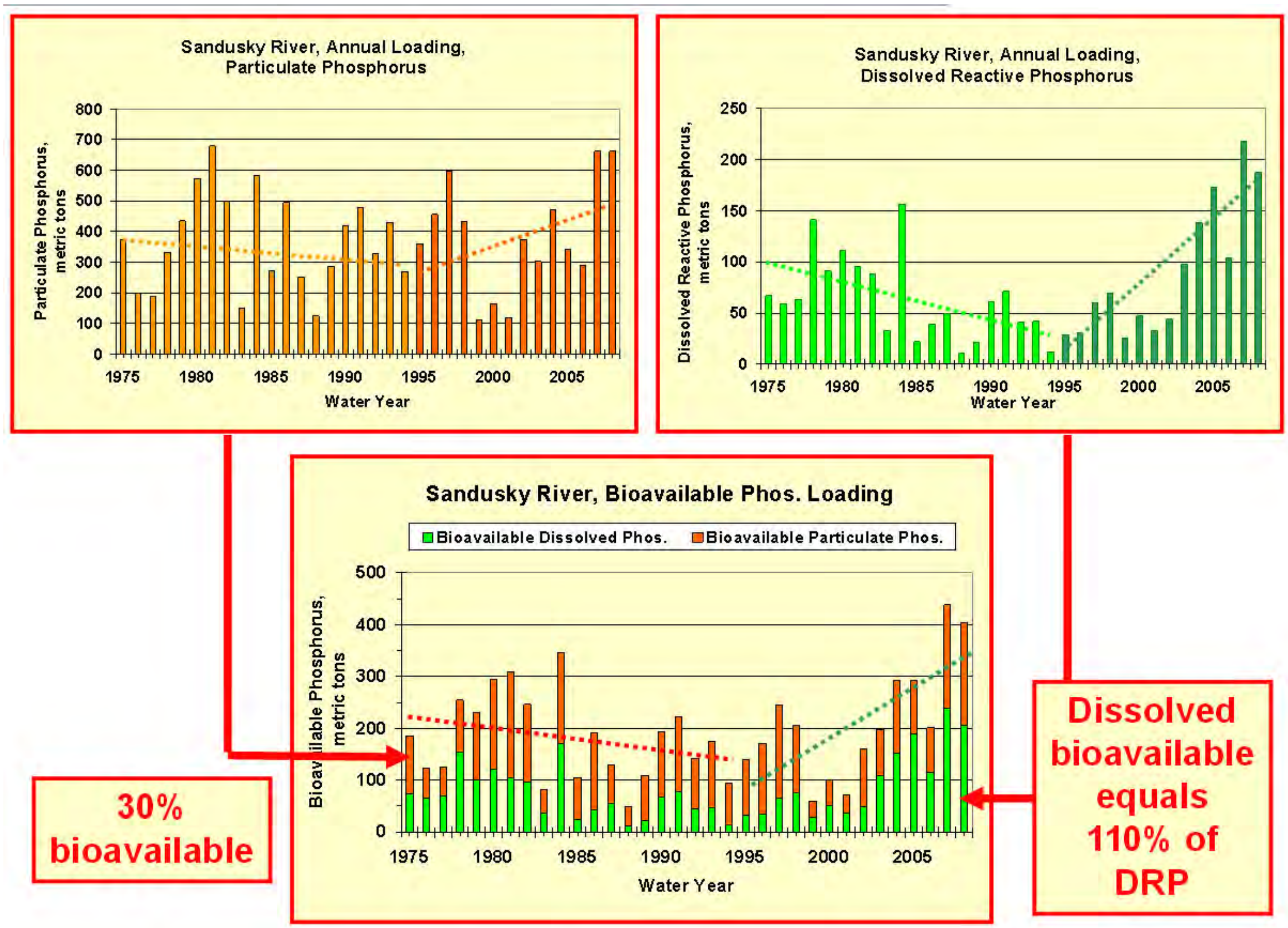


Figure 14 — Estimates of the export of bioavailable phosphorus from the Sandusky River at Fremont, 1975-2008. Percentages of bioavailability are based on unpublished research by the National Center for Water Quality Research at Heidelberg University. (Graphs prepared by David Baker)

2.4 — Land Use Influences on Nutrient Loads

Land cover and land use in the Lake Erie basin ultimately impact nutrient and DRP loads to the Lake. Humans are an integral part of the Lake Erie ecosystem and manage the use (agriculture, recreational lands, urban development, transportation, and utility right-of-ways) and the non-use (wetlands, forest, and shrub land) of the entire Lake Erie basin landscape. Nutrient loads to the Lake are the result of both natural and human-influenced runoff. There is an imbalance of nutrients delivered to the Lake due to the density of the human footprint in the urban setting, the widespread use of agricultural fertilizers, and the density of livestock operations.

Alexander and Smith (2006) looked at trends in nutrient enrichment in U.S. rivers in relation to changes in stream trophic conditions. Similar to the findings by Heidelberg University's Ohio tributary monitoring program, they observed declines in total phosphorus (TP) concentrations in approximately 40% of the monitored sites from the mid 1970s to the mid 1990s, even though 60% of the sites in predominantly urban and agriculture watersheds were still considered eutrophic. In agricultural areas, commercial nitrogen and phosphorus fertilizer use increased by orders of magnitude from the 1960s through the early 1980s, when its use peaked. Thereafter, nitrogen use varied, but overall showed a net average increase of 25% from 1973 through 1995. In contrast, commercial phosphorus fertilizer use showed a net average decline of a similar magnitude over this same period.

2.5 — Land Use and Land Cover: Ohio's Contribution to Lake Erie Tributaries

Land use and land cover in the Lake Erie basin is characterized by the 2001 National Land Cover Data (NLCD), released by the Multi Resolution Land-use Consortium (MRLC) in 2007. The data were collected and processed from 2001 satellite imagery data from the Landsat 7 multi-spectral scanner (MSS). Other efforts specific to Ohio have been done using Landsat 7 data as well, such as the 2001 land use data interpreted by ODNR and the 2004 land-use characterization effort by Ohio EPA. Neither of these data layers extended beyond the State boundaries, and therefore do not include those portions of the Maumee and Ottawa River watersheds that extend into Indiana and Michigan, nor do they include portions of the Conneaut River watershed that extend into Pennsylvania. Land use and land cover classifications provided by the 2001 NLCD range from the general classification (Level I - urban, agriculture, forest, grassland, to wetland) to the more specific (Level II - urban low density residential, row crops, pasture/rangeland, etc.). Table 2 shows the Level I and II land use classification types reported by the 2001 NLCD for all watersheds fully or partially within the Ohio Lake Erie watershed. Additionally, 2001 NLCD land use/land cover was calculated for each of the large scale (8-digit) hydrologic units that are fully within or partially contain portions of Ohio. Complete tables showing Level I classifications for each hydrologic unit fully within or draining portions of Ohio to Lake Erie can be found in the Appendix Table A-1.

Overall agricultural row crops accounted for 59% of land use in the Ohio watersheds draining to Lake Erie, followed by urban residential and commercial at 16%, forested lands and wetlands combined at 16%, and pasture at 5% (Figure 15). Ohio tributaries draining to the western basin of Lake Erie (Ottawa, Maumee, Toussaint, Portage, and Sandusky rivers) show a disproportionately high percentage of row-crop agriculture at 72% when compared to the tributaries draining to the central basin (Huron, Vermilion, Black, Rocky, Cuyahoga, Grand and Ashtabula rivers) of Lake Erie, at 26%. Tributaries draining to the central basin show an integrated mix of land use from row-crop agriculture (26%), to urban residential and commercial (27%) and forest cover (30%) (Figure 15).

In Northwest Ohio agriculture is the dominant land use in watersheds such as the Auglaize, Blanchard, Sandusky, Tiffin, and Upper Maumee, where agricultural row crops account for 52-82% of the land use; pasture accounts for 1-17% of the land use; urban land accounts for 8-14%, and forest and wetland land cover accounts for 5-13%. Alternatively, watersheds in Northeast Ohio, such as the Cuyahoga, Chagrin, Black, and Ashtabula are heavily influenced by commercial, residential and transportation land uses, although natural land cover and agriculture land use are also prevalent. Urban land in these watersheds ranges from 21-56%, forest and wetland cover ranges from 31-46%, and agriculture ranges from 28-36%.

Figure 16 shows several representative watersheds within the Lake Erie Basin and their relative land-use percentages. Bean Creek and the Tiffin, St. Joseph and Auglaize rivers are all sub-watersheds of the Maumee River basin, whereas the Vermilion, Black, Rocky and Cuyahoga rivers each drain directly to the central basin of Lake Erie. Of the many Lake Erie riverine watersheds, the Auglaize River has the highest percentage of row-crop agriculture at 82%. The Tiffin River and Bean Creek, and the St. Joseph River have the highest percentage of pasture land draining to the western basin of Lake Erie at 10 and 17%, respectively. Moreover, despite the urban and forest dominated nature of the Northeast Ohio watersheds, pastures in the Vermilion, Black, Rocky and Cuyahoga river, still account for 12 to 8% of the land use.

Table 2 — Land Use / Land Cover Classifications for the 2001 National Land Cover Data (NLCD), and the relative percentages for Ohio tributaries draining to Lake Erie. Percentages are rounded to the nearest 0.1% so may not sum to 100%

Level I	Level II - 2001 NLCD Classes	Ohio tributaries to Lake Erie
1. Water	11. Open water	1.5%
2. Urban Land	21. Developed, Open Space	8.4%
	22. Developed, Low Intensity	5.6%
	23. Developed, Medium Intensity	1.7%
	24. Developed, High Intensity	0.7%
3. Barren Land	31. Barren Land	0.1%
4. Forest land	41 Deciduous forest land	13.1%
	42 Evergreen forest land	0.2%
	43 Mixed forest land	0.0%
5. Shrub land	52. Scrub/Shrub	0.2%
7. Grass Land	71. Grassland/Herbaceous	1.4%
8. Agricultural Land	81. Pasture/Hay	5.4%
	82. Cultivated Crops	59.1%
9. Wetlands	90. Woody Wetlands	2.0%
	95. Emergent Herbaceous Wetlands	0.6%

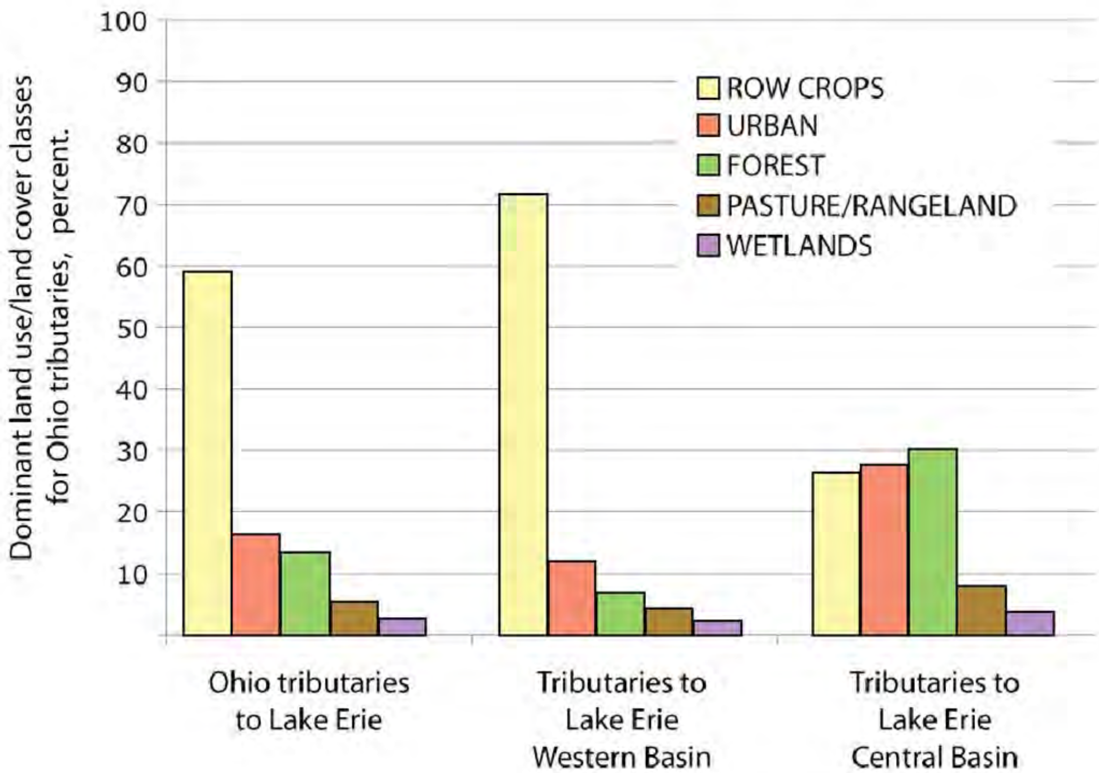


Figure 15 — Dominant land use/land cover classes for groups of tributaries in the Lake Erie basin. Row-crop agriculture is more prevalent in tributaries draining to the western basin, whereas mixed land use/land cover is found in the tributaries draining to the central basin. (Prepared by Dan Button, USGS for the Phosphorus Task Force)

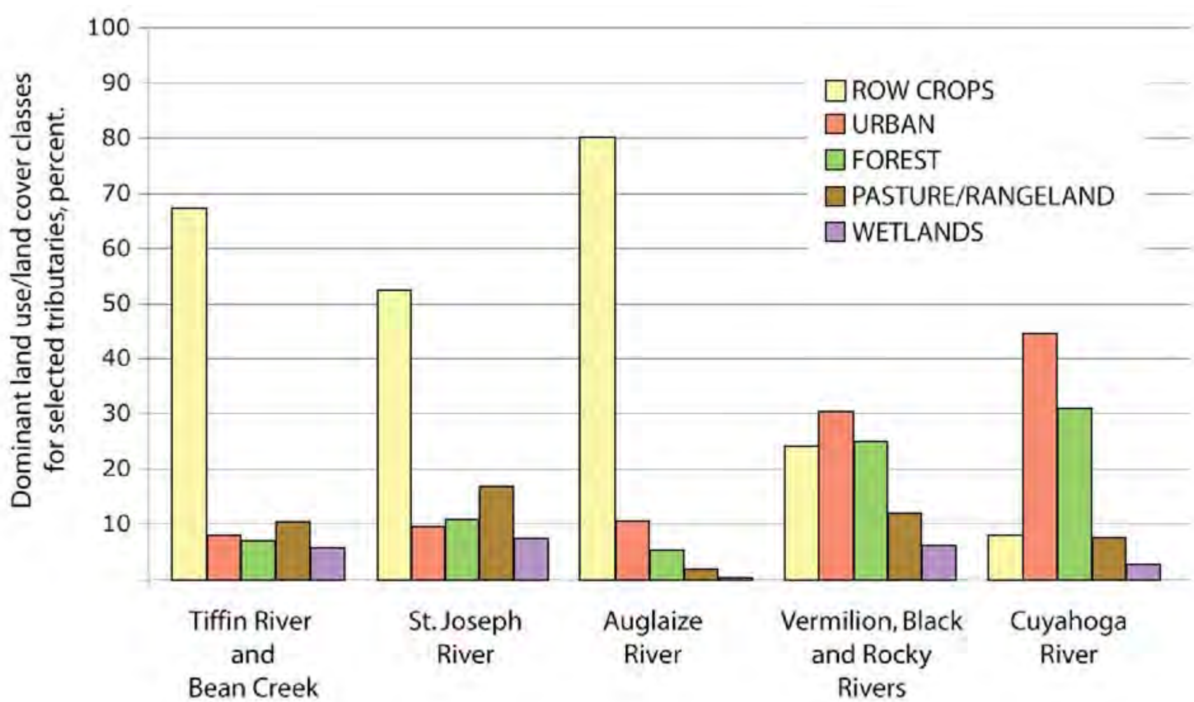


Figure 16 — Dominant land use/land cover classes for a select few watersheds in the Lake Erie basin. Row-crop agriculture is more prevalent in Northwest Ohio watersheds than in the urban and forest dominated watersheds in Central and Northeast Ohio

Section 3 — Types and Dynamics of Phosphorus in Water and Soils

3.1 — Phosphorus Dynamics in Water

Phosphorus is an essential nutrient for living organisms and is often the limiting nutrient for plant growth (Walker et al., 2007; Dodson, 2005). Phosphorus is found in many forms in the aquatic ecosystem. Total phosphorus (TP) measures all of the phosphorus present in the water, and it is frequently used to measure a lake's nutrient status. Most lakes have TP concentrations between 10µg/L and 80µg/L, but very clear ultra-oligotrophic lakes may have only 1µg/L of TP while hyper-eutrophic lakes may have 200µg/L of TP (Dodson, 2005). Flowing streams can have even higher concentrations, particularly after storm events or if they are the recipients of highly concentrated discharges. Dissolved reactive phosphorus (DRP) consists of both inorganic and organic forms that are dissolved in water. DRP is largely bio-available phosphorus that is available to phytoplankton, macro-algae, and macrophytes. Orthophosphate is an inorganic form of DRP which has an electrostatic attraction to polar chemicals including ferric hydroxide colloids.

Additional forms of phosphorus include particulate organic phosphorus and particulate inorganic phosphorus. Particulate organic phosphorus is incorporated into living organisms and released through feces or when the organism dies (i.e. dead leaves). Particulate inorganic phosphorus is typically orthophosphate attached to particles, and this form is insoluble in water. Particulate phosphorus ends up sinking to the bottom of lakes or streams, where it either becomes trapped within the sediments or is taken up by aquatic plants. Once the phosphorus is taken up by aquatic plants the phosphorus does not return to the aquatic ecosystem until the plant dies and begins to decay. Streambed or lakebed phosphorus can also be recirculated by strong storms or heavy flows.

These types of phosphorus enter the aquatic ecosystem through many avenues. Natural pathways for phosphorus are usually from waste products of organisms, decaying organisms, rocks and dissolved minerals containing phosphorus, atmospheric deposition and tributary inputs. Human activities can add significant amounts of phosphorus to aquatic ecosystems through industrial and municipal effluents, detergents, fertilizer runoff, agricultural activities, and increased soil erosion (Walker et al., 2007).

Typically Lake Erie's central and eastern basins undergo thermal stratification into three main layers during the summer months: the epilimnion (warmer upper layer); the metalimnion (the transition layer between warm upper and cool bottom waters); and the hypolimnion (cool bottom layer). During thermal stratification the three layers do not mix and oxygen can become depleted in the hypolimnion. In Lake Erie, oxygen typically becomes depleted (hypoxia/anoxia) only in the central basin because its morphology supports the development of a relatively thin hypolimnion. Oxygen becomes depleted because it is consumed by bacteria and fungi engaged in the decay of algae and other organic matter. Oxygen in the hypolimnion does not get replenished until the lake mixes in the fall after stratification ends. Additional phosphorus continues to be transported from the epilimnion to the hypolimnion as algae die off and fall to the bottom to decompose.

Phosphorus regeneration back into the water column happens aerobically during decomposition. Another process happens in summer during periods of stagnation in the western basin and when the central basin hypolimnion becomes anoxic. Under anaerobic conditions this regeneration releases DRP that was weakly bound to clays and ferric hydroxide. The sediment-to-phosphorus bond is sensitive to redox potential which responds to low oxygen concentrations and anoxia, as ferric iron is reduced to the more soluble ferrous form. This explains how this phosphorus stays in the sediment through most of the year. Sediment regeneration phenomena are incorporated into observations of ambient phosphorus in lakes and do not represent a new load or a new source of phosphorus. Sediment phosphorus re-cycling can delay the recovery of lakes but even when the re-cycling occurs, the phosphorus inexorably moves towards permanent storage or to the outflow so the net effect in the long term is to clean the lake (Hiriart-Baer et al., 2008).

The fall weather cools the epilimnion and causes thermal stratification to end. The lake circulates freely from top to bottom and the oxygenated surface water mixes with the phosphorus-rich bottom water. This causes the entire water column to become phosphorus enriched. Much of this phosphorus is left within the water column until spring since the phytoplankton growth has slowed due to the cooler temperatures and shorter day length.

Many types of compounds in particulate and soluble forms with different abilities to grow algae (bioavailability) may be components of total phosphorus (TP). Apatite mineral phosphorus (calcium hydroxyl phosphate) from shore erosion, for example, is a particulate form that is largely unavailable to algae. Dissolved reactive phosphorus (DRP) is a soluble form found in sewage and fertilizers that is highly bioavailable. Algal cells (particulate) contain organic phosphorus which will be released upon decomposition. Where there are high loads and concentrations of TP there is usually a significant component of bioavailable P such as DRP. This is why TP load has become a sort of shorthand criterion for communicating the nutrient status of water with regard to potential algal problems. Operationally, TP is easier to measure chemically than its component fractions, and this is another reason for its general usage.

Recent open water spring TP concentrations have not consistently been below target levels (eastern and central basins: 10 µg/L; western basin: 15 µg/L). For example, in 2007 average spring TP concentrations were: 29±12 µg/L, 12±3 µg/L and 17±7 µg/L, for the western, central and eastern basin, respectively. Western basin concentrations tend to be much higher than the other basins. Spring TP concentrations had been decreasing in all three basins over the last three decades.

Summer TP concentrations decline in all three basins, and in 2006 average summer epilimnetic TP concentrations were: 24±18 µg/L; 10±5 µg/L; and 6±2 µg/L, for the western, central and eastern basins, respectively. A phosphorus gradient from the west to the east is apparent. In the summer, both the east and central basins are at or below their water quality target of 10 µg/L, and have been for the past decade with few exceptions. Summer TP concentrations in the western basin, however, are often above the water quality target of 15 µg/L, and seem to exhibit a higher variability than either the central or eastern basins.

The relationship between phosphorus and algae as indicated by chlorophyll remains strong in offshore waters. Nearshore, there is a serious problem with attached filamentous algae in the eastern basin and parts of the western basin. Algal problems are usually associated with sources of elevated nutrient supplies. The presence of dreissenid mussels has been found to support increased *Cladophora* growth in the eastern basin. The filter feeding by the mussels increases water clarity to provide more light and also recycles phosphorus in the benthic area for use in *Cladophora* growth (Higgins et al., 2005). A correlation has not been established between dreissenids and *Lyngbya*.

The nearshore forms a small part of the lake area but it is the most visible and most heavily used by humans, therefore, phosphorus-algae relationships here are particularly important to the public's perception of Lake Erie's health. However, any scientific definition of "nearshore" remains controversial. For some, the surf and swash zone at the shoreline means nearshore while to others the water between 0 and 20 meters deep may constitute the nearshore. Generally, given the open boundaries of the nearshore, it must be characterized operationally since there is no consistent, defensible, and unique definition from an ecological perspective. Due to its shallow depth, most of the western basin is nearshore along with Maumee Bay, Sandusky Bay, the river mouth outflow areas and the shore of the central basin out to the 15 meter depth contour. In general, the ranges of total phosphorus and chlorophyll-a concentrations in the nearshore and offshore areas overlap. However, both the variability and the average concentrations are generally higher nearshore (Kelly, 2008).

3.2 — Glacial Geology, Physiographic Regions and Soils of Northwest Ohio

This section provides a brief background on the formation of the soils in this region because they have a significant impact on how the area is drained and how nutrients are cycled. Soil as discussed in this document refers to mineral-based soils, but not the organic soils formed in glacial-aged peat deposits (See *www.dnr.state.oh.us/Portals/10/pdf/glacial.pdf* for the locations of significant peat deposits). Organic soils containing high amounts of organic materials behave differently than the "typical" mineral soils that are discussed in this document. Furthermore, organic soils need to remain saturated to survive. Since most of these soils are tile drained and, therefore, unsaturated for at least some portions of the year, they are oxidizing and slowly disappearing from the landscape.

The formation of the clay-rich soils in northwest and north central Ohio is a two part process including the deposition of the parent materials during glacial ice melting and the subsequent process of soil formation. The first important consideration is the grain-size (texture) of the "parent material" on which the soils are formed. The Lake Erie watershed glacial deposits post-date the Erie-Interstadial meltback event of glacial ice during the Late-Wisconsinan ice age. Large lakes formed in front of the retreating ice, filled with fine-grained water-lain layered deposits. Some of these deposits remain today and can be seen as lake deposits and wave-planed ground moraine as far south as Mercer, Logan, and Marion counties. When the Late Wisconsinan ice re-advanced, it ground up and reworked the previous lake beds, creating a much finer glacial drift than that found further south and east in Ohio. The southern boundary is generally considered the Broadway-Powell End Moraine which is the dark green band that touches the Franklin-Delaware County line. This area is referred to as the Central Ohio Clayey Till Plain physiographic region of Ohio and can be seen on the map at: *www.dnr.state.oh.us/Portals/10/pdf/physio.pdf* .

Approximately 14,000 years ago, the Late-Wisconsinan-aged ice melted back out of Ohio and a series of larger and older Lake Eries were formed. The oldest and highest lake was Lake Maumee and its shoreline can be seen on *www.dnr.state.oh.us/Portals/10/pdf/glacial.pdf* , the southern shore found in Van Wert, Allen, and Hancock counties and represented on this figure as the large wave-planed ground moraine and lake deposits in northwestern and north central Ohio. This area is also identified on *www.dnr.state.oh.us/Portals/10/pdf/physio.pdf* as the (7) Maumee Lake Plains. It is not uncommon for these materials to be made up of 40 to 50% (or even more) clay-sized textural materials.

Over time, the amount of clay-sized (colloidal) textural materials within these deposits increased as part of the ensuing weathering and soil forming processes. Also, clay-sized materials moved out of the upper or "A" horizon and were deposited into the "B" horizon, further enriching the amount of clay-sized materials that are found near the surface in agricultural settings where the upper or "A" horizon has been eroded away. Some of these "B" horizon soils now contain 70% or more clay-sized materials in their textural classifications. These soils are easily recognized on *www.dnr.state.oh.us/Portals/12/soils/pdf/SoilRegions.pdf* as the Region 1 Hoytville-Nappanee-Paulding-Toledo Association in the Maumee Lake Plains region of the physiographic map (*www.dnr.state.oh.us/Portals/10/pdf/physio.pdf*).

It is not, however, solely the amount of clay-sized materials that affects the transport of phosphorus from the uplands to the lake. It is also the types and relative abundance of specific clay minerals that are contained within the clay-sized portion of the soils. For the most part, clay minerals in northwest and north central Ohio are Illite, Kaolinite and Chlorite. There are very limited amounts of high shrink-swell Smectite clay minerals in Ohio, especially this portion of Ohio. The clay minerals have negative charges on them and have the ability to bind with particulate phosphorus, allowing that portion of the total phosphorus load to be transported into western Lake Erie with the sediment load. Since clay-sized materials take so long to settle out in quiet water and can be so easily re-suspended, these colloidal clay minerals can be actively re-suspended in the water column and/or can flocculate and fall to the bottom where some portion of the particulate PO^4 can be dissolved and returned to the lake as a flux of dissolved PO^4 (See Figure 34).

For more information on these topics, see Brockman and Szabo (2000), Tornes et al. (2000), Szabo (2006), Weatherington-Rice et al. (2006) and Kim (2007).

3.3 — Phosphorus Dynamics in Soil

Compared to the concentrations of P in lake water and lake sediments, the P content of soil is enormous, ranging from 200 to 5,000 mg/kg with a mean of 600 mg/kg (Lindsay, 1979). However, the soil solution concentration is rarely greater than 1% of the total P content (Brady and Weil, 2002). Soil P naturally fluctuates between dissolved forms, in soil solution (pore water) or runoff/leachate, and solid forms, such as a component of a large variety of P minerals, but it is the dissolved P that feeds plants and algae. Nevertheless, in soil systems, the equilibrium between DRP and solid mineral forms of P is regulated primarily by the solubility of the P-minerals present in the soil or added as P fertilizer, manure/biosolids, and to a lesser extent by the decomposition of organic matter.

A fundamental concept of equilibrium is the understanding that few chemical reactions proceed only in one direction, but are reversible, at least to some extent. This is certainly true for reactions that involve soil phosphorus (P) in natural soil systems. Neither dissolved nor mineral forms of P remain as discrete entities, but rather, are always moving toward equilibrium with each other. Henry Louis Le Chatelier, a French chemist, stated that when an equilibrium system undergoes a perturbation the system will adjust to offset the perturbation and re-establish equilibrium (Chang, 1991). There are a large variety of soil P minerals with a wide range in mineral solubilities. Additions of highly soluble P minerals, such as P fertilizer and manure/biosolids, perturb the equilibrium system triggering a multitude of reactions to re-establish equilibrium. Similarly, depletion of soil solution P by plant and micro-organism P uptake, as well as removal in runoff water or leachate perturb the equilibrium triggering reactions to re-establish equilibrium.

Soil P minerals impose limits on the concentration of P (and other elements) in the soil solution. If the soil solution becomes too concentrated (supersaturated), with respect to any soil P mineral, then that mineral will begin to precipitate removing dissolved P from solution. For example, when completely soluble P fertilizer is added to the soil, it does not remain completely soluble for long. In fact, in most cases, the dissolved P concentration declines quickly as dissolved ions establish lower free-energy states by precipitating into more stable P minerals. Alternatively if the soil solution becomes too dilute (under-saturated) with respect to the P-minerals present, they will begin to dissolve. Both the precipitation of DRP and dissolution of mineral P are natural processes that tend to maintain soil solution P equilibrium. Both precipitation and dissolution can be operating at the same time. When the two processes are equivalent and there are no observable changes in soil solution P, the system is said to be at steady state or dynamic equilibrium (Lindsay, 1979; Chang, 1991).

Under natural soil conditions, temperature, pH and dissolved chemicals will also play a role in phosphorus solubility. Soil pH can have a tremendous effect on soil mineral solubility, as can be seen by comparing the equilibrium solution P concentrations for some common soil P minerals at soil pH 5 with those at pH 7 (Table 3). Note that the iron (Fe) and aluminum (Al) minerals are less soluble (more stable) at low pH and the calcium (Ca) minerals are less soluble (more stable) at high pH.

Table 3 — Phosphorus (P) solution concentration at pH 5 and 7 for typical soil P minerals (Lindsay, 1979)

P-Mineral		pH 5	pH 7
		------ mg P/L ------	
Variscite	$AlPO_4 \cdot H_2O$	1.24	98.1
K-taranakite	$H_6K_3Al_5(PO_4)_8 \cdot 18H_2O$	24.6	490
Strengite	$FePO_4 \cdot 2H_2O$	0.049	31.0
Brushite	$CaHPO_4 \cdot H_2O$	310	4.92
Hydroxapatite	$Ca_5(PO_4)_3OH$	196	1.96×10^{-3}
Fluorapatite	$Ca_5(PO_4)F$	0.317	6.0×10^{-5}

Another solid-phase stable binding mechanism for P is the adsorption, or surface binding, of P onto metal oxide clay minerals, primarily of iron (Fe) or aluminum (Al). These surface reactions are referred to as specific adsorption or ligand exchange, where phosphate is the ligand. Other chemicals such as sulfate and some organic acids can compete with phosphate for these binding sites. Although specific adsorption is a solid-phase form of P unlike other mineral forms, binding to oxide surfaces is not concentration dependent, so even at low solution P concentrations, P can bind to oxide surfaces. Removal of soil solution P by plants or microorganisms, P leaching into the soil profile, and loss of dissolved P in runoff water can all remove P from the soil solution. As the soil solution P becomes depleted, mineral species begin to dissolve to re-establish the soil solution P at the equilibrium concentration (Figure 17).

Alternatively, large inputs of highly soluble P as fertilizer or in manure or biosolids and, to a lesser extent, the decomposition of plant or other soil biota residue will increase the precipitation of soil P minerals and adsorption onto oxide surfaces, thereby sequestering the P in less soluble forms (Figure 17).

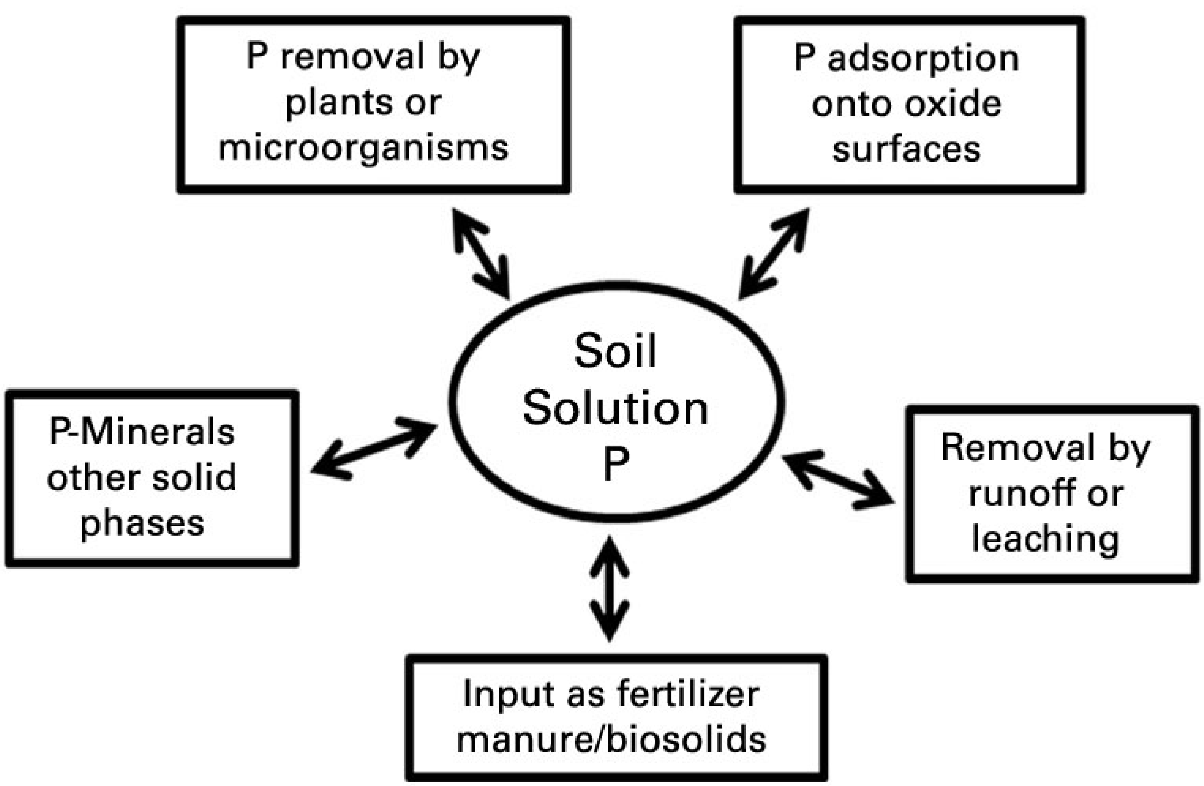


Figure 17 — Factors affecting soil solution phosphorus concentration (Lindsay, 1979)

3.3.1 — Intensity and Capacity Factors

In addition to soil solution P, two important parameters influencing P availability to a growing crop are the soil's intensity and capacity factors. The intensity factor is the measured P concentration in the soil solution. The capacity factor is the ability of the soil to replenish the soil solution P concentration as it becomes depleted due to plant uptake or P transport through runoff/leaching. Differing mineral P solubilities will determine both the intensity and capacity factors.

Given the large number of P minerals exerting control on soil solution P equilibriums, both the intensity and capacity factors are subject to change depending on soil mineralogy. For example, Figure 18 illustrates the relationship between intensity and quantity factors for 3 minerals A, B & C. The solubility of mineral A is the highest, so as long as it is present the equilibrium solution concentration will be maintained at the high A level. This means that the solution will be supersaturated with respect to minerals B and C so they will be precipitating, removing P from solution and contributing to continued dissolution of mineral A. Once all of mineral A has dissolved, the new equilibrium soil solution concentration will be set at level B. Solution P at level B is still supersaturated with respect to mineral C. As long as mineral B remains, mineral C will continue to precipitate contributing to the continued dissolution of mineral B. Ultimately, in this example, mineral C will control the solution P concentration at level C. As the intensity diminishes, the capacity is increasing as less stable more soluble P minerals transform into more stable less soluble P minerals over time. However, the solution P concentration (Intensity) at level C may not be sufficient for crop nutrition. In addition, as mentioned earlier, other factors contribute to soil solution P, such as degradation of organic P, equilibrium between the soil solution and oxide bound P. As these contributions enter the solution, they too are subject to the P solubility of the controlling minerals. The transformation of more soluble less stable to less soluble more stable P minerals explains why additions of highly soluble P fertilizer do not remain highly soluble for long. Alternatively, Figure 18 shows that even at low total and low soil test P levels the equilibrium soil solution P concentration will be set by the most soluble controlling P mineral present (Lindsay, 1979). Phosphorus soil chemistry is thus as complex as it is interesting. There are many "players" (i.e., minerals, oxide surfaces, organic matter, fertilizer) all competing to control soil solution P concentrations.

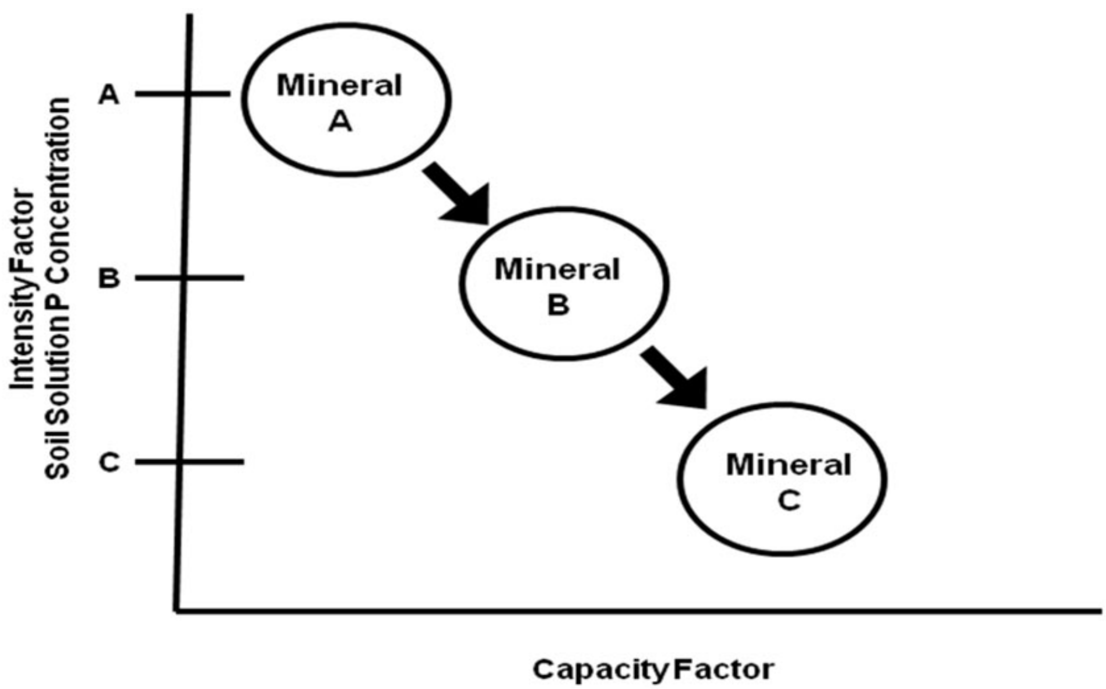


Figure 18 — Relationship between intensity and capacity factors as less stable P minerals transform into more stable P minerals over time (Lindsay, 1979)

Section 4 — Sources of Phosphorus Delivered to Surface Waters

4.1 — Point Sources

4.1.1 — Wastewater Treatment Plants

Point sources are very consistent from day to day and year to year. As described previously, aggressive action related to controlling the discharge of TP from point sources, largely wastewater treatment plants (WWTPs), led to rapid and significant decreases in TP loads to the lake by the early 1980s. Between 1972 and 1985 approximately $8.8 billion was spent by the U.S. and Canada in upgrades to WWTPs. Phosphorus released from point sources is generally considered to be nearly all bioavailable (Black, 1980; Sonzogni et al., 1982) so concentrating on reducing these sources first had the most immediate impact on the lake.

Dave Dolan (currently with the University of Wisconsin – Green Bay) has calculated TP loads to Lake Erie for a number of years. This was first done for the International Joint Commission to determine whether the loading targets set in the Great Lakes Water Quality Agreement were being met. More recently, the U.S. EPA has funded this work to follow changes in both point and nonpoint sources of TP relative to biological changes observed in the lake. Dolan follows the approach described earlier in the background section (c.f., Section 2.1) as developed under LEWMS and PLUARG (c.f., Dolan and McGunagle, 2005). Point source calculations are based on data in U.S. EPA's Permit Compliance System (PCS) database. The direct point sources are those discharging directly to the lake or downstream of the USGS gauging/monitoring station. The indirect point sources are those discharging above the gauging station and are included as part of the overall tributary load. A comparison of Dolan's data since 1985 shows the annual loads from both direct and indirect point sources to be fairly consistent (Figure 4).

There are 703 Ohio National Pollutant Discharge Elimination System (NPDES) permitted WWTPs discharging to the Ohio Lake Erie watershed. They account for a total discharge volume of approximately 1,076 million gallons per day (MGD). About 464 (66%) of these permits are issued to small package plants discharging less than 50,000 gallons per day. However, the majority of the flow comes from the 12 (1.7%) major WWTPs with a discharge greater than 15 MGD. These are also the plants that contribute the majority of the phosphorus load. Based on U.S. EPA PCS data, Dolan estimates an average load of 585 metric tonnes per annum (MTA) of total phosphorus from Ohio WWTPs.

4.1.2 — Bypasses and Combined Sewer Overflows (CSOs)

The WWTP estimates do not include bypasses that occur when wet weather flows exceed the capacity of the WWTP. Under these high-flow conditions, influent to the plant receives only partial treatment before being discharged to the receiving water. Although the phosphorus concentration in these bypasses may be higher than what is found in the treated effluent, the TP load is only a small percentage of the total yearly load discharged by the WWTP. Not enough information is available on the concentrations in bypasses or the volume of the discharge to estimate a load.

Combined sewer overflows (CSOs) may discharge sewage directly into the Lake and its tributaries when storm water overloads the capacity of storm drains designed to discharge through WWTPs. Unfortunately, there are few direct measurements of TP or DRP contributions from CSOs. For the purposes of this exercise, therefore, using TP measurements from some of the Northeast Ohio Regional Sewer District (NEORSD) CSOs and an estimated total CSO annual flow of 10.9 billion gallons as presented in a 2007 report on sewage overflows to Lake Erie (Environment Ohio, 2007), the Task Force estimates an annual CSO TP load to Lake Erie of 90.4 MTA.

4.1.3 — Industrial Point Sources

As compared to WWTPs, there are few industrial sources of TP in the Ohio Lake Erie watershed. There are 84 dischargers with NPDES permits that include phosphorus monitoring or loading conditions. Of these, it is the few dischargers with a high effluent volume that contribute the majority of the load. Most of those discharges are associated with food processing. Dolan calculated an average load of 32.5 MTA from industrial sources.

4.1.4 — Home Sewage Treatment Systems

The Ohio Department of Health examined the potential contribution of phosphorus from home sewage treatment systems (HSTS) (ODH, 2008). They estimated a total of 25 MGD of effluent was generated from the approximately 148,000 homes with discharging home sewage treatment systems in the Lake Erie watershed. Assuming an average TP concentration of 10 mg/L, the average annual TP load was estimated to be 352 MTA. However, trying to determine how much of this TP load actually reaches the local waterway is difficult. For the purposes of this exercise the Phosphorus Task Force chose to estimate that about 25% of the 352 MTA TP discharge eventually reaches a waterway, for a total load of 88 MTA. Data also collected by ODH indicate that 23% of the HSTS installed are failing, with an additional 13% projected to fail within the next 5 years. Soil limitations, substandard or poor design, space limitations, system age, shallow seasonal water tables and poor operation and maintenance were reported as reasons for system failures. These issues could increase TP loads from HSTS in the future and increases the potential for localized water quality impacts.

4.1.5 — Summary and Recommendations for Point Sources

Combining Dolan's average estimates for WWTP loads (585 MTA), Dolan's average industrial loads (32.5 MTA), and the HSTS load estimate (88 MTA) with the CSO load estimate (90.4 MTA), generates an average annual total point source TP load to Lake Erie from Ohio of 795.9 MTA. Considering the fact that most of the phosphorus in the point source load is bioavailable, this is a significant source of phosphorus to Lake Erie. However, this load has remained fairly consistent since 1981 and is not considered to be a significant contributor to the increases in DRP loads being measured in Ohio's Lake Erie tributaries.

Recommendations for future actions relative to phosphorus point source loads include: 1) maintain an effective permit compliance and enforcement program for NPDES-permitted facilities of all types; 2) maintain timely issuance of discharge permits; 3) continue to enforce implementation of Long Term Control Plans for CSOs, sanitary sewer overflows and bypasses; and 4) evaluate the need to further reduce phosphorus concentrations in effluents based on the findings of TMDL studies, watershed plans, and the Lake Erie Lakewide Management Plan (LaMP).

Specific recommendations with respect to HSTS include: 1) Establish statewide rules for HSTS management to provide program continuity across the state; 2) design systems for proper treatment (not off-site disposal) of household sewage; 3) ensure proper design and siting of systems based on soil and site characteristics combined with an inspection and maintenance program; 4) minimize the use of off-lot discharge; and 5) develop training and continuing education programs for system designers, installers, inspectors, regulators, and operators.

4.2 — Nonpoint Sources

Nonpoint sources of phosphorus have typically been associated with sediment load and considered to be of low bioavailability. In comparison to point source loads, nonpoint source loads are difficult to quantify. However, now that the majority of annual phosphorus loading to Lake Erie has been documented to be from the storm-pulsed runoff from the landscape into the tributaries that drain to Lake Erie, a focus on better management of nonpoint sources will be needed. The connection to weather events makes these loads highly variable from week to week and year to year. Accordingly, the control of nonpoint source runoff must be addressed through the implementation of a variety of best management practices (BMPs) in the drainage basin. This section addresses nonpoint sources of phosphorus from agriculture, urban storm water runoff, turf grass management, and the use of orthophosphate in public water supplies.

4.2.1 — Agriculture

4.2.1.1 — Overview of Historical Trends

Across the United States, agriculture has been in a constant state of change. Market forces, consumer demands, economic and environmental considerations all place ongoing challenges to the sustainability of today's farmers. As one farmer put it "change is occurring faster than most farms can plan and adapt to it." From 210,000 farms a century ago, Ohio has decreased to 89,000 farms statewide in 1978 and to 75,000 farms in 2007. Because of specialization, the remaining 75,000 farms do not grow nearly the diverse varieties of crops and livestock of 30 years ago.

As shown in Table 4 below, Ohio livestock production has undergone the following changes from 1978 to 2007.

Table 4 — Change in number of farms raising livestock

	1978	2007
Number of farms with cattle	43,000	26,000
Number of farms with hogs	17,000	3,700
Number of farms with dairy cattle	12,698	3,650

While the numbers of farms and total animals raised have decreased, the number of animals per farm has increased.

Row crop agriculture including corn, soybeans, wheat, and other forages is still the predominant land use in Ohio and in the Lake Erie watershed. Based on 2001 National Land Cover Data, 59% of the Ohio Lake Erie watershed is in row crop agriculture. This ranges from highs of 78% and 76% in the Maumee and the Sandusky drainages, respectively, to a low of 16% in the Cuyahoga and 6% in the Chagrin. Areas and percentages for the major tributaries can be found in Appendix Figure A-1 and Table A-1.

Corn, soybeans, wheat and hay crop acreage information for Ohio collected from the USDA National Agricultural Statistics Service indicates that in the Lake Erie basin, corn acreage has not changed appreciably since the late 1970s while soybean acreage has increased. Wheat acreage has remained constant, but hay acreage has decreased. However, advances in agricultural technologies have resulted in increased yields for corn and soybeans on relatively the same numbers of acres.

The adoption of conservation practices (such as no-till and reduced tillage) over the last 30 years significantly reduced soil erosion rates and the associated phosphorus loads. As discussed previously, focusing on soil conservation methods was the recommended approach to reducing nonpoint phosphorus loads because a large portion of the agricultural nonpoint source phosphorus load was attributed to particulate phosphorus attached to sediment particles. However, since tributary watershed loads of DRP have been increasing since the early 1990s, phosphorus loading from nonpoint sources may no longer be primarily related to sediment load.

4.2.1.2 — Fertilizer Management in Row Crop Agriculture

The Task Force considered the multiple variables related to fertilizer management in row crop agriculture. Since the majority of current phosphorus loading to Lake Erie has been documented to be related to storm-pulsed runoff from the landscape, the methods, amount, form, placement and timing of phosphorus applied to the agricultural landscape are key management considerations. Figure 19 provides an estimate of the total annual elemental phosphorus (in metric tonnes) that is used in the Lake Erie watershed by way of commercial fertilizer application, manure production, and biosolids from WWTPs intended for agronomic application in the watershed.

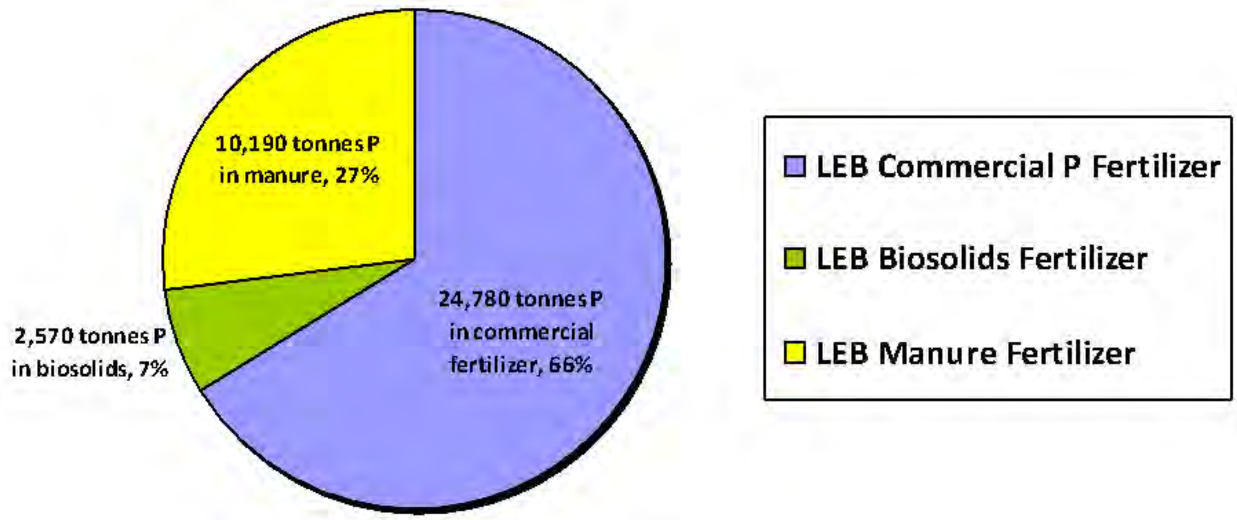


Figure 19 — Ohio EPA comparison of estimated elemental P handled annually (in metric tonnes) for commercial fertilizer, manure and biosolids on the agricultural landscape in the Ohio Lake Erie basin (LEB). (Estimates are based on available data from 2006, 2007 and 2008)

The Task Force analyzed each of these three inputs of phosphorus into the Lake Erie basin to understand changes in fertilizer and landscape management since the mid 1990s when the algal blooms began to re-appear.

4.2.1.3 — Commercial Inorganic Phosphorus Fertilizer

Analysis of statewide Ohio phosphorus fertilizer sales from 1955 through 2006 reveals that fertilizer sales have decreased dramatically from the late 1970s and early 1980s when they were at their peak (Figure 20), with some stabilization beginning in about 1991. Sales trends in the Ohio Lake Erie watershed were estimated by developing a ratio based upon Lake Erie watershed agricultural land area in production versus total Ohio agricultural land area in production and multiplying by the tonnage of P fertilizer sold in Ohio, producing an estimate of 62,600 tons (56,789 MT) of phosphate (P_2O_5) or 27,320 tons (24,784 MT) of elemental phosphorus land applied in the Lake Erie watershed for agronomic use in 2006.

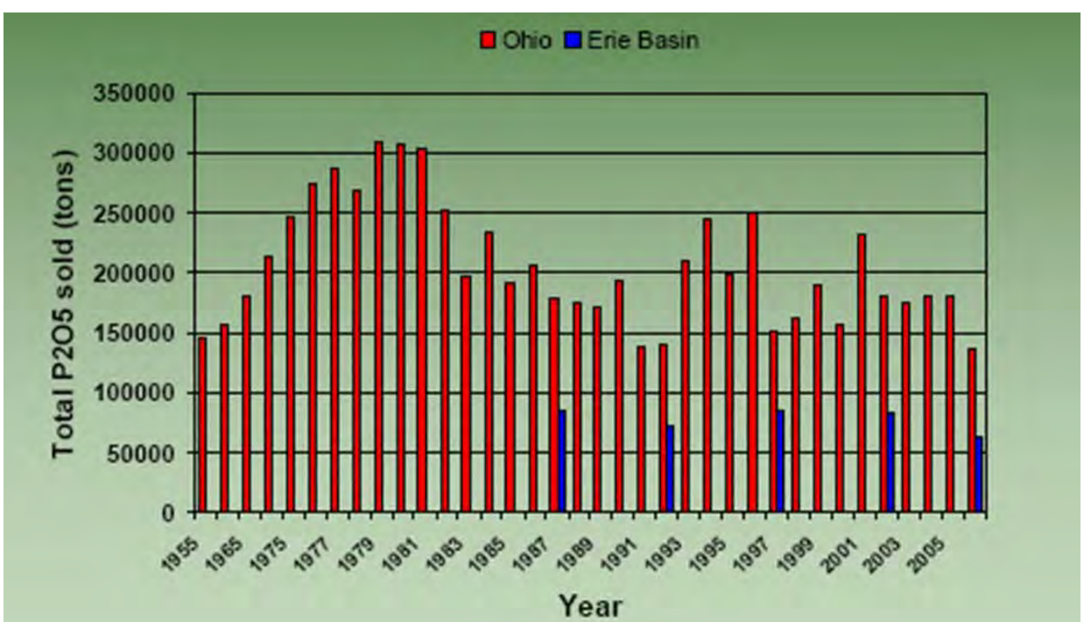


Figure 20 — Analysis of Ohio commercial phosphorus fertilizer sales from 1955-2006.
Source: Commercial Fertilizer Report, published by the Association of American Plant Control Officials

There is neither an exact means to track fertilizer usage by watershed nor a way to estimate how much of the phosphorus-containing commercial fertilizer that was sold in Ohio was land applied in the Lake Erie watershed. While this approach affects the accuracy of the estimates, the Task Force compared these estimates with those for other inputs of P to the Lake. Additional knowledge gaps include an understanding of the portion or percentage by fertilizer type sold and land applied from year to year in the Lake Erie drainage area. Other unknowns include the relative seasonal timing of the commercial P fertilizer applications across the basin.

Commercial fertilizer containing phosphorus is manufactured by converting rock phosphate [$Ca_3(PO_4)_2$] into a product that is much more water soluble. Wet or dry treatment processes are used to produce phosphoric acid. The forms of P in the acid are orthophosphate or polyphosphate that converts to orthophosphate upon contact with soil. Either these fertilizers or manures provide the principal P inputs for crops in interaction with the P pools found in the soil (Figure 21).

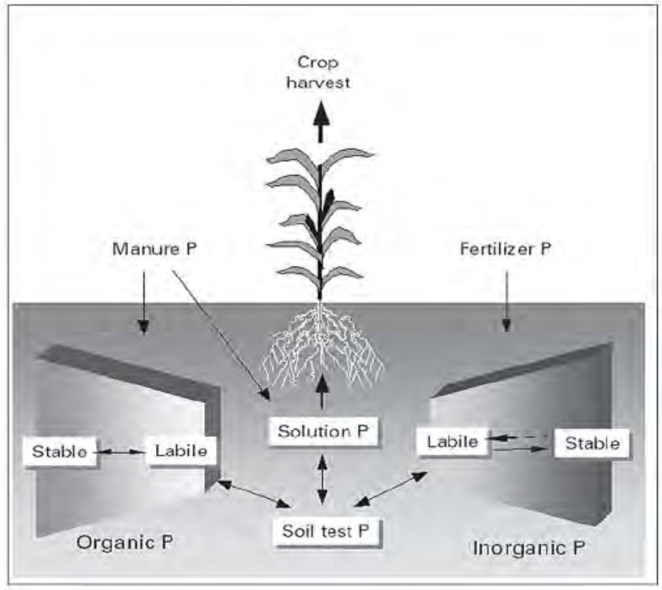


Figure 21 — The main phosphorus pools in soil. (Sharpley 2006)

According to Wortman et al. (2005), "Soluble Soil P is typically less than 1% of total soil P and is readily available to plants. Labile Soil P is typically less than 5% of soil P and is less tightly bonded than stable P. Stable P is more than 95% of the total soil P. It includes tightly bonded P in secondary and primary minerals and in organic forms." Orthophosphate is readily used by plants and it is the form of interest relative to the increasing DRP load to Lake Erie. It is a key nutrient in the development of harmful algal blooms (HABs). Application of fertilizer to soils causes an initial increase in soluble P at the point of contact, but chemical equilibrium is rapidly re-established as much of the P enters the labile pool (Wortman et al., 2005).

All of the forms of commercial phosphorus fertilizers in use today (Superphosphate [$Ca(H_2PO_4)_2 + CaSO_4$, 7.5-9% P], Concentrated Super Phosphate [also $Ca(H_2PO_4)_2$, but without $CaSO_4$, 17-23% P], Monoammonium Phosphate [MAP], Diammonium Phosphate [DAP] and Ammonium Polyphosphate [APP]) exhibit relatively high water solubility (>80%) compared to the insolubility of the rock phosphate [$Ca_3(PO_4)_2$] used as the starting P material in making superphosphate and concentrated super phosphate fertilizers. The more soluble commercial fertilizer forms have been in use since the 1940s, therefore the increased solubility of fertilizers is not considered to be a recent change that is contributing to the increasing DRP loads and the recurrence of the algal blooms in Lake Erie.

4.2.1.4 — Manure Phosphorus Fertilizer

Manure is another source of fertilizer utilized on the agricultural landscape and includes both organic and inorganic phosphorus compounds. Land application of manure is estimated to contribute approximately 27% of the annual fertilizer input in the Lake Erie basin (Figure 19).

Manure has been used for many centuries as an important source of fertilizer. Sources include animal manure, various types of compost, and biosolids. In manure, 45-70% of the P is inorganic, and the rest is organic. While dependent on soil temperature, soil pH and soil moisture, organic P decomposes and mineralizes somewhat readily, with the final decomposition product being orthophosphate (DRP) (Rehm et al., 2002).

Kleinman et.al (2002) compared the relative solubility between different types of manure P and diammonium phosphate (DAP) fertilizer, a commonly used commercial fertilizer. They compared dissolved P in runoff from plots applied with swine, dairy, and poultry manures with runoff from a plot fertilized with DAP. Each manure type released soluble nutrients in runoff in concentrations less than, but at least half of the value of concentration of soluble nutrients released by DAP. Similarly, Mallarino and Haq (2009) found DAP contributed much higher concentrations in runoff generated from fields treated with equal amounts of DAP, swine, poultry, or beef manure (100 lb P_2O_5/acre) applied without incorporation into the soil (Figure 22).

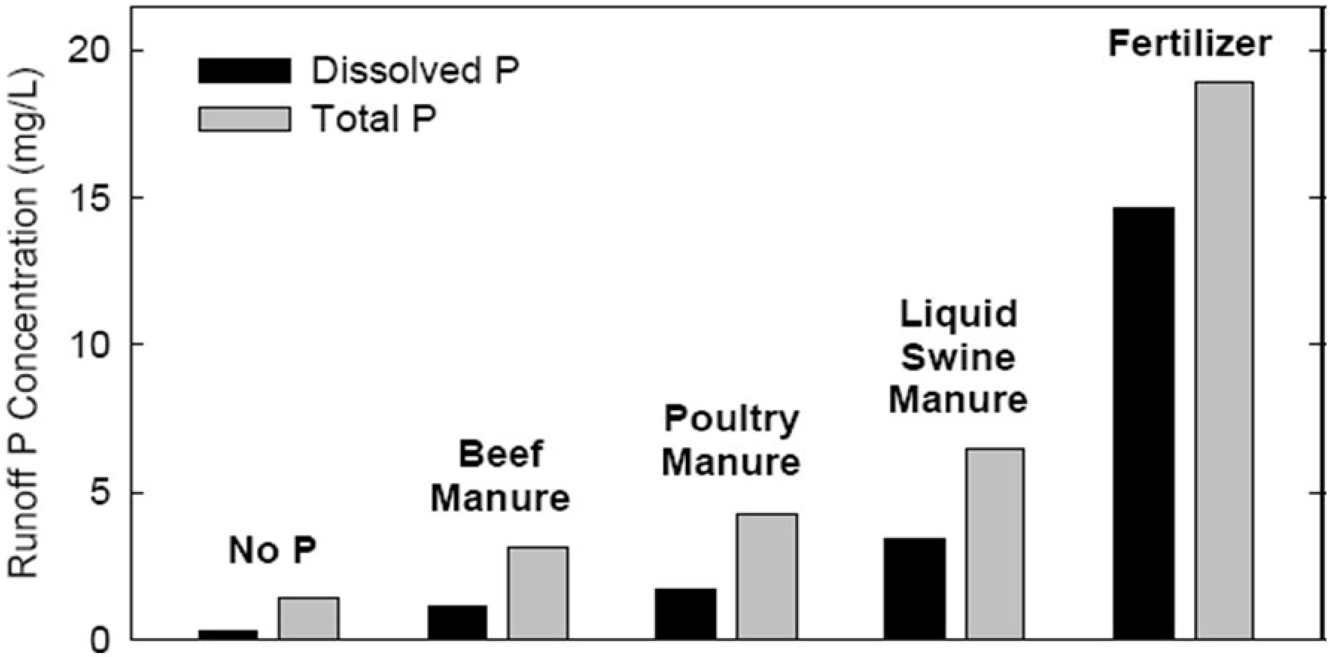


Figure 22 — Runoff P concentration within 24 hours of applying 100 lb P2O5/acre using fertilizer (DAP), beef, poultry, or swine manure without incorporation into the soil (averages across 21 Iowa fields). (Source: Mallarino and Haq, 2009)

The amount of P applied to the Lake Erie drainage basin as manure is related to the number of animals present and the relative P content and excretion rate of their respective manures. Accordingly, the Task Force quantified the livestock and poultry population in the Lake Erie basin using available data from the National Agriculture Statistics Service, Ohio Department of Agriculture-Livestock Environmental Permitting Program, Indiana Department of Environmental Management (IDEM), and interviews with Ohio livestock industry representatives. Using the estimated livestock and poultry inventory numbers, a calculation was made based on manure-P production estimates by species to estimate the current amount of manure-generated phosphorus land-applied in the Lake Erie basin. The total estimate of elemental manure P generated (and assumed to be land-applied) in the Lake Erie basin in 2007 is approximately 11,235 tons (10,192 MT) of manure-derived elemental P (Figure 19).

Swine

Swine inventory numbers reached a low point in 1993 (~611,400), down almost 30% from a 1984 inventory. However, swine numbers have since rebounded to a near historic high level (~860,000 in 2006). The Ohio EPA analyzed the swine population inventory in facilities in the Lake Erie basin, including those in Indiana and Michigan, and estimated ~950,000 swine were located in the basin in 2007. The mid-1990s marked a shift in swine housing towards larger and more concentrated swine facilities (960-1000 head per/barn, up to 2000 per barn). Today, almost all swine manure systems are liquid systems. In total, swine-generated elemental P was estimated to be 3800 tons (3447 MT) P in 2007 which is approximately 34% of all Lake Erie basin manure production.

Cattle (Dairy and Non-Dairy)

The reported inventories for cattle in the Ohio Lake Erie basin were highest in 1975 when numbers exceeded 603,000 head. By 1997 the cattle inventory in the Ohio Lake Erie basin had decreased to 339,000, a drop of almost 44%. For the past 10 years, however, cattle inventories in the Ohio Lake Erie basin have remained relatively constant at around 338,000 head.

Cattle herds can be on pasture, in complete confinement, on open-feedlots, or a combination of these systems. Manure management in open confinement areas is crucial to efficient agronomic use of manure nutrients due to the exposure to precipitation. In a confinement system, manure may be managed as a solid pen-pack material, or as is the case in larger cattle confinement facilities in Ohio, liquid manure storage and management systems are primarily used.

While overall cattle numbers are down, dairy cattle inventories in the Ohio Lake Erie basin show an increase of 39% since 2002. Beginning in the late 1990s, a trend toward construction of large, confined dairy facilities with herds from 650 to 3000 head began to occur. Many new dairies are located in the Lake Erie basin, especially the upper Maumee watershed in Michigan, Indiana, and Ohio. The largest dairy operations, i.e., those with greater than 500 head, handle the bulk of their manure as a liquid. Dairies with more than 700 head are also required (under Concentrated Animal Feeding Operation Rules) to contain and manage storm water runoff from the production area.

In total, cattle-generated elemental P was estimated to be 5670 tons (5144 MT) P in 2007, which is 50% of the total Lake Erie basin manure production. Approximately 36.5% of all cattle manure generated in the Lake Erie basin (from OH, IN, and MI) is generated by producing dairy cows.

Poultry-Egg Laying and Turkey Operations and Poultry Manure Brokering

Ohio EPA analyzed the poultry layer population and grower turkey inventory to include Ohio, Indiana and Michigan facilities in the Lake Erie basin and provided an estimate of 7.72 million hens and pullets (baby hens) and 266,000 grower turkeys located in the basin in 2007. NASS data are vague with respect to poultry operations. The Ohio Department of Agriculture, Livestock Permitting Program provided inspection data for Ohio where approximately 87% of the Lake Erie basin egg-laying hens and pullets are located. These data were considered to be an accurate source for inventory and manure generation calculations. Almost all of the Lake Erie basin turkey population is located in Ohio.

A large portion of the Lake Erie basin egg-layer inventory sits on or is very close to the Lake Erie/Ohio River watershed divide in Ohio. In those cases, a 50% adjustment was made to account for poultry manure anticipated to be land applied outside the Lake Erie watershed. In western Ohio, an estimate was needed to account for poultry manure generated outside the Lake Erie watershed (especially in Grand Lake St. Mary's and Wabash River watersheds) and hauled north into the Lake Erie watershed.

For poultry-egg laying generated manure-P, approximately 870 tons (789 MT) of P (7.7 % of Lake Erie basin manure production total) was generated in 2007. For turkey generated manure-P, approximately 260 tons (236 MT) P (2.3 % of Lake Erie basin manure production total) was generated in 2007. Poultry manure brokered into the Lake Erie watershed was estimated to contain at least 640 tons (581 MT) of elemental P in 2008 or 5.7% of the annual total estimated manure-generated phosphorus in the Lake Erie basin.

4.2.1.5 — Biosolids in the Lake Erie Basin

Application of biosolids from wastewater treatment plants onto agricultural land may only be done according to Ohio EPA permit requirements. Estimates provided by Ohio EPA show that approximately 123,000 tons (111,503 MT) of biosolids were land applied in the Lake Erie watershed in 2007. Ohio EPA conducted a literature review and a cross verification of Ohio NPDES biosolids monitoring reports and found that phosphorus concentrations in biosolids are highly variable and are dependent upon the type of wastewater treatment plant and how the biosolids are processed. Typical concentrations of phosphorus in biosolids range from 10,000-36,000 mg/kg.

Using the tonnage described above, this calculates to a range of 1,230 tons (1116 MT) – 4,428 tons (4017 MT) (average = 2,829 tons/2566 MT) of total elemental P per year from land applied biosolids in Ohio. This estimate does not include biosolids generated and land applied from municipalities or industries in Lake Erie basin counties of Indiana and Michigan. As previously stated, land application of biosolids represent 6.8% of the total application of fertilizer.

4.2.1.6 — Glyphosate as a Source of Phosphorus

Another potential source of phosphorus is the application of glyphosate. Glyphosate is the main chemical in the commonly applied herbicide Roundup which is also used to pre-treat corn and soybean seeds prior to planting. The preliminary results of recent research by McKay and Bullerjahn of Bowling Green State University suggest that blue-green algae (cyanobacteria) can utilize the phosphonate portion of the glyphosate molecule. Phosphonate is traditionally viewed as a form of phosphorus that is not highly bioavailable. The researchers estimate that as much as 1,000 metric tonnes of Roundup is applied in the Lake Erie watershed per year, and it is being detected in adjacent waterways particularly in the spring. The next step in their research is to determine if the presence of glyphosate is increasing the amount of blue-green algae (Brannan 2009).

Mullen and Diedrick (2009) took a different look at glyphosate to determine if it could be a significant source of phosphorus loads. The 1,000 metric tonnes of glyphosate converts to about 2.2 million pounds. Assuming that the phosphonate content of glyphosate averages 15% (depending on the formulation) it works out to about 330,000 lbs. of phosphonate (approximately 150 metric tonnes of elemental P) applied. Spreading this over the approximately 3.7 million acres of corn and soybeans in the Lake Erie watershed that would likely receive glyphosate treatment, results in about 0.1 lbs per acre, most of which should be absorbed in the process of killing weeds. Although it does not appear to represent a significant threat to water quality, there may be a risk of transport if glyphosate is applied near surface waters or when conditions threaten a major storm water/sediment runoff event.

4.2.1.7 — Balance of Agricultural Phosphorus Inputs and Outputs

Based upon current estimates from NASS on crop acres and productivity in the state of Ohio, state-wide fertilizer sales trends, and manure generated from animal production, the state of Ohio has been approaching a phosphorus balance in the last decade (Figure 23). This "balance" has historically not existed. This balance between phosphorus inputs (fertilization of both commercial fertilizer and animal waste) and phosphorus crop removal is likely the result of several factors including: higher fertilizer prices; decreased animal numbers; improved crop productivity; newer crop varieties and hybrids; and increased awareness of nutrient management.

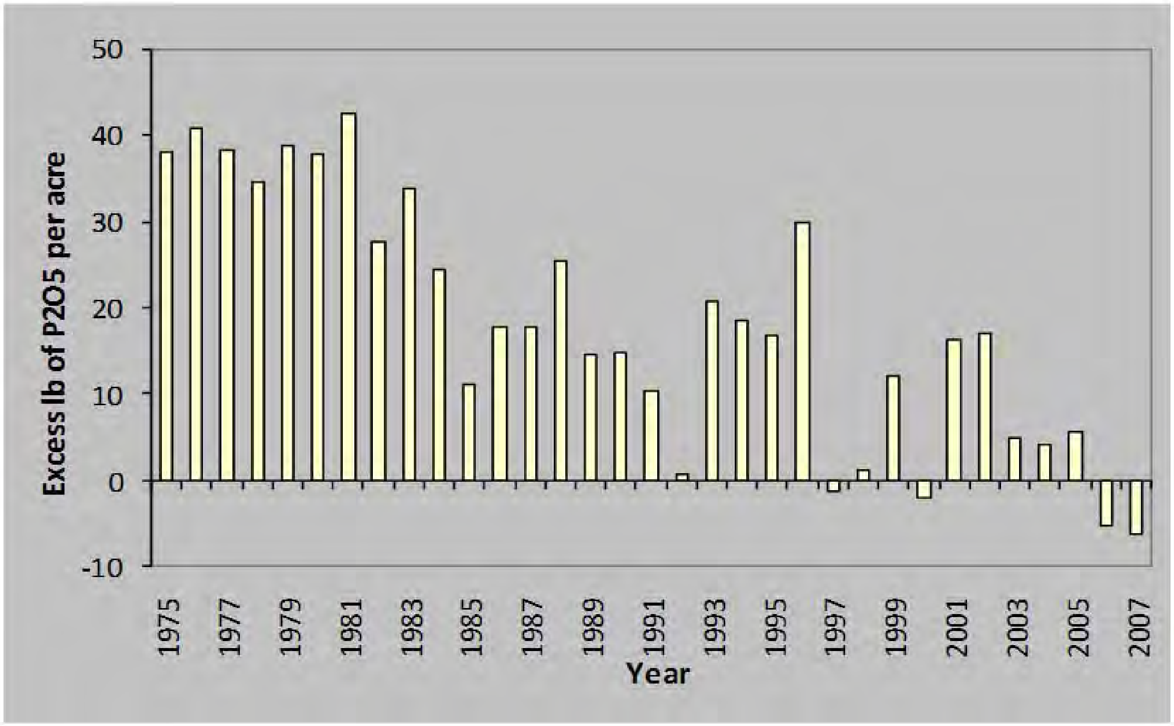


Figure 23 — Excess phosphate per acre based upon commercial fertilizer sales information in the state of Ohio, manure generated from animal operations and the resultant amount of phosphorus that theoretically will be land applied, and crop removal phosphorus estimates based upon USDA-NASS information. (USDA-NASS, 2007; Terry, 2006; OSU, 2006; Bast et al., 2009)

Despite this net balance, the DRP load to Lake Erie continues to increase. This suggests that there are changes in agriculture having an effect on the delivery of DRP to Lake Erie. Nutrient inputs to the Lake Erie watersheds need to be managed carefully for the timing of applications, the amount applied and the degree to which applications are incorporated into the soil profile.

Some of the aspects that may be influencing changes in nutrient movement include:

- Changes in tillage practices, such as increases in the use of minimum till and no-till. In addition, there is more fall preparation of seedbeds for spring planting (stale seedbeds).
- Changes in drainage and runoff related to installation of surface drainage systems; installation of additional subsurface drainage on closer spacing; enlarging fields and removing fencerows; and utilizing tillage practices that minimize surface roughness.
- Larger farms and larger fields have resulted in changes in the type and size of equipment used. Planters and tillage equipment range from 30 to 120 feet in width compared to those 12 to 24 feet in width used in the 1970s. Larger farms require spreading the work load over the year which increases the tendency of applying fertilizer after crop harvest.
- Changing methods, amount, form, timing and placement of nutrients, such as; more surface application of nutrients with less incorporation, instead of using row fertilizers.
- Unknown and uncertain use of soil testing to assess field nutrient levels prior to application and unknown and uncertain adherence with nutrient application recommendations.
- Changes in soil quality, such as: decreasing soil organic matter content, soil tilth and infiltration rates; and increasing compaction, soil densities and aggregation.

- Phosphorus build-up (stratification) in the upper two inches of the soil may result in increased DRP concentrations in runoff water. Stratification can result from surface application of fertilizers and manures and the phosphorus releases from the breakdown of crop residue in the soil surface. Further study is needed on the extent of stratification and its potential role in DRP in runoff.

Positive changes in nutrient management include utilizing precision farming and grid sampling which result in more detailed specificity in the application of fertilizers designed to meet agronomic needs. However, these practices have not been adopted at a scale sufficient to counteract excessive movement.

Task Force participants readily acknowledge that these trends are having significant impact in agricultural management. And based on what we know today, these trends are nearly impossible to quantify in terms of their contribution to nutrient movement from fields to the western basin of Lake Erie. The research recommendations discussed later in this report will yield many answers to the knowledge gaps we have. But the Task Force also acknowledges that much needs to be done to address nutrient management in the near term to address the issue of algal blooms.

The ability of soils to adsorb phosphorus and the soil nutrient interactions for many of the over 400 soil types in Ohio (especially the lakebed soils of the Lake Erie basin) are not well known and will require additional research. Current tools to assist agricultural managers with nutrient management include the use of soil tests and other indices. These tools provide managers with the data and assessment of field-based conditions to guide nutrient inputs to agricultural fields. While these tools have been in use for many years, their application needs to increase significantly to adapt nutrient management practices to highly variable and frequently changing conditions. The following section describes these tools and their current application in Ohio.

4.2.1.8 — Soil Tests and the Phosphorus Index

The Ohio State University is the primary source of agricultural nutrient recommendations in Ohio. Recommendations were developed for the Tri-State area of Ohio, Michigan and Indiana through collaboration with Ohio State University, Michigan State University and Purdue University. These recommendations are agronomic in nature and based upon soil test information. Current phosphorus recommendations were developed through years of field experimentation to identify a soil extractant that provides a good approximation of available phosphorus, and are now based upon Bray-Kurtz P1 extractable phosphorus. This is an acidic solution that causes aluminum and calcium-phosphate minerals to dissolve representing the soil's ability to re-supply solution phosphorus during a growing season as plants take up phosphorus from solution. Thus available P, expressed in a soil test report, is not a measure of solution P.

Critical levels and rate recommendations were then determined based upon correlations between crop yield and soil test level. Based upon several site years of information collected at the Western Research Station of the Ohio Agricultural Research and Development Center, the critical level for both corn and soybeans was identified at 15 ppm or 30 pounds per acre (Figures 24 and 25). These two figures illustrate that as soil test phosphorus approaches 15 ppm (30 pounds per acre) the probability of nutrient deficiency decreases as does the probability of crop response to additional phosphorus. Traditionally, critical levels are set when the percent of maximum yield surpasses 95% which is evident from both figures at or near 15 ppm/30 pounds per acre. Current Tri-State critical levels for soil test phosphorus are presented Table 5.

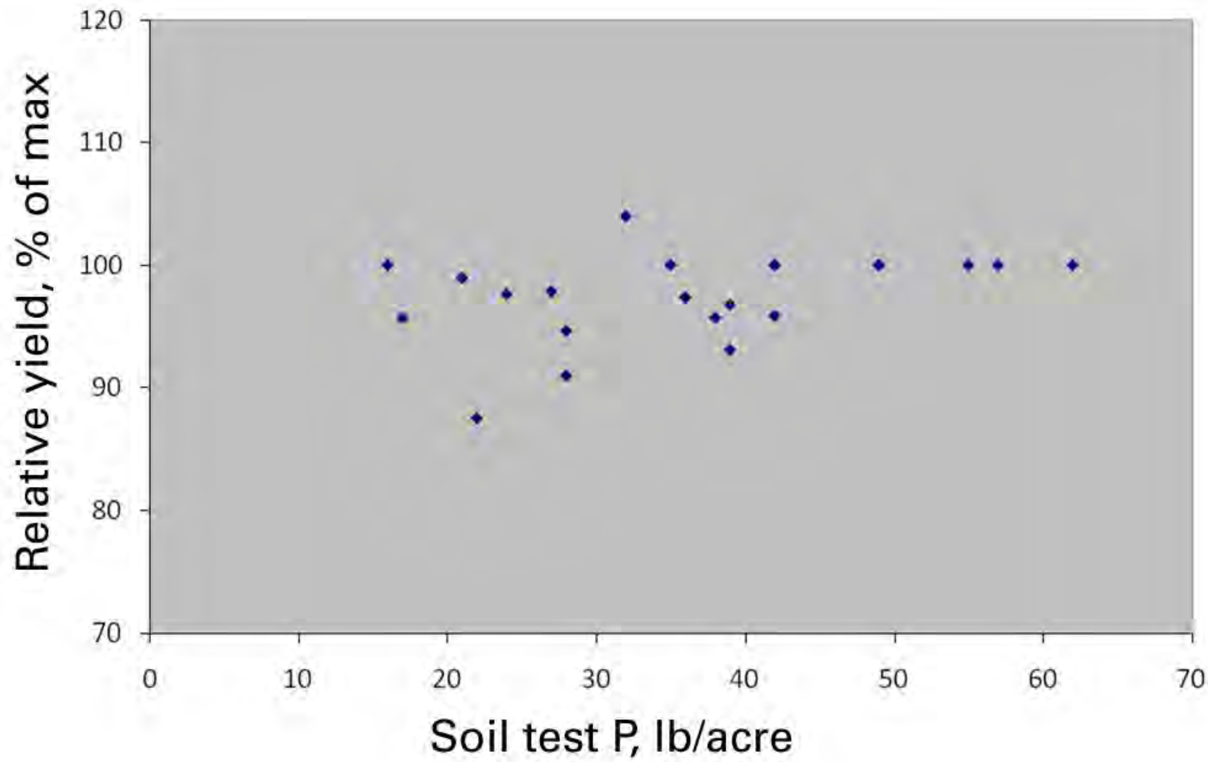


Figure 24 — Correlation between soil test P level and corn relative yield as the result of tests conducted at the Western Research Station of the Ohio Agricultural Research Development Center, 1993-1999

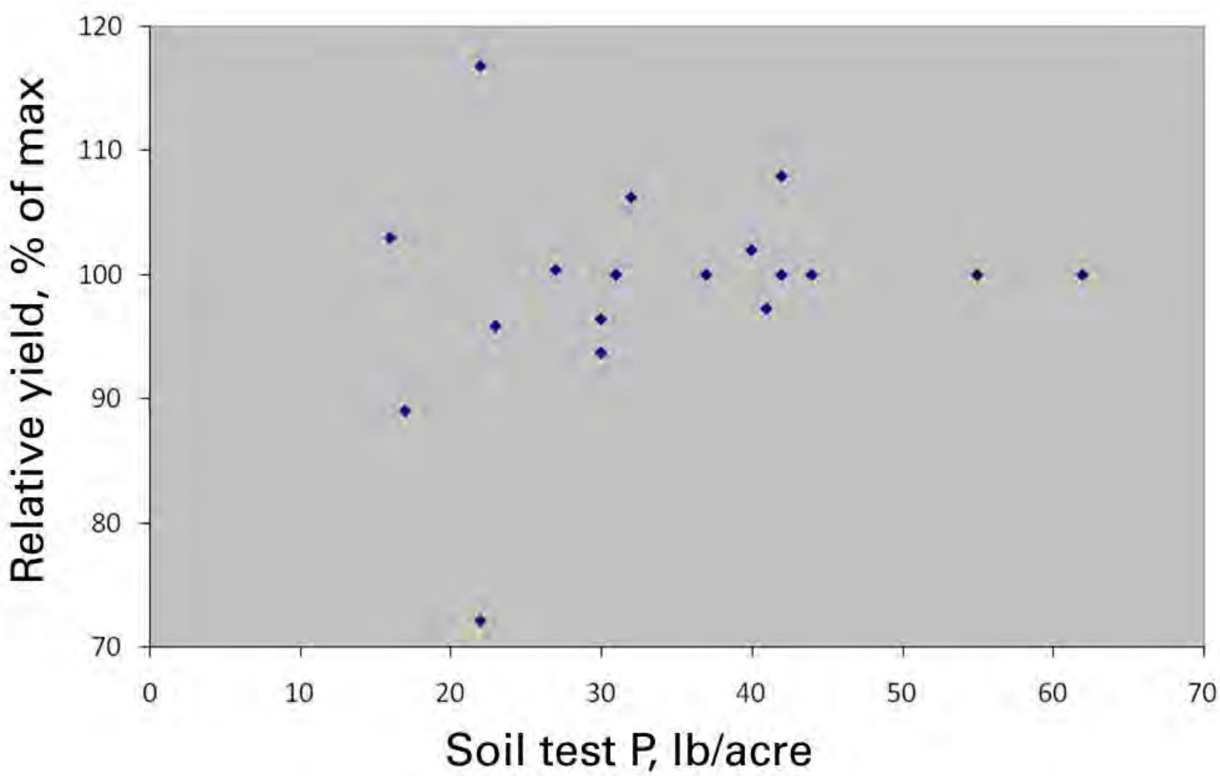


Figure 25 — Correlation between soil test P level and soybean relative yield level tests at the Western Research Station, 1994 – 1999

Table 5 — Current critical soil test phosphorus levels for corn, soybean, wheat and alfalfa. (OSU Extension Bulletin E-2567)

Crop	Critical level ppm (lb/acre)
Corn	15 (30)
Soybean	15 (30)
Wheat	25 (50)
Alfalfa	25 (50)

Ohio fertilizer recommendations are based upon a build-up, maintenance, drawdown concept. Soils with soil test phosphorus levels below the critical, receive recommendations designed to increase the soil test to the critical level within four years. Soils with soil test phosphorus levels at or slightly above (plus 15 ppm or 30 pounds per acre), receive a recommendation designed to replace crop removal so as to maintain current soil test levels. Soils with soil test phosphorus levels well above the critical (> 15 ppm or 30 pounds per acre), receive recommendations that decrease the recommended phosphorus rate to reduce soil test levels. Soil with soil test levels well above the critical (≥ 40 ppm or 80 pounds per acre for corn and soybeans), receive a phosphorus recommendation of zero.

Many land grant universities do not utilize the build-up, maintenance, and drawdown approach to phosphorus recommendations. However, due to spatial variability in soil test phosphorus, the Tri-State continues to endorse the build-up, maintenance, and drawdown approach. Fields that have soil test levels near or just slightly above the current critical level are likely to have areas of the field where soil test P is below the critical. In order to ensure that these areas are as productive as possible, the field still receives a phosphorus recommendation. Current Tri-State phosphorus recommendations for corn and soybeans are present in Tables 6 and 7.

Table 6 — Current Tri-State phosphorus recommendations for corn. (OSU Extension Bulletin E-2567)

	Yield potential (bu/acre)				
Soil test	100	120	140	160	180
ppm (lb/acre)	------------lb P_2O_5 per acre---------				
5 (10)	85	95	100	110	115
10 (20)	60	70	75	85	90
15-30 (30-60)	35	45	50	60	65
35 (70)	20	20	25	30	35
40 (80)	0	0	0	0	0

Table 7 — Current Tri-State phosphorus recommendations for soybeans. (OSU Extension Bulletin E-2567)

	Yield potential (bu/acre)				
Soil test	30	40	50	60	70
ppm (lb/acre)	------------lb P_2O_5 per acre---------				
5 (10)	75	80	90	100	105
10 (20)	50	55	65	75	80
15-30 (30-60)	25	30	40	50	55
35 (70)	10	15	25	25	30
40 (80)	0	0	0	0	0

In response to continued degradation of surface water, the USDA-NRCS in each state has been mandated to choose a P-based nutrient management strategy. One of these approaches has been establishing a P risk index system to evaluate the risk of P transport. Lemunyon and Gilbert (1993) first proposed the P risk index in order to identify agricultural fields vulnerable to P loss (transport). In a P Index, site characteristics contributing to P loss are considered, and weighting factors (modifiers) are often applied to account for differences in each characteristic's relative contribution to P loss (Dayton and Basta, 2005). In Ohio, the risk of agricultural P transport into surface water is assessed by either the USDA-NRCS-Ohio P Index Assessment Procedure or the Soil Test Risk Assessment Procedure (STRAP) within the Nitrogen and Phosphorus Risk Assessment Procedures (Ohio NRCS, 2001).

The Ohio P Index is a procedure that combines well established factors that influence the transport of P from agricultural fields to surface waters. Each factor is evaluated based on site specific data and weighted, or modified, according to its overall effect on P transport. Each of the site sub-values are added together to establish an overall site rating, or score, of Low, Moderate, High or Very High risk. The P Index is a tool used to evaluate the risk of agricultural P transport at the field scale. All P indices, including Ohio's, consider both P transport and source factors. Transport factors considered in the P Index include: soil erosion potential; field runoff class; and connectivity to water. Source factors considered in the P Index include: soil test P (STP); planned amount of P fertilizer (manure/biosolids or inorganic) applications; and method of P fertilizer application (management). In addition, the P Index score is reduced by 2 points if a designed filter strip (≥ 33 ft wide) is installed to intercept surface runoff.

Based on the risk assessment score, the appropriate land treatment and nutrient application treatments can be planned to minimize phosphorus transport from the site. Field characteristics relevant to both P transport and P source factors considered in the Ohio P Index are shown below.

P Index Score =	Transport Factors +	P Source Factors
	Soil erosion potential Connectivity to waterway Runoff class (slope) Presence of filter strip	Soil test P Planned P fertilizer applications Method/timing of fertilizer application

Initially used to assess risk, the P index is nationally developing into a tool to evaluate alternative management practices for planning and regulation of P application (Benning and Wortman, 2005). In fact, currently the Ohio NRCS is reviewing the Ohio P Index with the intention of validating and, if necessary, revising the parameters presently used. A team of agency representatives, scientists and agriculture professionals has been assembled, as the Ohio P-Index Revision Team, to accomplish this effort. The existing Ohio P Index parameters are programmed into the Purdue Manure Management Planner (MMP). Ohio NRCS requires the use of the MMP software when developing a Comprehensive Nutrient Management Plan (CNMP). Therefore, whenever a CNMP is developed the P Index is being utilized to help prioritize fields for nutrient application. A P Index system is especially valuable for sites that may already have excessive STP, in that it considers a multitude of management practices which can be used to reduce the risk of P transport.

The Soil Test Risk Assessment Procedure (STRAP) is used to predict risk of P transport based on the Bray-P1 extractable STP level. As STP levels increase above150 mg/kg Bray-P1 it is presumed that there will be an increase in P transport and no additional phosphorus application is recommended. Once field STP levels exceed 150 mg/kg Bray-P, the P Index can be used to evaluate risk of P transport and it is possible that the use of the P Index may allow for additional P application. The benefit of a threshold P level is it is quicker and easier to explain to farmers, suppliers and nutrient applicators than the P Index. It is understood that the P soil test threshold number will be higher than agronomic P sufficiency for crop needs. However, considering the increase in DRP in Ohio streams, the current threshold value of 150 mg P/kg is being brought into question. Currently, 150 mg kg^{-1} Bray-P1 extractable P is considered the threshold STP level where risk of increased P transport is considered likely. Testing the validity of this claim and identifying a soil P test method, whether it continues to be Bray-P1 or another, that is strongly related to P runoff (transport), have been identified as top priorities of the Ohio NRCS sponsored, Ohio P-Index Revision Team. As illustrated in Figure 26, soil has an assimilative (binding) capacity for P. Phosphorus becomes more soluble and the risk of P transport increases as the soils assimilative capacity is exceeded.

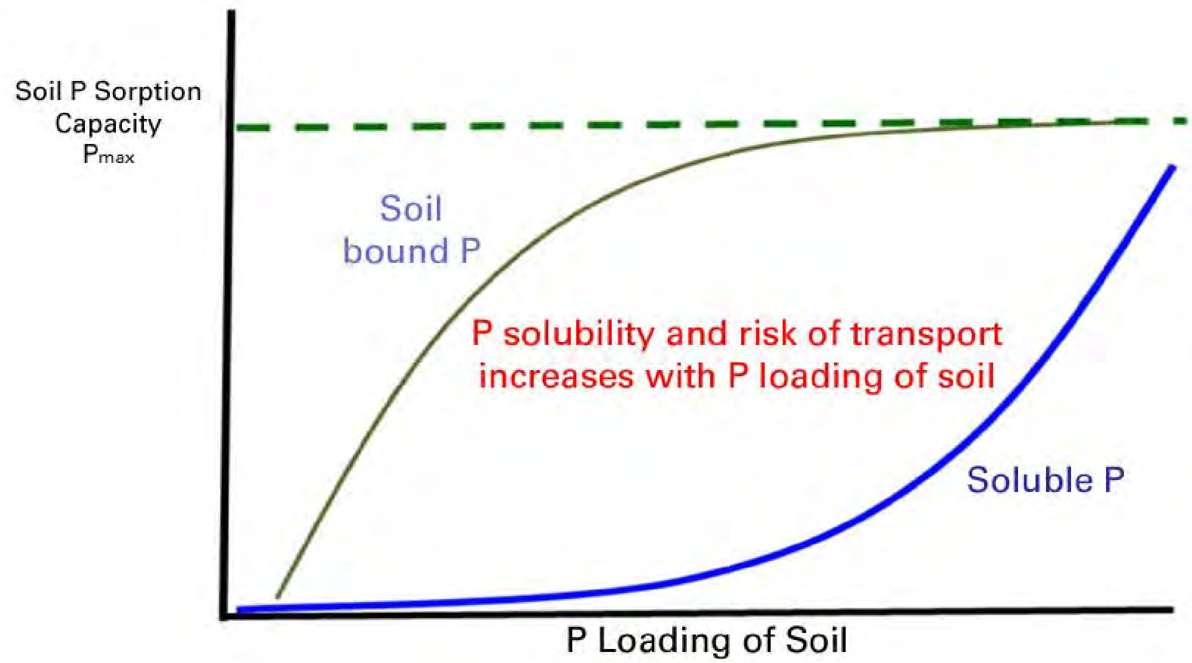


Figure 26 — Schematic presentation of the assimilative binding capacity of soil for phosphorus

Many factors influence whether P is bound to the soil or dissolved in the soil solution, as discussed in Section 3.3. An example of the complexity is illustrated by the data plotted in Figure 27. These data are from a long term small plot P runoff experiment being conducted at the Ohio State University, Waterman Research Farm. Relationships between STP and runoff dissolved P (RDP) under varying treatments are being evaluated using simulated rainfall. Thirty-two field plots (2x2m) were established and initial background surface STP (22 to 136 mg/kg Bray-P1) and RDP (0.12 to 1.4 mgP/L) were determined. Varying amounts of poultry litter were thoroughly tilled into the plots to provide a broad range of STP levels and the plots were allowed to age for 1 year. The plots were re-evaluated after one year and STP ranged from 30.5 to 753 mg/kg Bray-P1, and RDP ranged from 0.14 to 3.0 mgP/L. With all of the data plotted for the entire experiment with and without added manure, Figure 27A shows a strongly significant (r^2 = 0.68, P<0.01) relationship between RDP and Bray-P1. However, a closer examination suggests that this relationship may be misleading and not represent what is happening at low STP.

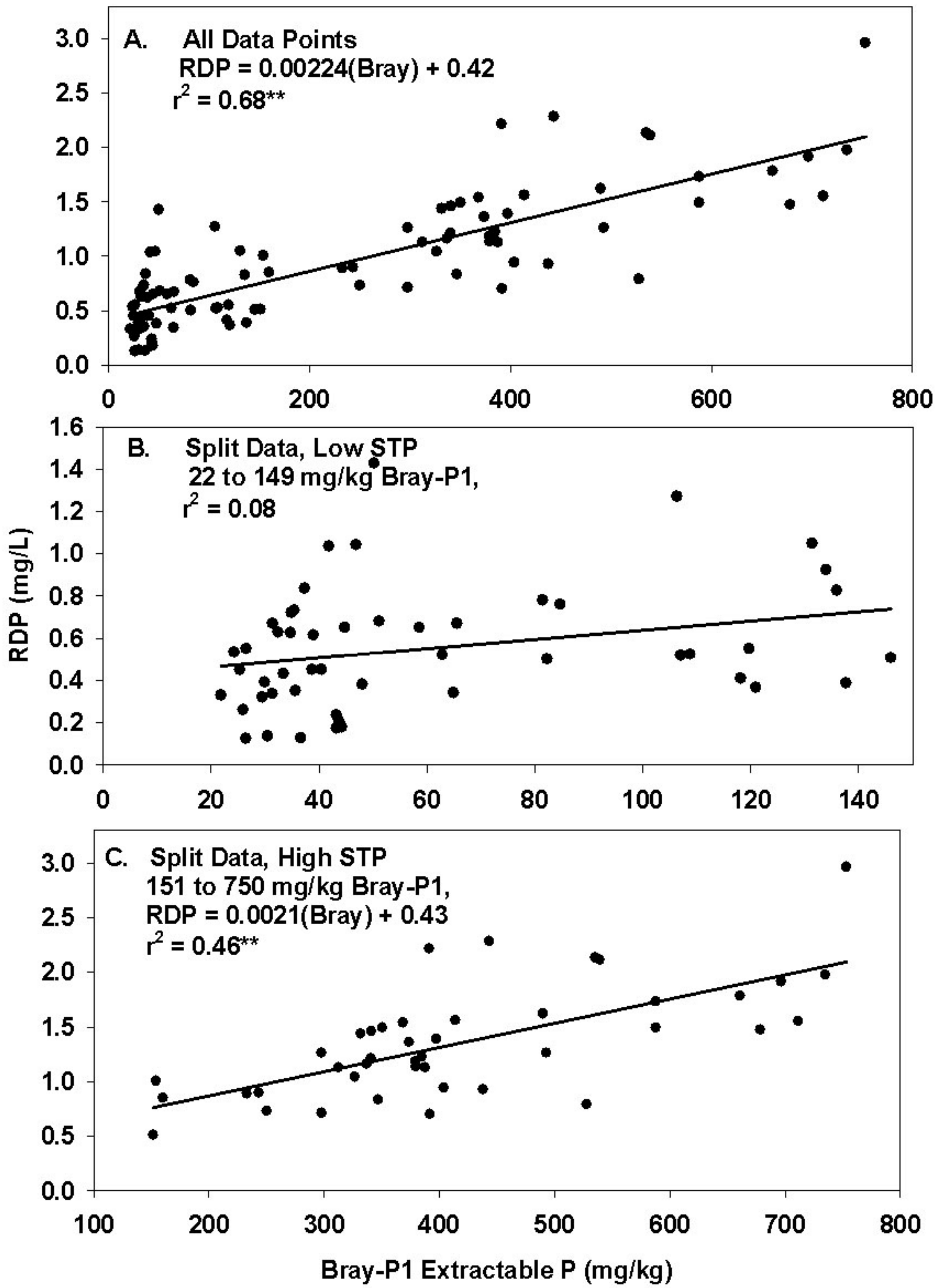


Figure 27 — The complexity of the relationship between soil test phosphorus (STP) and runoff dissolved phosphorus (RDP) under varying treatments using simulated rainfall. (Note: RDP is equivalent to DRP)

In Figure 27B, only lower STP (22 to 149mg/kg Bray-P1) samples are plotted. There is no relationship between RDP and STP, with RDP ranging from 0.12 to1.4 mgP/L. The variability in RDP at seemingly low STP levels is not surprising. Soil P solubility/runoff potential is controlled by a combination of P mineralogy (speciation) and soil properties as well as by the actual amount of soil P, as discussed in Section 3.3. This is especially apparent at low levels.

Figure 27C considers only the higher STP (149 to 753 mg/kg Bray-P1) and again there is a significant ($r^2 = 0.46$, $P<0.01$) relationship between RDP and STP. When soil P is excessive, soil properties relevant to P assimilation become saturated and P solubility/runoff P control is shifted toward the mineralogy (speciation) of the added P (fertilizer/manure). It is interesting that, while the addition of high levels of poultry litter resulted in an almost six-fold increase in STP, there was only an approximately two-fold increase in RDP, again, illustrating the soil's assimilative capacity to bind P.

Ideally, a soil test used to evaluate P transport risk should function across a range of soil types, STP levels, and management practices. Although STP is not the only site characteristic that contributes to P transport, identifying a STP level where P solubility begins to rise sharply is an important part of understanding the risk of P transport. Traditionally, phosphorus soil tests are designed to predict the amount of P available for crop nutrition and the probability of a crop response to P fertilizer across a growing season (Bray and Kurtz, 1945; Mehlich, 1984). Due to increasing concern about P transport and water quality issues, there has recently been an attempt to extrapolate STP data to predict risk of P transport (Dayton and Basta, 2005; Sims et al., 2000; Hooda et al., 2000; Pote et al., 1996; Sharpley et al., 1996; Sharpley, 1995). However, little comprehensive data across a range of STP under varying site conditions (tillage, soil type) is available to determine if this extrapolation is valid (Sims et al., 2000). Further, it is likely that other STP methods, not directly related to crop fertility, may do a better job at predicting risk of P transport.

Some small plot work has shown agronomic soil tests, such as Bray-P1 and Mehlich 3, correlate with DRP (Pote et. al., 1996; Sims et al., 2002; Andraski and Bundy, 2003). However, application of these models to soils with different P retention properties has not been successful (Schroeder et al., 2004), possibly because both Mehlich 3 and Bray-P1 are strong acid fluoride extractions. Some recent work has suggested that water or weak salt solution extractable P may mimic what happens in soil during rainfall and so better predict runoff P (Dayton and Basta, 2005; Hooda et al., 2000; Pote et al., 1996).

Another potential issue that may make extrapolation of soil fertility P testing inappropriate for evaluating environmental P transport risk is that when STP is used to evaluate fertility for crop nutrition the soil is sampled up to 8 inches deep, to represent P availability in the root zone. However, runoff P is a surface phenomenon and is strongly related to the upper couple of inches of soil (Sharpley and Halvorson, 1994). If the soil is well mixed and the STP is consistent throughout the soil test depth there is no problem. However, if soil P becomes stratified due to surface applications of P fertilizer that are not incorporated into the soil, a surface soil sample may be more representative of P transport risk than a soil sample used to evaluate crop nutrition. This may become increasingly important in no- or low-till situations.

Increased robustness of the relationship between STP and runoff P will make STP a powerful and inexpensive tool to make accurate estimates of the risk of P transport. However, in order to be robust, models must be developed across different soils and tillage/management practices, across different soil P levels and perhaps using surface soil samples, as these factors may alter P retention and release (Dayton and Basta, 2005; Sharpley, 1995; Sharpley et al., 1996; Pote et al., 1999). Nationally, as well as in Ohio, this has implications for previously set STP thresholds as well as the soil test methods used that are presumed to be protective of surface water quality.

4.2.1.9 — Fall and Winter Fertilizer Application

Fall and winter application of agriculture nutrient applications is often identified with increased potential for nutrient runoff. The runoff potential is a result of application on frozen or snow covered ground, when there is little to no opportunity for plant uptake or for the nutrients to incorporate into the soil leaving the nutrients susceptible to runoff. Recent trends in weather patterns in the Ohio region indicate higher intensity storms overall and less snowfall in winter. These trends parallel observed increases in winter runoff and associated increases in DRP.

Many factors influence nutrient applications in the fall and winter. Fertilizer dealers must turn over their inventory, particularly in the months between harvest and the end of planting. The quicker a dealer can turn their inventory, the more likely they can purchase new inventory at a lower price. Historically, fertilizer costs rise almost weekly over the winter as spring demand approaches. Most dealers need to turn their inventory 6-10 times during this period.

Farmers must also manage their inventories for space and cost considerations. Farmers may not be able to buy all of what they will need for a season due to inventory limitations. At the same time, farmers must be concerned about having the material on hand at the time they have available to apply.

Labor and equipment availability in the winter months are key considerations for both dealers and farmers. The more days a dealer can make the equipment available, the more opportunities it will be used by area farmers, adding more profit with existing assets. Likewise, farmers experience the same concern about optimizing availability of labor and equipment. Farmers also want to avoid soil compaction, a particular consideration with the tight clay soils of northwest Ohio, creating more incentive to utilize heavy equipment on frozen ground.

There are also many time sensitive tasks in the late winter, early spring timeframe that affect both dealers and farmers. These include:

- Seed and herbicide delivery and application
- Wheat nitrogen top dress, insecticide and fungicide
- Corn starter delivery
- Adapting to changes in plans (crops, labor and other business operations)
- Nitrogen delivery and application for corn
- Equipment upkeep

These activities occur during a critical time period in preparation for the upcoming crop year. If a delay to apply fertilizer goes on too long, a farmer may not apply for the crop year, creating missed opportunities for the dealer and farmer concern of lost yields. Some farmers will look to apply a double application the following year to make up for the missed application. There are also misperceptions that remain among some farmers about how long nutrients must be on the ground to break down and enter the “soil solution” to be available for the impending crops to take them up. All of these influences must be taken into account as we look to adapt past practices for agricultural production and reduction of nutrient runoff (Joe Nestor, Nestor Ag LLC, personal communication).

4.2.1.10 — Agricultural Summary and Recommendations

Agriculture is the largest land use in the Lake Erie watershed, especially in the western Lake Erie basin. While the DRP has been increasing, phosphorus application to cropland has decreased, crop production and yields have increased, soil erosion levels have decreased, and particulate phosphorus monitored in the streams has decreased. We do not have all the answers at this time as to what is causing the increasing DRP, but there are research projects underway and proposed that will provide the much needed information to direct future actions.

Given the changes and trends in agriculture previously discussed, we do know that agriculture needs to begin addressing movement of nutrients as best we know how right now. While there is a lack of evidence that differentiates the relative contribution of application of commercial fertilizers and land application of manure to P runoff, we do know that practices that address the methods, amount, form, placement, timing and incorporation will significantly benefit both sources of DRP. And, while there are many uncontrollable limitations and factors that enter into management of any landscape, including weather conditions which can change on a daily, weekly, monthly or annual basis, there are several Best Management Practices for nutrient management that need to be utilized. These practices have been documented to Avoid, Control and Trap (ACT) nutrients from getting into our streams and lakes. The list of recommended priority practices is presented in Appendix B. These practices address the timing, amount and incorporation considerations and apply to both the application of commercial fertilizers and land application of manure.

Some of these practices include:

- Soil testing according to University recommendations for frequency and sampling methodology;
- Follow Tri-State Fertility recommendations for application of additional nutrients to attain the planned for crops and yields;
- Applying nutrients to a growing crop or cover crop significantly increases the chance for nutrients to be taken up and temporarily stored in plant tissue. The growing crop also reduces soil erosion and increases water infiltration reducing both DRP and particulate P;
- Apply additional nutrients under conditions that will reduce chances of movement off site, avoiding frozen and snow covered ground application when possible and incorporating nutrients into soil where possible;
- Encourage and promote Recommended BMPs for nutrient management (Appendix B); and
- Utilize and install more effective hydraulic buffers (such as filter areas, wetlands, controlled drainage, cover crops and other practices in Appendix B) designed to reduce the rate and amount of water leaving the landscape and to filter and treat nutrients moving from the field to and through surface and subsurface drainage systems, waterways, streams and rivers.

Additional and more detailed actions can be found in the Recommendations Matrix.

4.2.2 — Urban/Residential Sources of Phosphorus

4.2.2.1 — Urban Storm Water Runoff

Storm water runoff from urban areas is another source of phosphorus loading and can be locally significant. Phosphorus in urban runoff is generated from multiple sources including sediments from erosion, fertilizers, detergents, leaves and other detritus, lubricants, animal waste (e.g., from Canada geese and pets) and organic and inorganic chemical decomposition (Carpenter et al., 1998; and Burton and Pitt, 2001). Data isolating urban phosphorus sources in Ohio are limited.

Information does exist regarding export coefficients associated with different land uses and representing loading rates that have been used by Ohio EPA to assess potential sources and to develop TMDL phosphorus targets (Ohio EPA, 2003).

One example that demonstrates localized significance of urban sources of phosphorus was shown by a study of nonpoint sources of phosphorus in Lake Champlain where 18% of the annual nonpoint source phosphorus load was attributed to urban lands although urban land use constituted only 3% of the area (Meals and Budd, 1998). Urban areas as well as agricultural croplands and livestock operations are a contributor of total phosphorus as shown by data from the Nationwide Urban Runoff Program (NURP) and other studies.

Just as the relative phosphorus concentration contributed from agricultural areas can be correlated with sediments associated with erosion from crop fields, an important portion of phosphorus contributed to urban or urbanizing streams is associated with construction site erosion and other significant erosion problems such as stream bank erosion. In one Wisconsin study, construction sites were associated with 28% of the phosphorus in streams. Land under construction has the greatest potential to generate phosphorus relative to other land uses, temporarily generating even greater loads per area than agricultural row crops (Burton and Pitt, 2001). As of March 10, 2003 Ohio EPA began implementation of Phase II storm water regulations which decreased the acreage-size for NPDES permit regulated constructions sites from 5.0 acres down to 1.0 acres. Some assumption of greater erosion and sediment control and lower phosphorus export might be made for these sites.

Phosphorus loads can also be generated from established impervious areas such as commercial, industrial, high density residential, freeways and parking areas (Burton and Pitt, 2001). Recently, the City of Columbus reported average event mean concentration (EMC) data for phosphorus and orthophosphate from a variety of catchments from four runoff events (one in each season). Although only one year of monitoring data was reported, Columbus found that the average EMCs for TP (0.19 mg/L) from three residential watersheds fell below the NURP book value of 0.47 mg/L. A commercial urban watershed and an industrial watershed were also monitored. The commercial watershed average EMC for total phosphorus (0.10 mg/L) fell below the NURP book value of 0.24 mg/L; but the industrial watershed average EMC for total phosphorus (0.41 mg/L) was higher than the NURP book value of 0.24 mg/L. There are no comparable data for Ohio cities in the Lake Erie basin.

As discussed in Section 2.5, urban land accounts for a small percentage of land area in northwest Ohio (8 to 14 percent). The Task Force concludes that any phosphorus contribution from urban runoff may have localized impacts, but is likely not a significant contributor to the algal blooms in the western basin. Targeting strategies to address local impacts will best be realized with existing permitting programs supported by more comprehensive monitoring on the use of storm water BMPs. Ohio EPA has issued two watershed specific storm water permits for the Big Darby and portions of the Olentangy River watershed for construction activities. These permits have additional requirements that differ from other construction activity permits to address the unique conditions in these watersheds. While these watersheds are outside the Ohio Lake Erie basin, the Task Force supports the use of this permitting tool in watersheds experiencing land use change that may be impacting water quality.

U.S. EPA has recently announced plans to strengthen the storm water program with a proposed rulemaking. The purpose of the rulemaking is to:

- Redefine the area subject to federal storm water regulations;
- Establish specific requirements to control storm water discharges from new development and redevelopment;
- Develop a single set of consistent storm water requirements for all municipal separate storm sewer systems (MS4s);
- Require MS4s to address storm water discharges in areas of existing development; through retrofitting the sewer system or drainage area with improved storm water control measures; and
- Explore specific storm water provisions to protect sensitive areas.

At the time of publication of this Task Force report, the comment period on the proposed rules was still open.

4.2.2.2 — Turf Grass Management

Research data and estimates presented by The Scotts Miracle-Grow Company (Scotts) and the USDA-Agricultural Research Service described the common elements of fertilizer management on turf grass, including the expanse of turf in the U.S., and how nutrients are managed on turf. These presentations and a review of several referenced research citations allowed for beneficial deliberation on turf and its relative contribution to DRP loading in Lake Erie.

Turf or sod, for the purpose of this report, is defined as the managed surface layer of soil, grass and the matted roots of the plants. Turf is located all around us, especially within the urban landscape where it includes home lawns, roadsides, park areas, golf courses, schools, sports fields, sod farms, airports, cemeteries, churches, commercial properties and other general areas. There are 40 to 50 million acres of turf in the United States (Milesi et al., 2005; Morris, 2003). Based on a review of various statewide surveys nationwide and other references, home lawns account for approximately 40 to 60% of the area of all turf location-types. This accounts for between 80 and 90 million home lawns nationally (data provided in ARS and Scotts' presentations). More specific to Ohio, the Ohio Turf Grass Association noted there were 4 million acres of managed turf in Ohio, statewide. Data for the number of acres of turf grass in the Lake Erie basin are not available.

It is also estimated that 56% of all home lawn areas receive some degree of fertilization. Nationally, Scotts estimates that 2% of all total fertilizer use falls into the home use segment (i.e., the do-it-yourself or garden care) of the fertilizer industry. Scotts provided data accumulated from Wisconsin and Michigan in 2006 that showed homeowner use of fertilizer was approximately 2% in Wisconsin and 3% in Michigan of the statewide annual use of fertilizer.

As with other land-use types, there are many factors that influence the concentration of phosphorus and runoff volume from turf. These factors include but are not limited to fertilizer type, method of fertilizer application, rainfall amount and intensity, climate, type and health of vegetation, depth of turf, and slope. Key human variables that influence concentration of turf runoff water include fertilizer selection (type) and the method, timing and amount of fertilizer application.

Timing of turf fertilization before runoff producing rainfall greatly increases the risk for phosphorus loss from turf, whereas, "watering in" the fertilizer (i.e., applying a light amount of water without causing runoff) greatly decreases phosphorus losses from turf by up to an order of magnitude (Soldat and Petrovic, 2008). Phosphorus runoff losses from turf have been found to vary directly with application rate (e.g., lbs. of product/1000 ft^2) (Shuman, 2001; 2003). Typical commercial fertilizer for lawns contains low concentrations of inorganic phosphorus, which is highly soluble. Slow-release fertilizers exist to reduce large losses caused by runoff during intense rainfall.

Due to high nitrogen requirements for turf, fertilizer selection should focus upon those with a high N:P ratio. For example, fertilizer designed for lawn use has a high N:P ratio versus products available for garden and landscaping that have much lower N:P ratio (i.e., higher P concentration). Consumer education and the separation of products on display (lawn from garden) have been implemented to reduce confusion for the customer when selecting a product. A method for recycling nutrients back into a turf system and minimizing the need for additional phosphorus fertilization is to leave mown clippings to decompose back into the soil. This practice eventually causes re-release of available phosphorus to the growing turf, one of several best management practices (BMPs) for turf fertilizer management that contribute to better water quality (Table 8).

Table 8 — Recommended Lawn-Care BMPs for Water Quality Protection

1) **Choose a low or no P fertilizer.**
   Apply a product with an N-P-K formulation of 26-0-3.
2) **Choose fertilizer designed for lawns.**
   The word "lawn or turf" should be on the label. "All purpose" formulations should be avoided for lawn use.
3) **Read and follow label directions.**
   Apply at the spreader setting recommended on product label. Do not apply if heavy rainfall is expected.
4) **Use a drop or rotary spreader with deflector shield to keep fertilizer on lawn.**
   Keep fertilizer, leaves and other organic matter off of walks and driveways to reduce loss to storm sewers and streams.
5) **Mow lawn at the highest setting and leave the grass clippings on the lawn.**
   Mowing high allows the grass to develop a deep root system that retains and uses water more efficiently. Returning clippings recycles nutrients.
6) **Fertilize in spring after first cutting and once again in the fall between Labor Day and Halloween.**
   Only apply fertilizer when grass is growing enough to be mowed.
7) **Soil tests can help identify if other nutrients are needed.**
   Contact your County Extension.

Reference: *www.cleanwaternj.org*

Healthier turf grass systems also have better water retention. The more water that stays in the soil, the less volume there is to carry soluble phosphorus away. In general, turf systems, unlike most row crop land use, are permanent, and have much lower runoff coefficients. That is, with all other variables equal, less volume of water runs off from lawns and turf systems annually than from agricultural land-use where fields are left bare or with limited residue. This ideal is an example of why there has been so much recent focus on promoting the use of cover crops (for water sequestration and nutrient uptake) between commodity crop plantings on the agricultural landscape.

Given the low ratio of turf land area to row-crop agriculture land area in the Ohio Lake Erie basin, the relative contribution of DRP load to Lake Erie from turf is likely to be low. The Task Force recognized the importance of BMP education for citizenry in urban settings, and also recognized recent efforts between the home and garden fertilizer industry and various states (e.g., Florida and Minnesota) to lower or eliminate phosphorus from home lawn products. Scotts intends to remove all phosphorus from lawn maintenance products by 2012 (personal communication, Chris Wible, The Scotts Miracle-Gro Company, April 2010). Phosphorus will remain in products designed for lawn installation and lawn repairs. Lawns or other turf systems located close to surface waters or Lake Erie could be the cause of localized impairment and algal blooms and should be the primary focus of outreach to citizenry. This may also be more of an issue in urban areas. There are several communities around the Great Lakes that have adopted ordinances to ban the use of lawn fertilizers containing phosphorus. Results have indicated a measurable decrease in phosphorus in the local watershed.

4.2.2.3 — Orthophosphate Use in Public Water Systems

In 1993, the Ohio Environmental Protection Agency adopted rules (OAC 3745-81, Rules 80-90) regarding the control of lead and copper in public water system (PWS) distribution systems. In order to prevent lead and copper from leaching out of the pipes at levels potentially harming those individuals who are exposed to the contaminated water, anti-corrosive agents are required to be added to the water at the treatment plant. These agents work by forming a protective coating on the pipes. Most PWS began adding phosphate-based inhibitors (phosphate, orthophosphate, polyphosphates, and zinc orthophosphate) to accomplish this starting in the mid-1990s.

The typical target range for total phosphate concentrations in finished drinking water is 1.0-3.0 mg/L initially, followed by a 0.5-1.0 mg/L maintenance level thereafter. About 5% of PWS in the Ohio Lake Erie basin, which serve approximately 50% of the population on public water, add some form of phosphorus. The total phosphorus load from those PWS is 410.7 metric tonnes/year. According to industry estimates, approximately 15% of finished water is lost in the distribution system. Using this value, the total phosphorus load directly entering the environment from leaks in the distribution system is approximately 62 metric tonnes per year. This is about 2% of the total phosphorus load to Lake Erie from Ohio nonpoint and point sources (2004 water year) and less than 1% of the load from all sources. This estimate does not account for any losses before the treated water enters Lake Erie and, consequently, the actual load may be significantly lower.

Some of the remaining treated water is used for residential lawn sprinkling and could be an additional load to the lake. The amount of water used for this is considered to be relatively insignificant, though, compared to what reaches wastewater treatment plants (WWTPs). For the quantity entering WWTPs, if it is assumed that all of the phosphorus passes through the plant, then phosphorus addition to drinking water would account for approximately 59% of the 590 metric tonnes/year phosphorus load from Ohio point sources (2001-2005 average). This is most likely an overestimation, because some of the phosphorus is removed through treatment processes. An assessment of total phosphorus effluent concentrations at WWTPs across the basin indicates that there has been no significant increase in the overall loading from these plants in the time period following the addition of phosphates to drinking water. It is possible that the percentage that is dissolved reactive phosphorus in the effluent from WWTPs has increased since that time, but this parameter is not often monitored.

Based on the estimates for WWTP effluent loads and the direct contribution to Lake Erie from losses in the distribution system, the addition of orthophosphate to drinking water is considered to be a low-magnitude source.

4.2.2.4 — Toledo Harbor Dredging and Open Lake Disposal

Another potential source of phosphorus to Lake Erie is the open lake disposal of Toledo Harbor navigation channel maintenance dredged material. Due to the shallowness of the western basin and the huge sediment load from the Maumee River, approximately one million cubic yards of sediment should be dredged annually to maintain Toledo Harbor and the lake approach channel. Prior to 1987, most of this material was placed in a confined disposal facility. Over the years, the concentrations of some metals and other contaminants have been decreasing in the sediments. The Corps of Engineers now considers most of the sediment to be clean enough for open lake disposal. The Ohio EPA remains concerned about the total loading of phosphorus and other contaminants in the sediments as well as the sediment itself being a pollutant.

Could the open lake disposal of sediment be considered a contributor to the phosphorus concentrations in the lake? Studies have shown that the majority of the material removed from the channel does come down from the river watershed rather than being washed in from the lake bed (Bedford et. al., 1999). Dredging removes a large quantity of sediment (similar to the total annual sediment load of the Maumee River) from relative storage in the shipping channel to an open lake dumping ground where it is spread throughout Lake Erie, according to Dr. Bedford’s work. What is not known, however, is the amount of phosphorus in this load that is bioavailable and if it is affecting the incidence of algal blooms. Recent calculations done by the Corps of Engineers, based on an average TP concentration of 584 mg/kg, indicate that open lake disposal of 1.25 million cubic yards of sediment would account for a TP load of approximately 1096 metric tonnes. Actual dredging has been on the order of 635,000 cubic yards/year and a backlog of sediment buildup in the channel is now estimated to be 4.4 million cubic yards. The 2010 dredging request was for up to 2 million cubic yards per year with 1.9 cubic yards proposed for open lake dumping. This would be approximately 1669 metric tonnes of TP per year.

The observations of the P Task Force were that the phosphorus concentrations in the sediment are similar to concentrations in agricultural soils. Aluminum concentrations in the sediment may be high enough to effectively tie up most of the phosphorus, keeping its bioavailability low. However, the constant mixing of the extremely fine clay sediment particles by wind and waves in the shallow western basin may increase the opportunity for phosphorus to dissolve in the water column. These sediments also have a fairly high iron concentration. As discussed in Section 6, much of the phosphorus on the surface sediments is bound with ferric iron. When the bottom water oxygen concentration drops below 2 ppm, iron reduction occurs and phosphorus is released into the water column. The western basin is known to stratify, if only ephemerally, but it can be enough to create anoxic conditions (Bartish, 1984).

Due to the lack of data related specifically to DRP and because the Task Force was focused primarily on assessing the sources/causes of increasing DRP in the rivers, they opted not to make any recommendations in regard to open lake disposal. However, considering the amount of sediment associated phosphorus that has been loaded into the lake for so many years, there could be an improvement to net phosphorus removal from the system if open lake disposal was discontinued.

Section 5 — Transport Mechanisms of Phosphorus to Lake Erie

In addition to identifying and monitoring sources of phosphorus to the aquatic system, it is important to understand how phosphorus moves through soils and into streams, and also how it is used or transformed in the stream before it reaches Lake Erie.

5.1 — Stream Assimilation

A healthy stream is able to process a certain amount of overland runoff without becoming degraded. Assimilative processes include the physical, chemical and biological components within a riparian corridor. Without the proper mix, a stream will degrade and likely affect the areas downstream, including Lake Erie. In addition to controlling the substances going into a stream, the natural physical features of the streamscape such as riparian zones, floodplains, channel morphology and habitat diversity must be preserved or the ability of the stream to assimilate nutrients or other pollutants may be compromised.

Riparian vegetation traps terrestrial sediment and the associated particulate phosphorus in surface runoff. The roots of both terrestrial and in-stream vegetation can also take up DRP in a stream habitat. Vegetated buffers, whether forested or grassed, can filter nutrients, provide habitat, provide shade to filter out light and control water temperature, stabilize stream banks and control erosion.

Floodplains provide similar services as riparian buffers. They also slow storm water runoff, reduce energy that would otherwise erode banks, provide storage of flood waters so nutrients can be released slowly as water levels recede, and help stabilize the stream morphology. The assimilative capacity of streams is greatest when there are natural stream features such as narrow low flow channels, accessible floodplains and forested riparian zones. Cumulatively, such a system results in a longer more natural nutrient spiral, buffered flows, stable geomorphology and reduced export of phosphorus downstream.

5.2 — Subsurface Drainage (Tile Drainage)

Subsurface drainage is an important production practice in the Lake Erie basin. It is widely adopted due to the soil and climatic conditions prevalent within this region and the need to support timely field operations for row crop grain production. Systematic subsurface drainage (i.e. the installation of 4-inch diameter drainage laterals at regular spacing in fields) expanded rapidly during the 1950s and 1960s, and continues to be a focus of growers. The successful transition to reduced and no-till farming is highly dependent upon good water management within the soil profile by using subsurface drainage. Properly designed and installed subsurface drainage enables earlier soil warming and deeper crop root penetration. Over time, subsurface drainage promotes the development of stable macropores that enhance infiltration and movement of water to the tile system.

Subsurface drainage promotes infiltration of a greater amount of precipitation, but it also promotes quicker delivery of infiltrated water to streams. As the infiltrated water moves through the upper portion of the profile and enters subsurface drainage tiles, it dissolves nutrients from the soil and quickly carries those nutrients to the streams with the drainage water. Consideration of the soil P levels at the surface (0.1-4 cm), termed the effective depth of interaction (Sharpley, 1985), likewise becomes an important factor for soil P release to leachate because topsoil generally serves as the primary source of leachate P that has moved by preferential flow along macropores (Addiscott and Thomas, 2000).

Subsurface drainage also promotes a well-aerated/oxidizing root zone within the soil. Soluble forms of phosphorus are more prevalent in poorly drained/reducing conditions in the root zone, so improving the subsurface drainage does not result in a direct increase in DRP. However, with subsurface drainage more of the incident precipitation moves into and through the soil profile and out through the drainage system, potentially exporting DRP encountered along this pathway.

According to unpublished data collected by the USDA-ARS Soil Drainage Research Unit, DRP is a normal constituent of tile drainage water from agricultural fields (personal communication, Norman Fausey, USDA-ARS, 2010). These data are part of on-going ARS research on drainage water quality and represent 1,364 tile discharge samples collected from one drainage tile outlet in Fulton County (Swan Creek Watershed) over the past 10 years. Approximately 40 acres drain to this outlet, and an automated sampler at the outlet collected samples at regular intervals during tile discharge events. The land was managed in a corn-soybean rotation with fertility inputs based on soil test recommendation. There were no surface inlets into the subsurface drainage system, and no manure was applied. The samples were analyzed for both total phosphorus and orthophosphate (i.e., dissolved form). Over the ten-year period, the average orthophosphate concentration was 0.10 mg/L and the average total phosphorus concentration was 0.19 mg/L. Similarly, the median orthophosphate and total phosphorus concentrations were 0.05 mg/L and 0.07 mg/L, respectively. The maximum concentrations observed during the 2005 to 2009 portion of the sampling period were 1.25 mg/L for DRP and 1.85 mg/L for TP.

This issue could be better mitigated by improved management of the drainage system through installation of drainage control structures or other hydraulic buffers, and by restricting pathways of preferential flow prior to or during nutrient application. Restricting leachate transport pathways points to other forms of modified tillage to prevent P losses from reduced tillage systems that preserve, even promote, preferential flow formation (Shipitalo et al., 2000).

Once the subsurface drainage infrastructure is in place, it is often utilized to provide an outlet for surface water in shallow depressions in crop fields and highway ditches. There is also considerable evidence of home sewage waste disposal via septic tanks with leach field systems being tied into subsurface drainage to provide an outlet. These sources of water contribute soluble and sediment bound phosphorus which can enrich the phosphorus content of the subsurface drainage waters not arising from the soil profile.

There are several BMPs (e.g., drainage control structures, cover crops, wetlands, etc.) available to reduce phosphorus loading to streams from tile drainage systems. These are described in Appendix B. Additionally, there have been recent projects in the Midwest where bio-reactors have been installed at tile drain outlets to reduce nutrient concentrations in the discharge. Bio-reactors for this discussion are best described as excavated trenches filled with wood chips. While there is limited information with respect to long-term effectiveness of bio-reactors on tile line outlets, results so far have been promising with respect to nitrogen removal in tile discharge. Additional research is on-going with respect to phosphorus in tile drainage water. In fact, the Ohio NRCS has agreed to fund tile drain bio-reactor projects in Ohio using EQIP funding.

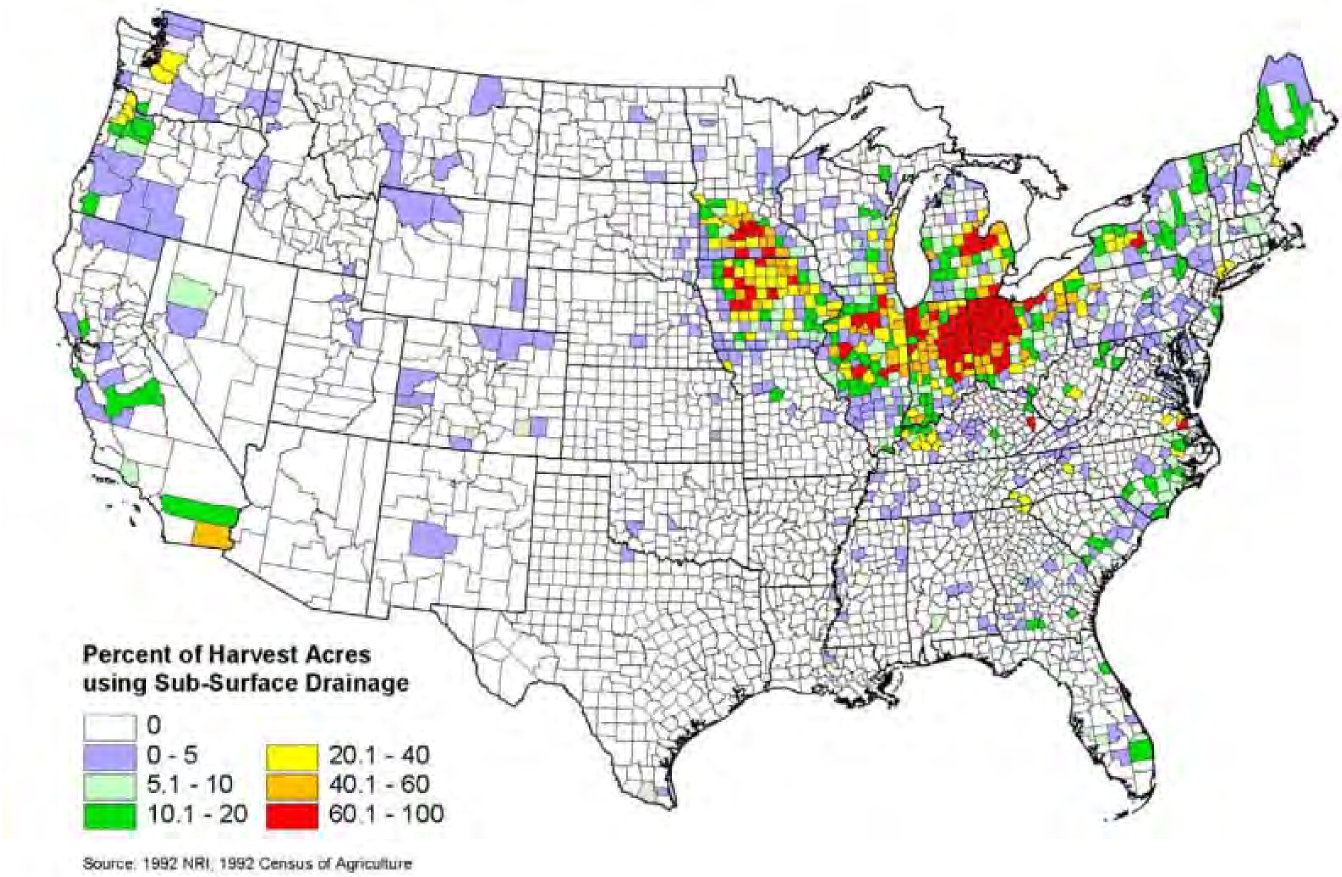


Figure 28 — Percent of harvest acres in the United States using subsurface drainage in 1992. (NRI Census of Agriculture, 1992)

The 1992 census of agriculture showed that northwest Ohio has the highest percentage of harvested land with subsurface drainage in the Midwest (Figure 28). All northwest Ohio counties, as well as those Indiana counties in the Lake Erie watershed, had between 60.1 and 100% of harvested land drained by subsurface tile. There continues to be a significant amount of additional tile installed throughout the region at closer spacing in fields that are already tiled. This practice, known as lateral splitting, can in effect double the drainage tile density on fields already historically drained. For instance, a typical sub-surface drainage project on a row crop field with initial lateral spacing of 50 feet would have another set of laterals installed to make the spacing 25 feet. Spacing of laterals can be anywhere from 25 to 40 feet after a lateral splitting projects and as low as 15 to 20 feet on some fields (personal communication: Albert Maag, Putnam SWCD; Bill Beckman, Paulding SWCD; Jeff Ankney, Defiance SWCD; Ken Kottenbrock, Van Wert SWCD; Ron Cornwell, OLICA; and Joe Nester, Nester Ag LLC, February 15 and 16, 2010). The most poorly drained clayey soils, like the Lacustrine clays discussed in Section 5.3, generally have the closest lateral spacing and the shallowest tile depths. These land areas in northwest Ohio appear in light and medium blue on the glacial map of Ohio at *www.dnr.state.oh.us/Portals/10/pdf/glacial.pdf*.

Generally, decisions to install more subsurface tile in tight northwest Ohio clay soils have been made easier with the advent of yield monitors that have proven the economic benefit of increased crop yields in fields with closer lateral drain tile spacing. There have not been any updates to the 1992 subsurface drainage census, so there is no data on the current density of subsurface drainage.

The environmental ramifications of increased subsurface drainage density are not well understood. Closer spacing of drains does increase the volume of water removed by the subsurface drainage, although we do not know by how much. The closer lateral drainage spacing shortens the path length in the soil through which water travels to the subsurface tile. In addition, the frequency of macropores intersecting the drains is greater where drainage laterals are closer. With this in mind, the mains will run at full capacity for a longer period of time if the size of the main is not also increased when the laterals are split. This means more opportunity for transport of soluble nutrients as well as surface particles (soil and manure sediments) into the subsurface drainage systems and ultimately to surface water tributaries.

5.3 — Surface Drainage

Early surface drain projects in the western Lake Erie watershed were installed along old fence lines and connected to roadside ditches. The purpose of this practice was to facilitate surface drainage on low to zero-slope agricultural land to improve productivity and reduce incidence of plant disease. Lacustrine clay soils (including Latty, Paulding, Nappanee, Defiance, and to some degree Hoytville) are typical of the soils that are surface drained. These soils are predominantly located in Putnam, Defiance, Paulding, southern Henry and western Wood counties in Ohio (*www.dnr.state.oh.us/Portals/12/soils/pdf/SoilRegions.pdf*).

Coincident with technology improvements (e.g., rotary wheel surface drain implement), a trend began in the late 1980s to install surface drains in fields at regular intervals (e.g., at 500 to 600 foot spacing) to facilitate drainage and improve crop productivity. In general, in-field surface drains are installed so that farm implements can pass over and through surface drains during the normal course of farming operations with no setbacks. Fields where surface drains are installed are often drained with subsurface drainage tile as well.

There are no data on the extent of acreage drained by surface drains in the western Lake Erie basin. Observations by area soil and water professionals estimate current in-field surface drainage installations exist in 60 to 70-plus % of agricultural fields with the soil types described above. (personal communication: Albert Maag, Putnam SWCD; Bill Beckman, Paulding SWCD; Jeff Ankney, Defiance SWCD; Ken Kottenbrock, Van Wert SWCD; Ron Cornwell, OLICA; and Joe Nester, Nester Ag LLC, February 15 and 16, 2010).

The Ohio NRCS provides a set of practice standards to address 79 resource concerns related to farming (NRCS 2001). In 2007, the Ohio NRCS program evaluated these standards by ranking each practice standard against each resource concern. Using this ranking, Ohio EPA identified 27 resource concerns related to water quality and linked them to five leading causes of water quality impairment, including nutrient impairment. Ohio EPA then analyzed each of the practice standards for its relative benefit to address a particular cause of water quality impairment (*www.epa.ohio.gov/portals/35/lakeerie/ptaskforce/BMP_Effectiveness_Final030110.pdf*).

This initial analysis reveals that subsurface drainage and surface drainage are among the least effective practices for protecting water quality and may have the potential to worsen water quality. Alternatively, those NRCS BMPs that most effectively reduce the rate and amount of runoff from land to surface waters rank among the best practices for protecting water quality. While surface and subsurface drainage practices are not designed nor promoted for water quality, this analysis highlights the importance of balancing the selection of practices to best ameliorate potential water quality issues while meeting drainage needs for crop production. This analysis is a first step in development of a BMP decision tool that can point conservation planners toward the most effective practice or practices to address specifically identified resource concerns, including nutrients (N, P and DRP).

5.4 — Channelized Streams and Ditches

The practices of channelizing streams and maintaining ditches go hand in hand with installation of subsurface drainage. Channelized streams are constructed to increase capacity and flow rate for storm water runoff, as well as to increase the efficiency of the subsurface drainage tiles. A survey conducted by ODNR in 2006 indicated the extent of county-maintained projects includes approximately 121 miles of grassed waterways, 5,070 miles of subsurface mains, and 5,473 miles of open ditches statewide (Figure 29). Although unable to be quantified, the number of privately constructed and maintained ditch projects statewide is estimated to be in the thousands.

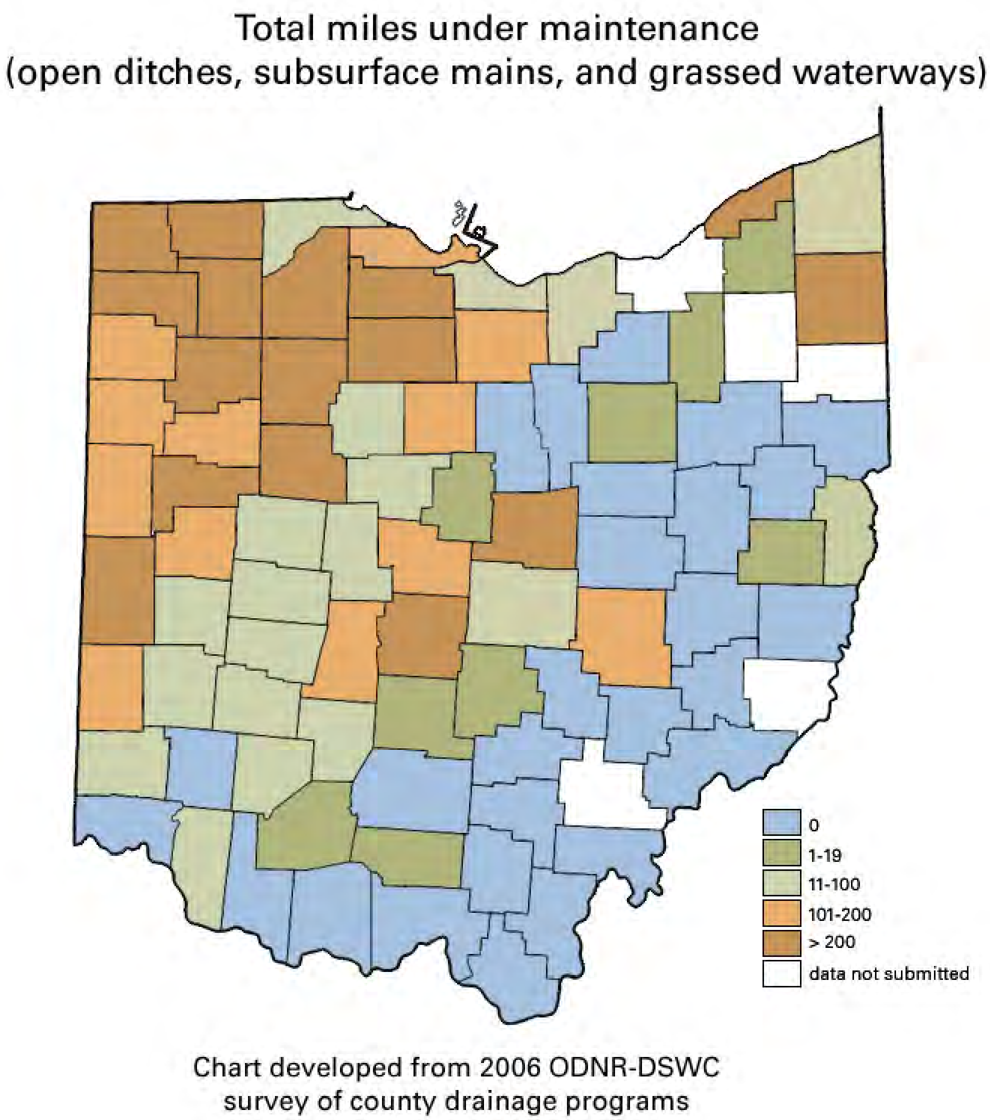


Figure 29 — Miles of maintained ditches, grassed waterways and subsurface mains in Ohio (ODNR, 2008)

Stream channelization and ditch projects constructed without best management practices often cause environmental impacts. Ohio EPA identifies disruption to the natural hydrology of a stream system (hydromodification) as one of the top five causes of aquatic life use impairment. In the Lake Erie basin, 87% of the area with recent assessment data is impaired due to hydromodification and/or habitat alteration (Ohio EPA, 2008).

Poor quality habitat with reduced or debilitated riparian zones (either no riparian zone is present or runoff bypasses the zone via field tiles) and simplified channel morphology generally exacerbate the deleterious effects of nutrients. Several factors that influence the severity of the nutrient impacts from channelized streams and ditches include:

- Reduction of the riparian uptake and conversion of nutrients;
- Decreased retention time for nutrients due to loss of sinuosity, increased gradient, increased flow velocity and lack of contact with a floodplain;
- Decreased retention of nutrients within the channel due to diminished filtering time during overland flow events; and
- Lack of riparian corridor leading to unblocked sunlight and stimulation of nuisance algal growth.

The Ohio Rural Drainage Advisory Committee was formed in 2006 to create a balance between drainage needs and environmental protection. The Committee has made recommendations for outreach and education, infrastructure, funding and incentives. The Ohio Drainage Manual has been updated as part of this effort. These actions, along with changes in Ohio's water quality standards regulations to include new use designations for primary headwater habitats, should lead to both improved tributary nutrient processing and wildlife biodiversity while improving management of storm water runoff.

5.5 — Summary and Recommendations

The Task Force concluded that diminished stream assimilative capacity and current drainage practices in northwest Ohio are contributing factors to the transport of DRP load to the western Lake Erie basin. The lack of available data, however, prevents a more thorough analysis of the scale of this contribution to the increases in tributary DRP loading.

Task Forces members support the work of the Ohio Rural Drainage Advisory Committee. These recommendations can provide both localized and downstream benefits and encourage more and larger stream restoration projects.

The P Task Force recommends that complementary practices (such as tile drainage control structures and management and other hydraulic/treatment buffers) be promoted to facilitate more widespread adoption of the BMPs designed to ameliorate water quality impairments attributable to subsurface drainage. Surface drainage systems should be evaluated to determine which complementary BMPs can best address water quality problems caused by pollutants carried by surface drainage systems.

Data on the extent of subsurface drainage is dated (1992) and lacks information on drainage intensity (e.g., lineal feet of tile/acre). The P Task Force recommends that the National Agricultural Statistics Service (NASS) be encouraged to include questions in the next Agricultural Census that can provide better information on subsurface drainage intensity. Alternatively, the P-Task Force recommends county level surveys be conducted to obtain information on subsurface drainage intensity.

The P Task Force recommends that more extensive research be conducted on sampling discharges from tile drain systems incorporating data on the land management variables that contribute to the quality of tile drain discharges.

The Task Force recommendations establishing a multi-stakeholder workgroup to build upon the initial Ohio EPA BMP effectiveness analysis by developing a robust BMP decision tool through consensus.

Section 6 — Internal Loading and Recycling Processes

6.1 — Background

Once phosphorus is delivered to the Lake it is subject to a complex series of in-lake processes including physical transport, biological uptake, and chemical transformations and reactions before deposition onto the sediment. In addition, much of the phosphorus that is deposited on the bottom is regenerated by microbial degradation of organic matter and by mineral and redox reactions and is recycled from the sediment back into the overlying water. As a result of this internal cycling of phosphorus, many lakes exhibit a slow response to reduced external phosphorus loading (Sondergaard et al., 2003). So although internal phosphorus loading is not "new" phosphorus to the lake system, understanding and quantifying these recycling processes are critical to addressing the larger management issues of establishing phosphorus loading targets and system response times.

There are three types of internal phosphorus cycling in Lake Erie. First, much of the phosphorus that is loaded to the Lake is delivered to the western basin. A portion is cycled in the western basin and the rest is transported to the east as loading to the central and eastern basins.

Second, there are various biological transformations and food chain transfers of phosphorus that recycle the highly bioavailable DRP to organic phosphorus in various trophic levels and the water column and to organic phosphorus in the sediment. Early modeling efforts used to establish target nutrient load levels were either empirical (Vollenweider, 1971) or assumed the lake behaves like a well mixed batch reactor (USACE, 1975; Chapra, 1977; DiToro and Connolly, 1980). These models developed into complex ecosystem models that used external nutrient loads and weather conditions as input and described the various biotic and abiotic pools of nutrients and trophic transfer as output. They were used to establish phosphorus loading rates to the lake based on minimizing the areal extent of the anoxic area in the central basin and maximizing the mean hypolimnetic dissolved oxygen concentration (Figure 30).

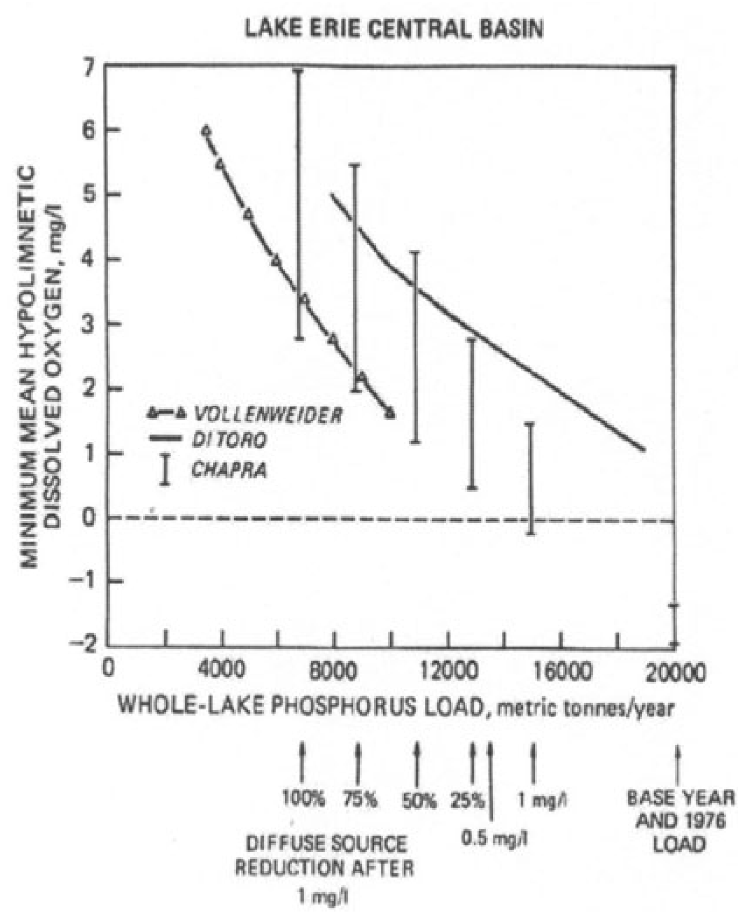


Figure 30 — Relationship between mean minimum hypolimnetic dissolved oxygen concentration and whole lake phosphorus load in the central basin of Lake Erie for the Vollenweider, Chapra and DiToro models (Figure provided by Joe DePinto, LimnoTech)

One major difference between early model representations of lake behavior and current conditions has been the invasion of dreissenids (zebra and quagga mussels). The arrival and establishment of dreissenids has led to huge alterations in the pathways of phosphorus transfer and in the ecology of Lake Erie (Figure 31). It has been proposed that the success of dreissenids in the nearshore environment has resulted in a cascade of effects which potentially make the nearshore zone overly significant in controlling whole lake dynamics (i.e., the nearshore shunt; Hecky et al., 2004). If true, then early models used to establish lakewide nutrient targets are invalid.

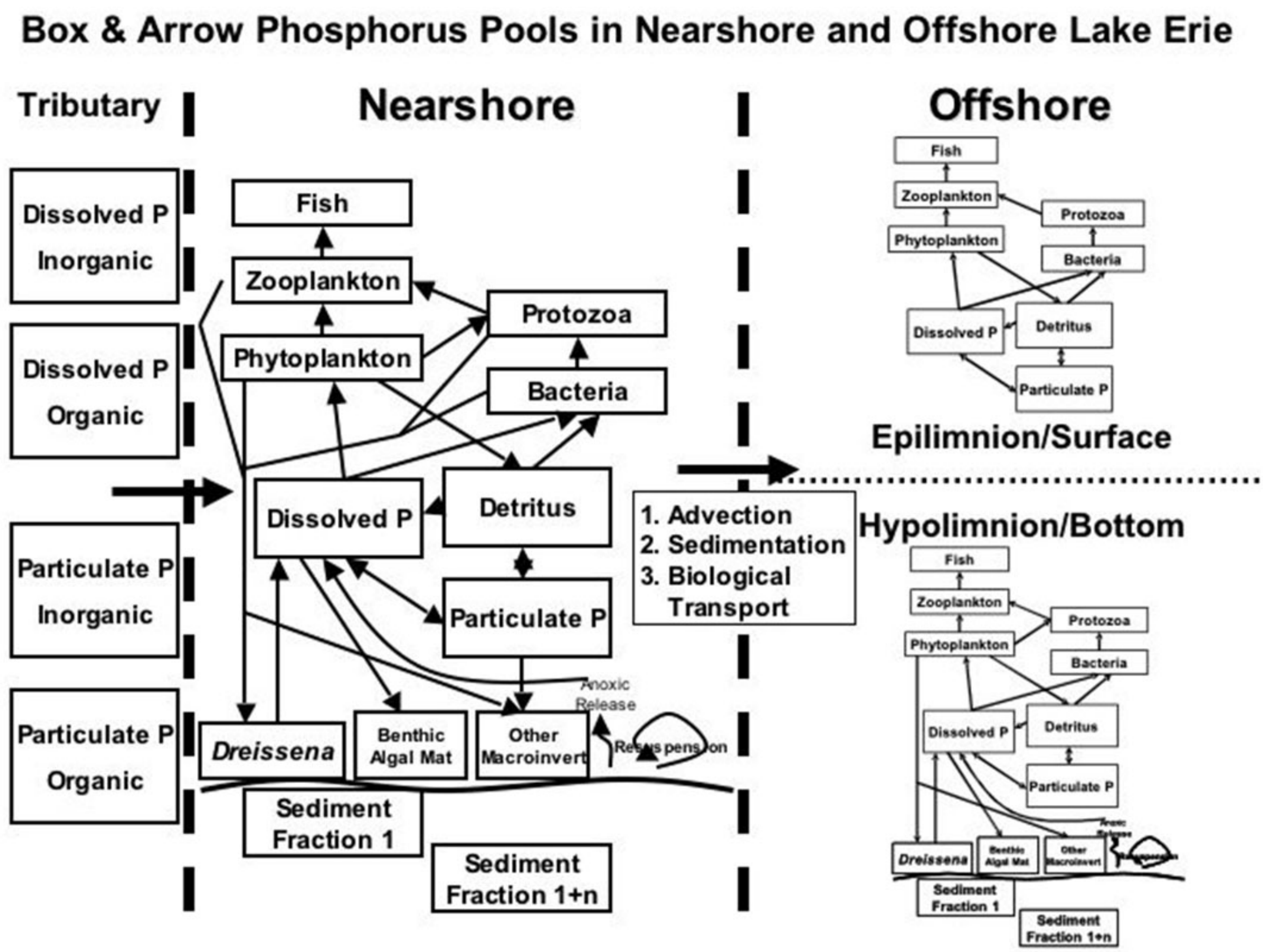


Figure 31 — Conceptual diagram of major nearshore and offshore nutrient pools and interactions following the establishment of dreissenid mussels in both the nearshore and hypolimnion benthos. (Graphic provided by Joe DePinto, LimnoTech)

The third type of internal lake phosphorus cycling is regeneration of sediment phosphorus and its transport back into the water column. Benthic phosphorus release from sediments subject to bottom water anoxia is well known (Mortimer, 1941). Benthic release of phosphorus may also occur under oxic bottom water conditions driven by organic matter degradation and biologically enhanced transport of dissolved or adsorbed phosphate from greater sediment depths (Meile and Van Cappellen, 2003; Slomp et al., 1998). In this case, the benthic release of phosphorus is controlled by the retention of phosphorus in the underlying anoxic sediment (Gächter and Müller, 2003; Moosmann et al., 2006).

The major forms of phosphorus in anoxic freshwater sediments are organic-P, phosphorus associated with Fe(III) oxyhydroxides, Fe(II) phosphate minerals (e.g., vivianite, $Fe_3(PO_4)_2 \cdot 8H_2O$) and calcium phosphates (House, 2003). Dissimilatory Fe(III) reduction by sulfides is typically limited in freshwater environments, where sulfate concentrations and sulfate reduction rates are low (Canavan et al., 2006; Wersin et al., 1991). Thus, in freshwater sediments, Fe(III)-oxyhydroxides may be an important sink for P. This has been observed in the freshwater part of the Scheldt estuary where Fe(III)-bound P accounts for up to 70% of total P burial (Hyacinthe and Van Cappellen, 2004). Ferrous phosphate minerals such as vivianite are also important as a sink for P when rates of sulfate reduction are low because the Fe^{2+} required for their formation is otherwise sequestered in the formation of FeS and FeS_2 (Gächter and Müller, 2003).

Recently there has been an attempt to account for benthic phosphorus release and phosphorus - iron mineral phases (DiToro, 2001; Canavan, 2006; personal communication Joe DePinto, LimnoTech, 2009). DiToro (2001) developed a model for phosphorus flux from a 2-layer sediment column in which the phosphorus in the sediment is subject to regeneration from organic matter, diffusion, burial and partitioning between the pore fluid and an iron oxyhydroxide solid phase (Figure 32).

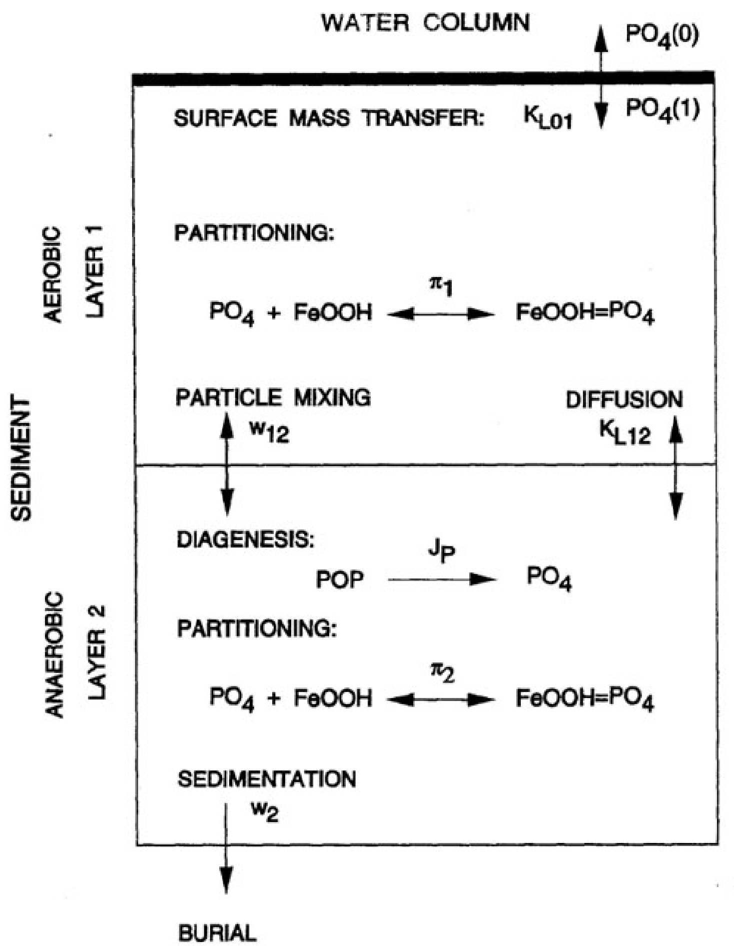


Figure 32 — DiToro's (2001) model for the internal loading of phosphorus from sediments

DiToro (2001) showed that although there is little relation between the depositional flux of phosphorus and the benthic release of phosphate from the sediments there is a significant increase in the phosphate flux when the bottom water oxygen concentration is less than about 2 mg/L (Figure 33). This increased flux at low oxygen concentration can be attributed to the reduction and dissolution of iron (III) oxyhydroxides and the concomitant release of sorbed phosphate.

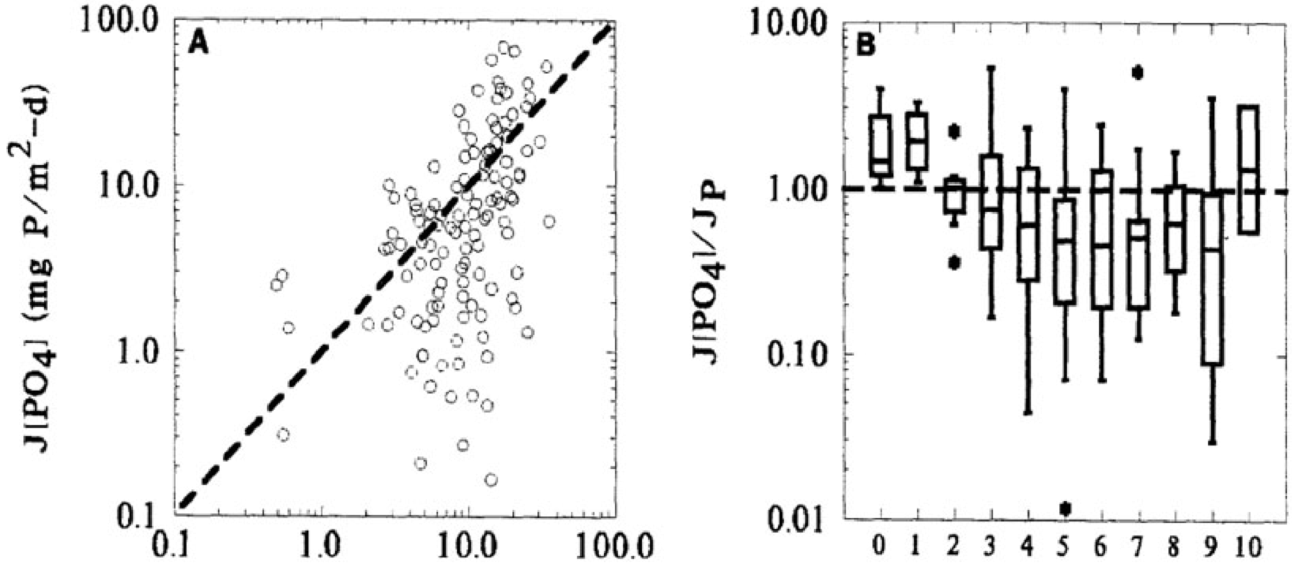


Fig. 6.6 (A) Phosphate flux $J[PO_4]$ versus phosphorus diagenesis J_P. (B) Ratio of phosphate flux to phosphorus diagenesis $J[PO_4]/J_P$ versus overlying water dissolved oxygen concentration $[O_2(0)]$.

Figure 33 — Relationship between the depositional flux of phosphorus (J_p) and the flux of phosphate ($J[PO_4]$) from sediments (left) and the flux of phosphate from sediment at different bottom water dissolved oxygen concentrations (right) (DiToro, 2001)

Canavan (2006) has conducted perhaps the most comprehensive study and modeling of phosphorus diagenesis and sediment flux. He collected pore water and solid phase data for sediments from Haringvliet Lake (The Netherlands) to investigate the coupling between the sedimentary cycles of iron, sulfur and phosphorus. He then modified the Van Cappellen and Wang (1996) multi-component reaction transport model to include phosphorus diagenesis. The extraction data indicate the presence of a reducible iron-phosphorus mineral (P-Fe (III)) in the surface sediment with an average molar Fe:P ratio of 2.6. Model results indicate that release of phosphate from this phase through reductive dissolution dominates the input of phosphate to the pore water in the upper 20 cm of the sediment. This is in agreement with DiToro's simpler model, although DiToro does not provide an Fe:P ratio for the mineral phase. Furthermore, Canavan finds that ~56% of the total P deposited on the sediment is returned to the overlying water through diffusion and bio-irrigation (the pumping of pore water by benthic macroinvertebrates through their burrows). The remaining phosphorus is buried in the form of organic phosphorus (P-org), P-Fe (III) and another inorganic P mineral phase (P-min). P-min accounts for 50% of total P burial and may be actively forming in the sediment.

Using the model, Canavan (2006) developed a sedimentary phosphorus cycle (Figure 34). His results show that release from P-Fe (III) is the dominant source of dissolved phosphorus in the sediment accounting for 75% of the total phosphate released within the upper 20 cm of the sediment. His model calculates that 58% of the Fe-oxide reduction is coupled to organic matter mineralization, with the remaining being accounted for by reaction with sulfide. The relatively low (~2.6) and constant molar Fe:P ratio with depth and nearly-identical dissolution kinetics of phosphorus and iron in ascorbate solution suggests the presence of a relatively stable iron (III) phosphate mineral as previously reported for sediments in the Scheldt estuary (Hyacinthe and Van Cappellen, 2004).

The P-Fe(III) phase is responsible for 17% of the total phosphorus burial below 20 cm depth. P-org is the other major source of pore water PO_4 and accounts for 33% of the total burial at 20 cm (Figure 34). Approximately 64% of the P-org and P-Fe(III) deposited on the sediment is released to the overlying water through bio-irrigation (47%) and diffusion (53%). Reversible sorption in combination with bio-turbation enhances the upward diffusive flux of dissolved phosphate (Slomp et al., 1998) and accounts for 25% of the total diffusive release at the sediment-water interface.

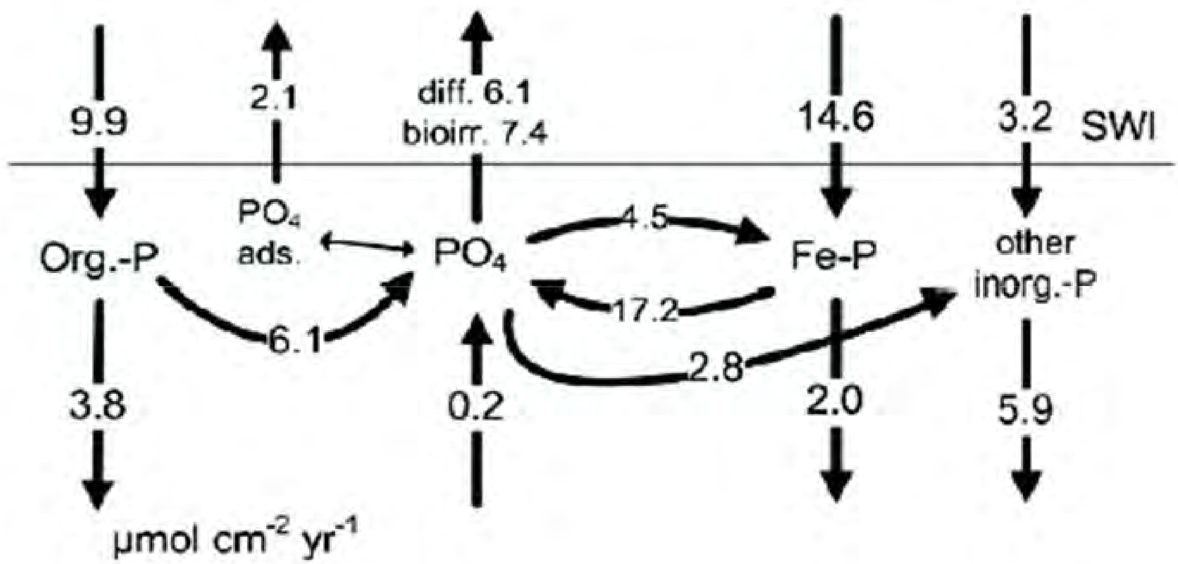


Figure 34 — Schematic representation of the modeled sediment P cycle.
All rates and fluxes are presented in units of µmol $cm^{-2}y^{-1}$. The upper boundary of the calculation is the sediment water interface (SWI) and the lower boundary is 20 cm depth (Canavan, 2006)

Recent work in the Great Lakes on phosphate release from sediments has been conducted by Joe DePinto as part of the ECOFORE project. In the initial stages of the project DePinto and Fitzpatrick have developed a 1-D model in which the sediment is coupled to the overlying water. Phosphorus cycling in the sediment is based on the DiToro model (Figure 35). Phosphate release from the sediment is coupled to dissolved oxygen in the water column (Figure 36). In the model the central basin hydrodynamic model is physically driven by air temperature, wind speed, and solar radiation. It has a static surface level, 48 vertical layers of 0.5 m thickness and a varying thermocline depth. The simple DO model is linked to the hydrodynamic model based on a water column oxygen demand that is the aggregate of production and consumption processes. The sediment oxygen demand occurs in the bottom layer.

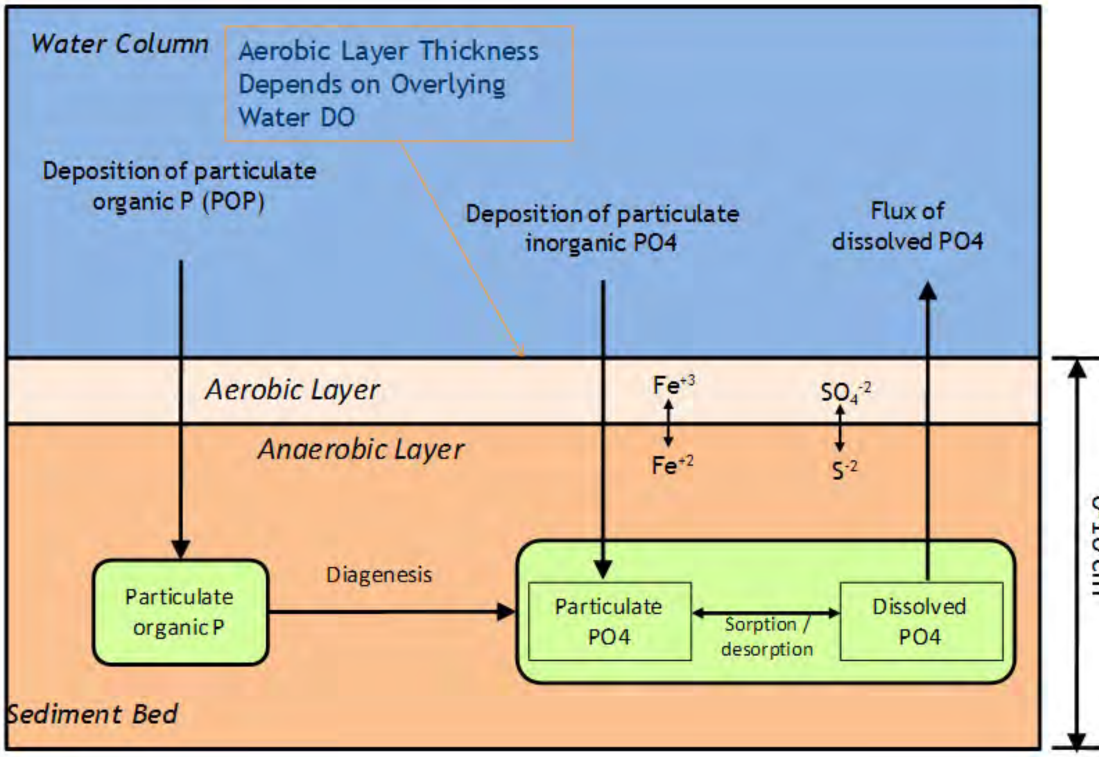
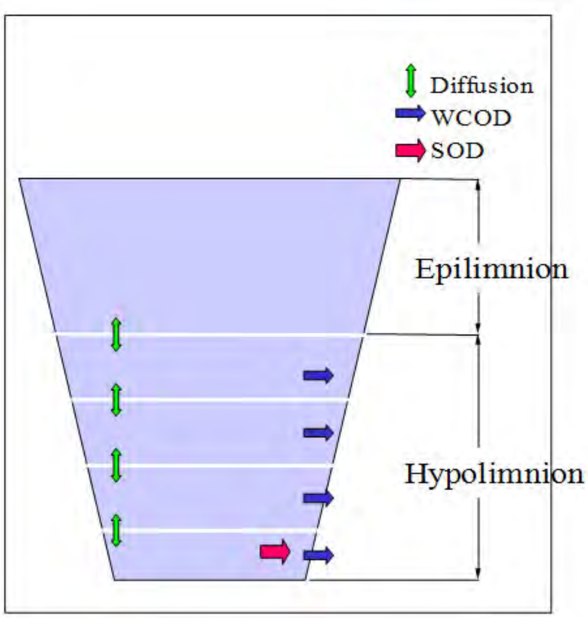


Figure 35 — Conceptual diagram of primary processes that affect sediment-water phosphorus exchange. (Sediment phosphorus model used in the ECOFORE project was provided by Joe DePinto, LimnoTech)



Model Description:

- 1D Vertical Dynamic Model for Central Basin
- Hydrodynamic model is physically driven
  - Air temp, wind speed, solar radiation
- Static Surface Level, varying thermocline depth
- 48 Vertical Layers of 0.5m thickness
- Simple Dissolved Oxygen Model linked to Hydrodynamic Model
  - DO rate term (WCOD) is aggregate of production and consumption processes in the water column
  - SOD in bottom layer

Figure 36 — ECOFORE one-dimensional linked hydrodynamic, dissolved oxygen and phosphorus model. (Graphic provided by Joe DePinto, LimnoTech)

The model results show a decrease in phosphate flux from 1985 to about 1995, and an increase in the Lake Erie phosphate release from the sediments since 1995 (Figure 37).

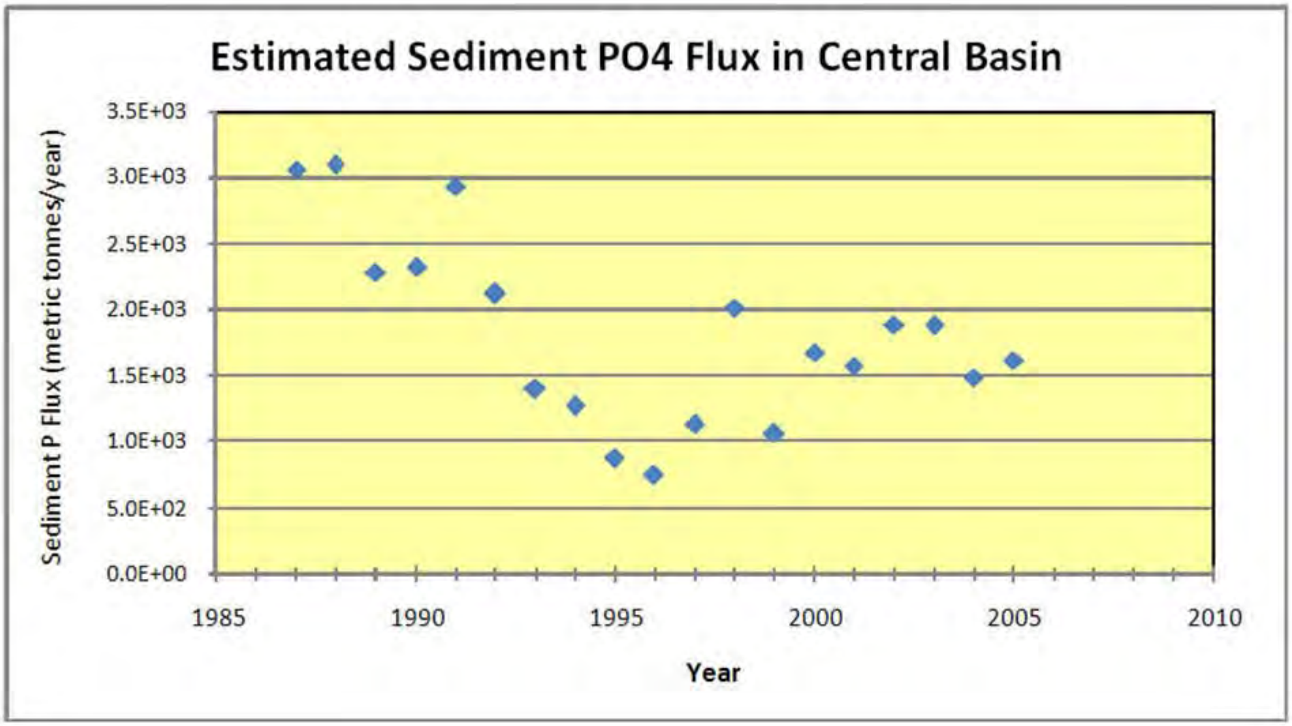


Figure 37 — Estimated annual phosphate fluxes from the sediments in the Lake Erie central basin since 1985. (Computed from area with overlying water dissolved oxygen < 2 mg/L * number of days with dissolved oxygen < 2 mg/L * 5 mg P/m^2/d) (Graphic by Joe DePinto, LimnoTech)

6.2 — Summary and Recommendations

This overview of prior work and current state of the knowledge about phosphorus behavior in sediment tells us the following about internal sources of phosphorus:

- About half of the phosphorus that is deposited as particulate organic phosphorus on the sediment surface is regenerated and returned to the water column as phosphate (inorganic phosphorus). This is a significant amount of phosphorus and is quantitatively important in the overall phosphorus budget of Lake Erie.
- Much of the phosphorus that is in the surface sediments is bound with ferric iron. When the bottom water oxygen concentration drops below about 2 ppm, iron reduction occurs and much of the adsorbed phosphorus is released to the water column.
- Biogeochemical models are needed to quantify the flux of phosphorus from the sediments to the overlying water. Current models for Great Lakes sediments are an improvement over older ecosystem models by including an iron (III) phosphate phase. However, these current models are still too simple, because other work has shown that phosphorus in sediments is also bound as organic phosphorus and as another mineral phase and that these forms of phosphorus are depth-dependent in the sediment.
- While it is important to acknowledge and understand the internal phosphorus cycle in the lake and the factors that influence release and use of phosphorus in the lake system, it is highly important to remember that once the phosphorus is in the lake there is nothing we can do. The focus of any phosphorus management work needs to be on the land to reduce phosphorus sources and loads. It may ultimately be necessary to adjust the existing loading targets to account for the impact of the changing internal load.

- In light of the substantial changes that are occurring in the lake, it is important to also consider the other components of the lake system that may be limiting factors in supporting algal populations. Other nutrients, such as nitrogen, have been steadily increasing over the years.
- Areas where additional research is needed to better understand internal phosphorus cycling are listed in the research agenda presented in Section 9.

Section 7 — Relevant Ongoing Actions

Since 2007, Ohio EPA, Division of Surface Water has significantly increased efforts to obtain DRP data in Ohio rivers. In 2007, 331 water samples were collected specifically for DRP analysis, while 806 samples were collected in 2008, an increase of 144%. Historically, considerable field staff time and effort went into collecting a discrete, field-filtered sample for DRP analysis and involved the use of a suction device to pull stream water samples through a 0.45 micron filter. Samples collected during higher stream flows were difficult to field-filter due to high sediment concentrations. As such, DRP samples were often not collected due to lack of time and resources. In 2008, the Division of Surface Water began to use a syringe method for collecting DRP samples. This method has allowed for much easier and timely collection of samples across flow regimes and at higher sediment levels. This point is important because it is more likely to see the highest levels of DRP in samples collected during higher flows. Having this data helps greatly to better inform the Ohio EPA on the scenarios and landscape variables that contribute the highest phosphorus loading levels to Ohio streams and, ultimately, Lake Erie.

Although the additional DRP data will be very helpful to target actions to reduce loads, loading and concentration targets for phosphorus are still based on total phosphorus. Open lake targets are still those proposed under the Great Lakes Water Quality Agreement for a load of 11,000 metric tonnes with associated concentrations of 15 µg/L and 10 µg/L for the western and central/eastern basins, respectively. While focusing on loading reductions is a practical approach to reducing nutrients, it is the concentration of nutrients in the water that the biological community responds to.

Protocols for developing water quality criteria are typically based on identifying the numerical limits that would cause chronic or acute toxicity. The effects of high concentrations of phosphorus are usually of an aesthetic nature rather than a toxic nature which is a more subjective measure of impairment. However, there are optimal levels of phosphorus needed to support the best health of biological communities. Using this approach, the Lake Erie Lakewide Management Plan (LaMP) has proposed TP ecosystem-based targets by habitat type. The LaMP supports the existing open lake concentration targets and proposes 20 µg/L for nearshore waters, 30 µg/L for coastal wetlands, and 32 µg/L for tributaries (Lake Erie LaMP, 2009). These numbers are based on concentrations that would support a diverse algal population but not cause blooms.

The Ohio EPA has taken a similar approach in developing nutrient criteria standards. Elevated nutrient concentrations are cited frequently as a leading cause of beneficial use impairment in Ohio streams. Given Ohio EPA's long and successful history of the development and use of biological criteria as a measure of overall stream health, Ohio EPA has taken an in-depth look at the association of nutrients, habitat and the aquatic biota in Ohio streams (Ohio EPA, 1999). While U.S.EPA has provided national nutrient criteria recommendations for states, those criteria were derived from percentiles of reference sites and not cause and effect relationships. Ohio EPA has been collecting stream information to support the selection of criteria based on actual data specific to conditions in Ohio waters. Nutrient criteria will soon be proposed for small and medium sized streams. Additional sampling is underway to collect data to continue the development of nutrient criteria for large rivers.

U.S. EPA-GLNPO and the Ohio Lake Erie Commission are currently funding 7 projects to better understand the sources and causes of the increasing eutrophication in Lake Erie. The projects were selected based on the needs identified by the Ohio Phosphorus Task Force and the Lake Erie LaMP. U.S. EPA is funding projects to: 1) track if algal blooms in the lake are being "inoculated" with algae from upstream in the river watersheds or from the sediment; 2) monitoring the differences/exchange of materials between the nearshore and open lake; 3) assessing the bioavailability of phosphorus from a variety of point and nonpoint sources, and tracking the discharge from storm surges all the way to the lake; 4) linking soil test phosphorus with agricultural runoff through the use of simulated rainfall events; and 5) investigating the use of selected BMPs in their effectiveness in limiting P runoff.

The Ohio Lake Erie Commission has funded two grants to 1) track nutrient and algae loading from the Maumee and Sandusky Rivers out into Lake Erie; and 2) comparing the use and changes/trends in soil test phosphorus levels in the western Lake Erie basin over the past 15 years. A larger multi-year study funded by the Great Lakes Protection Fund is also currently underway to look more closely at phosphorus stratification in soils and develop a P Index for DRP. The results of these studies will lead to a better understanding of when, where and how algal blooms begin, the connection between DRP concentrations and algal blooms, and begin to provide an understanding of where and why DRP is increasing.

There are a number of other programs around the country exploring the nutrient and algal bloom connection. Some areas are also experiencing the "dead zone" phenomenon seen in the central basin. In addition to the environmental degradation that these conditions are causing, the increasing presence of HABs is creating a potential health hazard. In addition to Lake Erie, some of the other areas in the Great Lakes that are experiencing threats from eutrophication include: Saginaw Bay, Green Bay, areas of the western shore of Lake Michigan and Hamilton Harbor in Lake Ontario. Many inland lakes around the county are also suffering from high nutrient loads and algal blooms. Most notably in Ohio is Grand Lake St. Marys.

The Association of State and Interstate Water Pollution Control Administrators (ASIWPCA), the Association of State Drinking Water Administrators (ASDWA) and U.S. EPA recently completed a review of the status of nutrient-related pollution nationwide (State-EPA Nutrient Innovations Task Group, 2009). The findings noted that: nutrient pollution significantly impacts drinking water supplies, aquatic life, and recreational water quality; a common framework of responsibility and accountability for all point and nonpoint sources is needed; current tools for better nutrient management are underused and poorly coordinated; current regulations disproportionately address certain sources in a watershed (e.g. municipal WWTP) at the exclusion of others contributing similar pollutants to the same watershed; and that specific aspects of state nonpoint source programs have been highly successful in addressing individual sources of nutrients, but their broader application has been undercut by the absence of a common multi-state framework of mandatory point and nonpoint source accountability within and across watersheds.

The report identified many of the same problems as the Ohio Lake Erie Phosphorus Task Force:

- Most agricultural manure production/application/disposal is unregulated
- Near-stream impacts are significant, but we also need to keep far-field impacts in mind
- Climate change can expand dead zones and potentially double the rate of runoff and erosion
- BMPs are available but aren't used consistently enough because policy and institutions don't require it
- Focus voluntary efforts on priority watersheds
- Implement the right practices in the right areas
- Most program dollars are still too broadly dispersed to get water quality results
- Avoid spreading manure on frozen ground
- Setback crops from waterways
- Eliminate unrestricted and unmanaged livestock access to streams

The Western Lake Erie Basin (WLEB) program led by NRCS and the US Army Corps of Engineers has been addressing nonpoint issues, outreach and solutions in the drainage to the western basin. Ohio EPA continues to work with U.S. EPA in managing Clean Water Act 319 funds to address nonpoint source related problems in Ohio. In addition to its other technical and incentive programs such as EQIP, the Ohio NRCS supports a Conservation Reserve Enhancement Program (CREP) focused on projects in the Lake Erie watershed, particularly in the western and western/central basins. A number of watershed action plans, TMDLs and the Maumee, Black and Cuyahoga River Area of Concern remedial action plans also continue to identify and address nonpoint source nutrient related improvement projects.

Changing weather patterns are another issue that may be influencing the current conditions in Lake Erie. Heidelberg University reports that river discharge has become flashier over time suggesting the increasing occurrence of shorter but more intense storm events. In recent decades a noticeable increase in average temperatures has been observed in the Midwest, despite the strong year-to-year variations. Heavy downpours are now twice as frequent as they were a century ago. Both summer and winter precipitation has been above average for the last three decades, the wettest period in a century (US Global Change Research Program). Other studies also show that precipitation has been increasing in the long term, particularly in the fall (USGS, 2007; Magnuson et al., 1997).

Section 8 — Discussion

The Task Force took a broad-based approach in analyzing the potential contributing factors related to the observed increasing dissolved phosphorus and the resurgence of algal blooms in the western basin of Lake Erie. The complexity of the dynamics of phosphorus as it moves over and through the land surface and its transport through water systems became readily apparent to the Task Force. As the group equipped itself with deeper knowledge about the interactions of phosphorus with soil and water, the group analyzed different sources of phosphorus and their potential for contribution to the algal blooms. While no modeling or monitoring efforts were undertaken on behalf of this analysis, the Task Force was able to assess different sources utilizing existing data and information to identify their relative contributions.

The following is a series of key observations made by the Task Force to support the conclusions included within this report. Much of what follows is detailed in the full narrative of this report. The following list intends to capture those elements believed to be critical to understanding the current situation and those elements that will have the greatest impact in reducing the delivery of DRP into the western basin of Lake Erie.

Relative Contributions

1. Point source discharges have remained consistent after a rapid drop in the 1970s. Historical discharge monitoring reports do not indicate any increases in phosphorus loadings. Point source loadings are not a major contributor to the increase in DRP.
2. Certain garden care products can contain high sources of phosphorus and can be potentially available to runoff to streams and watercourses. However, most products designed for lawn care have relatively low phosphorus levels. The runoff potential from any of these products is also highly dependent on management practices. Industry reductions in phosphorus content, better package labeling and improved application devices are all serving to minimize this potential even further. Lawn care products may be a contributing source with the potential for local impacts, but overall are not a significant contributor to algal blooms.
3. The invasive species of zebra and quagga mussels have altered the internal phosphorus cycle in the lake. Research continues to quantify this impact as models are being revised to account for the influence of mussels in the lake. While mussels may be having an influence on the internal cycling, the mussels are processing phosphorus input coming in from the rivers draining into Lake Erie. Once we realize reductions in phosphorus loadings, mussels may delay the response in the Lake, but researchers expect their influence will be short-lived.
4. While there are multiple contributors to phosphorus loading, currently the most significant is the result of runoff from agricultural nutrient applications. There is a lack of evidence that differentiates the relative contribution of commercial fertilizers and the land application of manure. Commercial fertilizer usage varies from year to year and its use outweighs the land application of manure or biosolids by a factor of two to one. Considering that agriculture accounts for about 59% of the land use in the Ohio Lake Erie basin, it follows that agricultural sources would contribute the greatest load. The significance is even more pronounced in the Maumee watershed where agricultural row crop land use ranges as high as 82%.

Agriculture

1. Overall, agricultural inputs are down (total number of animal units and lower sales of commercial fertilizer) yet the increases in dissolved reactive phosphorus tell us we need to manage the inputs we are putting into the system differently. There have been a multitude of changes in agriculture, all having an influence on the methods, amount, form, placement and timing of nutrient applications. The Task Force concludes that those recommendations that focus on the timing, amount and method of application of nutrient applications, will have the greatest beneficial potential for reducing the algal blooms in the western basin.
2. Although there are agronomic standards for the amount of phosphorus that soils need for fertility and crop yields, there is no database to track the frequency of soil tests and how the results are used to guide fertilizer application rates. The Task Force concluded that tools and indices need to be refined to account for crop fertility needs as well as environmental risk. Strategies that will improve nutrient management and reduce the runoff potential include improved soil test methodology, targeted education, consistent recommendations to producers and better follow-through on the recommendations made for phosphorus application.
3. Precision nutrient management utilizing management zones prepared from geo-referencing of crop production yield maps, soil maps and soil testing data has the potential to more accurately apply phosphorus where needed and to minimize over-application of phosphorus fertilizer.
4. There is no single agricultural practice that will result in a lowering of nutrient runoff. The reduction of DRP will require a system of best management practices that address the amount of commercial fertilizers and manures applied to fields, the methods of application and the practices that inhibit runoff delivery to local streams. The Task Force has developed a list of priority BMPs that have been identified as pivotal to reducing DRP. The list is included in Appendix B.

Other

1. DRP loading to Lake Erie has been increasing by large amounts since the mid-1990s and is now reaching historical highs after dropping substantially during the late 1980s and early 1990s. While there has not been any significant change in rainfall, there have been significant increases in fall and winter runoff. There has been less snow so that now a moderate winter rain can generate significant runoff as a result of frozen ground and little to no plant uptake. Changing seasonal patterns of rainfall and runoff have thus contributed to the increased runoff of dissolved phosphorus to Lake Erie.
2. Stream corridors can provide assimilative capacity for the uptake of in-stream nutrients in stream runoff, but these are primarily localized benefits to stream condition. There are no specific recommendations on developing the assimilative capacity through the restoration of stream corridors. The focus of the Task Force was to address the increase in algal blooms and the Task Force has concluded that addressing upland measures will yield the most beneficial results.
3. Although DRP is increasing in other monitored tributaries in Ohio (e.g., the Cuyahoga and Grand Rivers), the much higher loads from the Maumee and Sandusky make them higher priority watersheds for reducing impacts to Lake Erie. The concentrations and loads from the Maumee and Sandusky are higher than most other monitored tributaries in the entire Midwest region.
4. Based on historical evidence, we know that whenever we can reduce the DRP loads into the system, the conditions in Lake Erie will respond accordingly. Reductions in DRP inputs could result in near-term responses in ecosystem condition, particularly in the nearshore. Open lake responses may take longer (up to 10 years).

Section 9 — Recommendations

9.1 — Matrix

As an outcome of the deliberations and findings over the past two years, the Task Force has developed a myriad of recommendations, primarily focusing on upland measures that will better manage phosphorus inputs into the system. These recommendations are presented in the action matrix on the following pages.

	TOPIC	ISSUE	RECOMMENDATION	IMPLEMENTATION
Point Sources				
1	Point Source Dischargers	Point source dischargers are required to meet discharge limits under the provisions listed in NPDES permits. Ohio EPA issues the NPDES permits by Water Quality Standards, reviewing discharge data, reviewing records, doing inspections, considering the targets set in the GLWQA (0.5 to 1 mg/l TP), and the recommendations in TMDL reports.	A. Maintain effective permit compliance and enforcement program for NPDES permitted facilities. B. Continue to pursue progress with regard to Long Term Control Plans (LTCP) for Combined Sewer Overflows (CSOs) and Sanitary Sewer Overflows (SSOs). C. Maintain timely issuance of discharge permits. D. Evaluate need to reduce Phosphorus concentration limits in individual NPDES permits based on findings in TMDL reports or other action plans (WAP, RAP, LaMP).	Ohio EPA
2	Home Sewage Treatment Systems	Data collected by the Ohio Department of Health in 2008 indicate that 23% of the household sewage treatment systems are failing with an additional 13% projected to fail within the next 5 years. Soil limitations, substandard or poor designs, space limitations, system age, shallow seasonal water tables and poor operation and maintenance were reported as most common reasons for system failure.	A. A successful household sewage treatment system program for Ohio should be based on the establishment of statewide minimum standards/rules to provide program continuity across all 88 counties in Ohio. B. To protect public health and the environment, household sewage treatment systems must be designed to ensure the proper treatment (not disposal) of household sewage. C. Proper household sewage treatment system siting, design (based on the soil and site characteristics) and installation combined with an inspection and maintenance program will ensure system long-term sustainability and protect public health and the environment. D. The use of off-lot discharge for household sewage treatment systems should be minimized. E. A training and continuing education program for household sewage treatment system designers, installers, inspectors, regulators, maintainers and operators must be established.	Ohio Department of Health and Local Health Districts

	TOPIC	ISSUE	RECOMMENDATION	IMPLEMENTATION
Nonpoint Sources: Agriculture				
3	Current agronomic recommendations (Vitosh et al. 1996).	The current agronomic recommendations for rates of P usage are considered to be valid; however, it is apparent that some fraction of the farming community is either over- applying or applying P without proper consideration to timing or methods of application, contrary to Tri-state fertilizer recommendations for corn, soybeans, wheat, and alfalfa (Vitosh et al., 1996).	A. Agricultural agencies and crop consultants need to emphasize (and producers need to follow) the prescriptions called for in the Tri-State recommendations (Vitosh et al. 1996). B. Reinforce through increased training of agency staff, producers, crop consultants, etc. C. Update recommendations as needed, with special emphasis on timing and method application.	ODA, NRCS, OSU, Fertilizer dealers, Crop Advisors, producers
4	Soil Tests – increase usage	There is limited usage of soil tests for environmental purposes. Insufficient use of soil tests for agronomic purposes results in uncertainty as to how much cropland in Ohio is regularly soil tested.	A. Develop incentives to encourage more soil testing. B. Promote wider adoption of soil testing with a goal of getting a higher % of cropland tested C. Expand soil test procedures to include water extractable solubility, P-saturation and stratification in order to expand the base of knowledge and gain additional data sets to understand risks of P transport.	• Conservation Stewardship Program (CSP) • Special projects to emphasize nutrient management (e.g., EQIP) • Broader outreach (watershed groups, SWCDs, Extension, CCAs)
5	Linkage of soil test results to fertilizer recommendations and actual application.	Basis for recommendations from soil labs and crop consultants to guide decisions by producers with respect to P application rates and methods are currently unknown.	Conduct needs assessment of the soil labs, CCAs and others (Extension, landowners, unaffiliated consultants) to learn the basis of P recommendations given with soil test results	Currently funded by the Lake Erie Protection Fund

	TOPIC	ISSUE	RECOMMENDATION	IMPLEMENTATION
6	Reliability, availability and comparative usefulness of soil test laboratory results	Reliability of some soil test results remains questionable in the absence of sampling technique standardization • In order to validate program effectiveness, we need more access to soil test data from laboratories • We also need access to collection methods data to analyze them as one factor in soil test reliability	Encourage and support development and implementation of a soil P analytical lab certification program A. Establish a central clearinghouse of soil test results to: • analyze trends and levels • identify number and location by watershed of tests taken utilizing GIS capabilities • identify problem areas and targeted watersheds B. Standardize collection methods C. Standardize analytical methods D. In the absence of a state-sponsored certification program, the agencies should consider requiring data come from certified labs allowing the industry (laboratories) the flexibility of implementing their own certification requirements. E. Review the Wisconsin "discovery farm" experience (*www.uwdiscoveryfarms.org*) and the Ontario example.	TBD
7	P-runoff risk screening tool for farmers (expansion of Soil Test Risk Assessment Procedure in the NRCS *Section 1, Field Office Technical Guide*)	There is a need for development of a simple tool to be used in the field for a rapid determination of risk of P transport to surface water. A screening tool would serve as a precursor to the more detailed analysis of the P Index.	Develop and implement a P-Risk Screening Tool that includes: • potential for off-site P transport; • seasonality/weather conditions; • runoff and erosion potential to surface waters; • distance/connectivity to surface inlets and subsurface drainage systems to surface waters; • P solubility; and • soil test data (including stratified data where available).	USDA NRCS Recommendations #6 and #7 are to be considered together for purposes of developing and providing the most effective tools for consultants and landowners to make field application decisions that address crop yields and environmental concerns

	TOPIC	ISSUE	RECOMMENDATION	IMPLEMENTATION
8	Phosphorus Index (as defined in the NRCS *Section 1, Field Office Technical Guide*	The current phosphorus index in use by the NRCS is a comprehensive tool that is in need of updating.	A. Recommend revisions as needed to the P Index to NRCS if warranted based upon: • data from last 10 years • the need to make the P-Index more quantitative to risk of P runoff from site • include a dissolved P component B. Validate as specific to Ohio	USDA NRCS; project team underway
9	Promotion of phosphorus management using improved assessment tools	How to get P runoff assessment tools used more often and to be more useful.	A. Emphasize incorporation of fertilizer and manure B. Discourage application of manure and P-containing fertilizer unless P-Index/Soil Test Risk Assessment Procedure score is below a value that is determined to be acceptable. C. Promote the use of the P runoff risk assessment tools in nutrient management plans D. Promote potential economic benefit of Phosphorus management E. Develop incentives in State and Federal programs to increase usage of updated assessment tools such as: • Tax/rebates associated with P sales • Incentives directed at crop consultants	
10	Promotion of Recommended BMPs (see Appendix B)	Priority practices for nutrient management are currently available with existing cost share programs. However, these BMPs are not fully optimized by producers. Recommended BMPs for nutrient management need to be more strongly advocated with alternative approaches.	Recommend that cost-share agencies develop innovative approaches to agricultural programs such as: • linking the use of the P Index and/or a screening tool to allocating funds for adoption of BMP practices • explore on farm challenge projects (e.g., American Farmland Trust BMP Challenge Program) • identify options to more fully support Recommended BMPs that address nutrient management	Cost-share agencies and other technical assistance entities include: FSA, USDA-NRCS, DNR-DSWC, TSPs, CCAs, OSU-Extension Available agricultural agency resource concerns are significant. Other financial mechanisms to promote implementation of Recommended BMPs in targeted areas.

	TOPIC	ISSUE	RECOMMENDATION	IMPLEMENTATION
Nonpoint Sources: Urban and Residential				
11	Contributions of P from dishwasher detergent	SB 214 has been introduced to the Ohio legislature. If adopted, SB 214 would ban phosphorus from dishwasher detergents.	The P Task Force recommends passage of this legislation.	Legislation passed in 2009, effective as of July 1, 2010
12	Lawn care fertilizers	The Task Force considers P contributions to increasing algal blooms in Lake Erie from lawn care fertilizers to be low, but contributions could be locally significant as a result of the misapplication of lawn care products.	Identify opportunities to support low-P lawn care products and proper stewardship of product recommendations. A. Develop an MOU between the State of Ohio and lawn care manufacturers and service providers to achieve a reduction in pounds of phosphorus applied in lawn care products for all 88 Ohio counties. B. Support education and outreach targeted to homeowners to implement appropriate stewardship practices in the use of lawn care fertilizers.	Recommended Lawn-Care BMPs 1) Select low or no P fertilizer: Apply a product with an N-P-K formulation of 26-0-3. 2) Choose fertilizer designed for lawns**.** The word "lawn or turf" should be on the label. "All purpose" formulations should be avoided for lawn use. 3) Read and follow label directions**.** Reduce spreader setting to that recommended on product label. Over application can harm water quality and the lawn health. 4) Keep fertilizer off of walks and driveways to reduce loss to storm sewers and streams. Use drop spreader with deflector to keep fertilizer on lawn. 5) Mow lawn at the highest setting and leave the grass clippings on the lawn. Mowing high allows the grass to develop a deep root system that retains and uses water more efficiently. Returning clippings recycles nutrients. 6) Fertilize in spring after first cutting and in the fall after Labor Day and before Halloween**.** Only apply fertilizer when grass is growing enough to be mowed, and before dormancy. 7) Soil tests can help determine if other nutrients are needed.

	TOPIC	ISSUE	RECOMMENDATION	IMPLEMENTATION
13	Transport Mechanisms	Subsurface drainage, surface drainage and channelized streams and ditches -are contributing factors to the transport of DRP. Lack of available data prevents a thorough analysis of the relative contribution.	A. Support the recommendations of the Ohio Rural Drainage Committee. B. Promote/encourage complementary practices to surface and subsurface drainage practices to address potential delivery of DRP to streams. C. Conduct data collection on drainage intensity via the ag census and/or survey. D. Conduct research on sampling discharges from tile drain systems. E. Further develop BMP effectiveness analysis to guide BMP selection.	State and federal agricultural agencies
Other				
14	Public Education and Involvement	Education of residents about harmful algal blooms and local actions needed to address this problem on a long term basis.	A. Ohio EPA should work with sister agencies to coordinate the delivery of Phosphorus Task Force recommendations for public outreach and education utilizing current programs to the extent possible. Where gaps exist, funding should be sought to fulfill identified needs. B. Ohio EPA and ODNR should seek funding that will result in the development and implementation of new Watershed Action Plans and updates to existing plans to fully address Phosphorus Task Force recommendations in the Lake Erie basin.	Ohio EPA and ODNR; other state, academic and local partners

	TOPIC	ISSUE	RECOMMENDATION	IMPLEMENTATION
15	Research agenda for Ohio	Current research projects underway will yield valuable results in understanding the science and mechanisms in the movement of phosphorus and its impact to Lake Erie. The Task Force recommends an integrated, interdisciplinary approach to current and future projects to maximize the application of results to an adaptive management approach in addressing phosphorus delivery to Lake Erie.	A. Develop a research agenda designed to: • identify specific P reduction targets for the western basin; • identify nearshore targets; • identify potential linkages of DRP levels with rainfall intensity; • identify (any) direct linkages of DRP and harmful algal blooms; • determine extent of contributions of P from internal cycling; and • impacts of P stratification in soil. B. Develop a Discovery Farm and/or Watershed in Ohio (based upon the Wisconsin model) to demonstrate results from research (both agricultural and environmental) and linkages between land and water. C. Expand soil test procedures to include water extractable solubility, P-saturation and stratification in the soil to expand base of knowledge and data set to estimate the risk of P transport from a given site. D. Develop and implement a P-Risk Screening Tool (as described in #6). E. Validate the P-Index (as developed in #7). F. Develop new BMPs to minimize Phosphorus movement from the landscape where risk of P transport is known to be high.	See Section 10
16	Phosphorus Water Quality Standards for streams	Need WQ standards for TP and DRP; Need to consider loading standards vs. concentration standards.	A. Ohio EPA should monitor or require monitoring for dissolved phosphorus. B. Adopt and update nutrient standards for water quality. C. Develop standard operating procedures for dissolved phosphorus samples in runoff.	Ohio EPA and U.S. EPA
17	Create an Ohio Research Advisory Committee	The State of Ohio would benefit from a coordinated effort among researchers and program managers to assess research needs in Ohio	Form a committee of applied interdisciplinary researchers (including managers, users, academia).	This committee would address the research needs identified in Recommendation #15 above

Section 10 — Research Needs, Organization and Approaches

10.1 — Introduction and Background

TP loading to Lake Erie declined rapidly with the implementation of phosphorus removal programs at WWTPs, and met the GLWQA target load of 11,000 metric tonnes for the first time in 1981. Supported by the widespread adoption of soil erosion control BMPs, TP loads continued to decrease, with targets exceeded only in years of high rainfall and the associated increases in agricultural runoff. The Lake Erie phosphorus removal programs led to major improvements in water quality and are viewed as a major success story in large scale environmental management (Matisoff and Ciborowski, 2005). However, since the mid-1990s, the problems of eutrophication have returned to the Lake. Similar eutrophication problems are occurring in many other coastal areas and inland lakes and are often associated with nutrient runoff from intensive agricultural land use. These problems are particularly severe in the Gulf of Mexico and Chesapeake Bay, and exasperated by agricultural activities far up in the watersheds.

Examination of pollutant loading data for Lake Erie's major U.S. tributaries suggests that the problem stems not from any increase in the total amount of phosphorus entering the Lake, but instead from changes in the forms of phosphorus entering the lake from its large agricultural watersheds. Despite an 85% decrease in DRP from agricultural runoff between 1975 and 1995 (Richards and Baker, 2002), agricultural runoff DRP is now at its historically highest levels (Joosse and Baker 2009). This is particularly significant now as for every pound of phosphorus entering the Lake from WWTPs, three pounds are entering from nonpoint sources.

The challenges of reducing eutrophication in Lake Erie are great. As the shallowest and warmest of the Great Lakes, Lake Erie is particularly susceptible to harmful algal blooms and hypoxia. Agriculture, the dominant land use in the watershed, takes place on intensively tile-drained soils with high clay content. The tile drainage contributes to high delivery of nitrates to area streams. The high clay content contributes to rapid surface runoff during rainfall events, with that runoff carrying both dissolved pollutants and fine-grained sediments. Even though the cropland is relatively flat and has low erosion rates, and conservation programs have decreased particulate phosphorus runoff, the nitrogen and phosphorus export rates from these watersheds remain well above average for Midwestern cropland watersheds (Richards et al., in press). Yet another challenge may come from climate change. Agricultural runoff is driven by the seasonal patterns, amounts, and intensities of rainfall events. Changing seasonal patterns of rainfall and runoff have already contributed to the increased runoff of dissolved phosphorus to Lake Erie. If the weather changes predicted by most climate change models for this region do occur, the challenges will become even greater.

The Ohio Lake Erie Phosphorus Task Force has begun the diagnosis of the array of potential sources contributing to the algal blooms in the western basin, yet more needs to be fully understood to effectively manage the critical resource that is Lake Erie. Scientific analyses are needed to: understand the movement of sediment and nutrients through stream systems; target remedial measures to critical pollutant source areas at the watershed level; improve the science of watershed modeling relative to both predicting the extent of agricultural nonpoint pollution and estimating the benefits of targeted BMP adoption; and expand our understanding of the sociology of agricultural pollution abatement. More information is also needed relative to the transport and effects of nutrients and sediments as they move through estuaries, bays, nearshore zones and open lake waters during and following storm runoff events. These analyses are needed so that results can be applied to the most effective melding of modern soil conservation methods with advanced nutrient management measures and agricultural water management measures.

Researchers believe Lake Erie is well positioned for another recovery. Eighty percent of the water that enters Lake Erie is derived from Lake Huron and has very low nutrient concentrations. About 10% comes from rainfall and the remaining 10% from the tributaries draining the Lake Erie watershed. Recent increases in the costs of fertilizers should lead farmers toward more careful nutrient management. Reductions in nutrient concentrations in the Lake's agricultural tributaries should lead to relatively quick recovery since it is flushed out by clean water from the upper Great Lakes.

The unique, yet clearly defined characteristics of Lake Erie and its nutrient inputs position this water resource to serve as an important study site for environmental management and recovery. But we must better understand the dynamics of how nutrients are moving from croplands into the water pools in the watershed and its tributaries and ultimately to the lake to inform our management strategies. The interdisciplinary collaboration among the researchers, managers, agency personnel and stakeholder groups of the Ohio Lake Erie Phosphorus Task Force has sharpened our understanding of knowledge gaps and approaches we can use to fill those gaps. Solving these problems in Lake Erie will benefit similar efforts throughout the Great Lakes and the Midwest, and have significance at national and global scales.

10.2 — Research Needs as Reflected in Questions Raised During Task Force Deliberations

The research and information needs related to reducing nutrient runoff from agriculture and its subsequent impacts on the open waters of Lake Erie can be organized in terms of the sequential habitats shown in Figure 38. Many of the questions raised during the Task Force deliberations can be placed along these sequential habitats. These questions will be briefly noted and explained in this section.

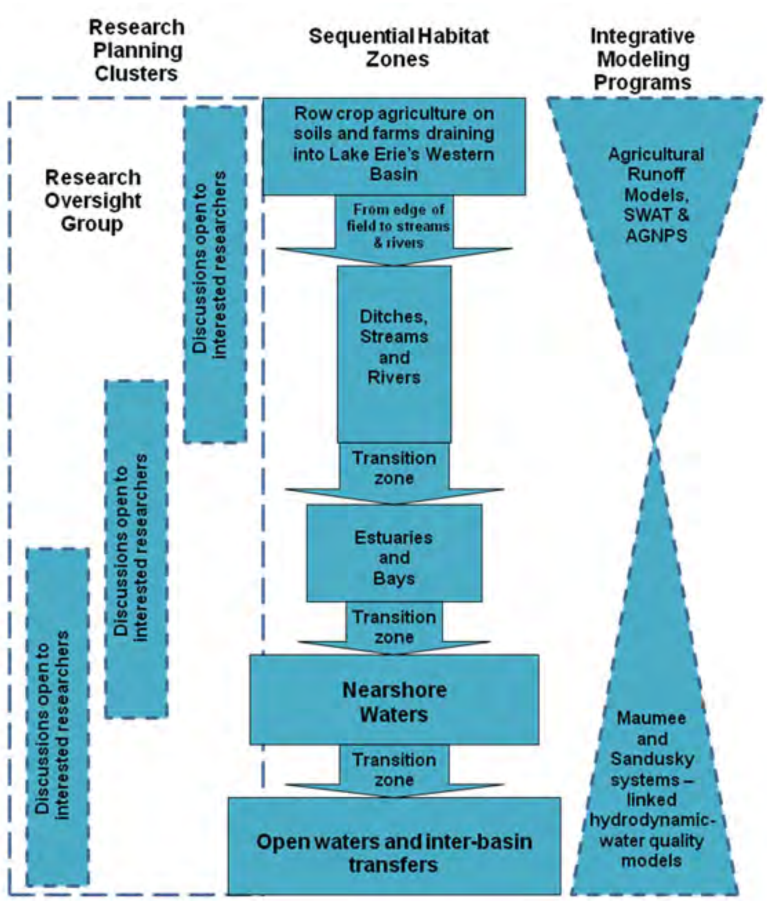


Figure 38 — Major habitats linking croplands to open waters of Lake Erie, modeling frameworks and research clusters

A. Cropland Issues (Note – the term "area cropland," as used below, refers to cropland in northwest Ohio and adjacent portions of Indiana and Michigan that drain into the western basin of Lake Erie).

1. Are the guidelines of the Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat and Alfalfa (Vitosh et al. 1996) adequate for today's high yield seed varieties, relative to critical soil test values for phosphorus that will produce maximum (economic) yields?
2. If farmers were to apply drawdown rates of phosphorus fertilizer, how quickly would phosphorus soil test levels drop to the agronomic critical levels for the various soil types present in area cropland?
3. What roles do gridded soil sampling, yield monitors and variable rate fertilizer applications have for overall nutrient management in area cropland?
4. What is the relationship between surficial soil test levels and DRP concentrations in surface runoff for the various soil types present in area cropland?
5. What is the relationship between the degree of phosphorus stratification on area fields and the various combinations of tillage practices and fertilizer placement practices for the various soil types present in area cropland?
6. What proportions of DRP export from area cropland move through sub-drainage (tile systems)?
7. What guidelines can be developed for targeting programs to reduce DRP export from cropland, and how can necessary information be collected and utilized?
8. What role does the application of manure to area cropland have in the overall problem of high DRP export from area cropland?
9. What role could programs to improve soil tilth have in reducing DRP phosphorus export from cropland, and how might such improvements be achieved?
10. What role could utilization of winter cover crops play relative to reducing DRP export from area cropland?
11. What is the overall magnitude of edge-of-field nutrient losses relative to nutrient removal by harvested crops for area cropland?
12. What role can revisions to Ohio's Phosphorus Index play in programs to reduce DRP export from area cropland?

B. From Edge-of-Field to Ditches, Streams and Rivers

1. What opportunities exist for intercepting edge-of-field nutrient and sediment losses prior to their delivery to stream systems?
2. Where, in area cropland landscapes, do opportunities exist for using field buffers, wetlands, and streamside buffers to reduce dissolved and particulate nutrient loading into area ditches and streams?
3. How can broader habitat and environmental benefits associated with buffers and wetlands be factored into programs fostering their adoption by area farmers?

C. Ditches, Streams and Rivers (Note: In this area, the term ditch generally refers to man-made extensions of the natural drainage network into cropland areas to facilitate tile drainage and increase the rate of removal of excess water.)

1. Ditches, streams and rivers constitute pollutant conveyance pathways between cropland and Lake Erie. What modifications or "processing" of nutrients and sediments occur within this drainage network that alter the amounts, forms and timing of agricultural pollutant delivery to the Lake?
2. Can these conveyance pathways be modified to enhance their assimilation capability and significantly reduce nutrient and sediment export to the Lake and are such modifications economically and socially viable?

3. Can or has the performance of such modifications been adequately evaluated relative to their effectiveness in reducing soluble nutrient transport during floods for various seasons, especially during winter periods when the bulk of DRP export occurs?
4. As important water resources in and of themselves, and as resources known to be impacted by agricultural land use in their watersheds, how will efforts to reduce nutrient and sediment export to Lake Erie from cropland interact with ambient water quality and/or flow regimes and flooding in these ditches, streams and rivers? (Ambient water quality includes uses for aquatic life, public water supply and recreation.)
5. What is the relative importance of agriculturally derived nutrients and point source derived nutrients in river eutrophication, a condition that sometimes develops in riverine habitats during low flow conditions?
6. What are the impacts of river eutrophication, and possible release of toxicants from algal blooms, on riverine biota and on drinking water supplies?

A special note on ditches, streams and rivers: Ditches, streams and rivers provide the only practical locations where quantitative measurements of pollutant transport can occur. At watershed outlets, tributary loading stations provide information on the cumulative pollutant export from upstream land uses, including both point and nonpoint sources. Such stations also provide information on the total amounts of pollutants exported to downstream receiving waters from watersheds. Tributary loading stations on rivers draining large watersheds provide the basis for tracking pollutant loading into Lake Erie, and for documenting the effectiveness of pollutant loading abatement programs. Pollutant transport studies on rivers require both continuous discharge measurements, such as those provided by the U.S. Geological Survey, and frequent sample collection for chemical analysis, such as those of the Heidelberg University National Center for Water Quality Research. It is not feasible to measure edge-of-field transport on a continuous basis for a large number of fields, nor is it feasible to accurately and continuously measure pollutant fluxes in estuarine environments. The Ohio portion of the Lake Erie Watershed is the home to the most detailed and longest-term pollutant transport studies in the Great Lakes Basin and the Midwest, thus it is uniquely positioned for addressing the questions posed herein.

D. Estuaries and Bays (Note: Wind driven seiches in Lake Erie create estuarine-like conditions in the lower sections of rivers near the lake. These constitute fresh water estuaries. Two major bays occur in the western basin of Lake Erie – Maumee Bay and Sandusky Bay.)

1. Estuaries and bays represent depositional environments for suspended sediments and particulate phosphorus that are exported from rivers during runoff events. What proportions of the sediments and particulate phosphorus delivered to estuarine portions of rivers during runoff events pass through these environments and reach nearshore and/or open lake systems, and how do these proportions change in relation to the size of runoff events and/or floods?
2. Under low flow conditions in rivers, what proportion of the nutrients entering the estuarine and bay environments come from river inflows and what proportion from point sources discharges and/or urban storm water runoff from adjacent land uses?
3. What roles do algal communities that develop in estuarine and bay environments have in subsequent algal bloom developments in nearshore and/or open lake environments?
4. Do bottom sediments in estuaries and bays serve as significant sources of dissolved phosphorus and/or bioavailable phosphorus for algal community development in overlying water?
5. What proportion of dissolved phosphorus and nitrate entering estuaries and bays from rivers during runoff events is taken up by algal growth and/or is otherwise removed by physical and chemical processes and what proportion passes through to nearshore and open lake environments?
6. What are the environmental impacts of eutrophication in the estuaries and bays?

E. Nearshore Zone (Note: The nearshore zone and associated shorelines of Lake Erie represent the major interface between humans and the Lake. The proximity to the land can result in high pollutant concentrations, their shallowness can allow for wave induced re-suspension of pollutants, and that same shallowness can support development of attached algal growths such as *Cladophora* and *Lyngbya*. The nearshore zone can moderate nutrient transport to open water habitats (the nearshore shunt). These areas also include biologically important coastal wetlands.)

1. What is the source of nutrients that support the development of excessive growths of benthic algae, such as *Lyngbya* and *Cladophora*, in nearshore zones? (What are the relative roles of storm derived agricultural nutrients and local point sources and urban runoff sources?)
2. What is the role of wave and/or current induced sediment re-suspension in nearshore algal bloom development?
3. What role, if any, do nearshore attached algae play in subsequent developments of harmful algal blooms in off-shore waters of the Lake?
4. Can nutrient loads from the land be reduced enough to eliminate nuisance benthic algal growth? If so, what level of load reduction is needed?
5. What are the broader impacts of toxins released by algae on aquatic life and, through contact recreation, food chains and drinking water pathways, on human populations?
6. How do inorganic nutrients interact with other environmental factors that influence the species composition and population densities of algal communities in the nearshore zone?
7. How do nutrient inputs and associated algal community responses affect benthic and fish communities in the nearshore zone?
8. Do nearshore zones interact with open lake waters such that they serve as “kidneys” that filter out nutrients from open lake waters?
9. What are the interactions between open lake hypoxia and nearshore benthic communities during seiche events?

F. Open Lake Waters (Note: These are the broad expanses of open waters that support the bulk of the fishing and boating activities in the Lake. These are the zones where problems of hypoxia have their greatest and most prolonged impacts.)

1. What is the appropriate balance of nutrient inputs that support a productive fishery in Lake Erie and nutrient inputs that avoid and/or minimize harmful and nuisance algal blooms?
2. What are the relative roles of internal phosphorus loading from bottom substrates and seasonal inputs from nonpoint sources in creating environments for harmful algal bloom development?
3. Within the western basin of Lake Erie, how does phosphorus release from dredging activities compare with phosphorus release from wind driven re-suspension of bottom sediments?
4. Do current levels of eutrophication in open waters warrant reinvestigation of target loads for total phosphorus?
5. Should target loads of phosphorus be set for bioavailable phosphorus? … for DRP?
6. Do direct point source phosphorus inputs, with their constant daily loads, have the same impact on open water nutrient levels as nonpoint derived loads which are delivered in large pulses?
7. Can the establishment of phosphorus standards be utilized in efforts to reduce harmful algal blooms, and, if so, should they be for concentrations or loading rates, for various seasons, for high flow or low flow, or for some combinations of the above? How could compliance with standards be judged or enforced?

8. Are there other controllable environmental inputs that could be modified so as to manage algal communities such that they better support fisheries food chains.

10.3 — Integrated Research Planning and Modeling

A. Research Planning Process

Since the overall objectives of the research programs relate to addressing the problem of harmful algal blooms in Lake Erie, it is essential that researchers communicate with each other along the habitat zones shown in Figure 38. We suggest that sets of overlapping research planning clusters be formed such as those shown in Figure 38. Such clusters should review, refine and prioritize the questions that have been posed relative to the habitats included in each cluster. Participation in these clusters should be open to all interested researchers, including those in governmental agencies, universities and the private sector. Invitations for participation should extend beyond those who have participated in the Ohio Lake Erie Phosphorus Task Force meetings.

Products of a first round of meetings would be detailed outlines of the research, monitoring and information collection that would be undertaken, along with summary descriptions of the methods to be employed and the cost estimates associated with the work. These products would be submitted to an oversight committee for approval. Detailed proposals would then be developed in accordance with oversight committee recommendations and with the endorsement of the oversight committee. Proposals would be submitted to a variety of funding agencies funded under the Great Lakes Restoration Initiative or other appropriate funding sources.

B. Integrative Modeling

Much of the research, monitoring and data collection from the above research efforts can be incorporated into modeling efforts such as those shown in Figure 38. In part, the models can guide some of the research and monitoring efforts, and in part, the research and monitoring data can help to evaluate and refine the models. The models can then be used to extrapolate results to neighboring watersheds or coastal systems.

Both the Sandusky watershed and the Maumee watershed have been the sites for extensive model applications. Likewise, linked hydrodynamic-water quality modeling has been developed for both Sandusky Bay and Maumee Bay. These models include lower food web components. Since these two bay systems differ greatly in their watershed area to bay volume ratios, comparative analyses of these two systems may prove valuable.

10.4 — Spatial Aggregation, Implementation and Adaptive Management

A. Spatial Aggregation

Much of the research outlined at the farm and field level could most efficiently be accomplished through the establishment of a set of demonstration or "discovery" farms for representative soils and farming situations in this region. Discovery farms have been used in other parts of the Midwest to advance applied research in those areas. Such farms provide critical links between land grant operated research farms and the working farms that populate large agricultural watersheds.

In addition, applied research can also be advanced through the establishment of research watersheds. Within research watersheds, monitoring programs are established to carefully track both human and climatic inputs, as well as watershed outputs. Research watersheds provide locations for evaluating the effectiveness of nonpoint source pollution reduction programs and for evaluating and refining watershed models. Research watersheds also pose favorable locations for studies related to the transport and processing of pollutants as they move through stream systems. Monitoring programs that support pollutant export at the watershed level can also help support assessments of stream processing.

B. Implementation Programs

Implementation of measures to reduce DRP loading to Lake Erie need not wait for results from the research programs described above. Management efforts inevitably proceed within the limits of the "best management practices" available at that time. The Lake Erie watershed is poised for large scale investments in nutrient reduction programs as part of the Great Lakes Restoration Initiative.

Implementation programs provide researchers who operate at the large watershed scale with the nearest thing to "controlled experiments" that they are likely to be able to afford. In fact the research can assume, among other things, the role of assessment of the effectiveness of the implementation programs. This is particularly true when the implementation occurs within the boundaries of established research watersheds.

Implementation and assessment efforts at watershed scales do not yield benefits that can be assessed in the short term. However, it is only when accomplished at large watershed scales that the goals of reducing nutrient loading to Lake Erie will be realized. Thus we must recognize the necessity of long-term efforts for both implementation and assessment. If implementation programs focus only on those problems that can be fixed and assessed in the short term, it is unlikely that we will be addressing the big problems that face Lake Erie.

C. Adaptive Management

In a changing world, and the Lake Erie basin is changing in many respects, Adaptive Management should be the *modus operandi* of environmental management. It simply involves: careful problem identification; addressing those problems through implementation of "best" technology and/or practices available and affordable at that time; monitoring to assess the effectiveness of those implementation programs and to identify emerging problems and/or tradeoffs; and research and development related to new "best" technologies and practices for reducing adverse environmental impacts associated with our ever more intensive uses of our land and water resources.

Adaptive management has worked for Lake Erie in the past and we trust that it will be applied and work in the future.

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Appendices

Appendix A — HUC Maps and Land Use Statistics

Figure A-1 — Hydrologic units (HUC) representing individual or a combination of Ohio watersheds draining to Lake Erie. Use as a companion to Appendix Table A-1

Appendix Table A-1 — Level I land use classifications and percentages based on 2001 National Land Cover Data (NLCD). Hydrologic units from 04100001 through 04100011 drain to the Western Basin of Lake Erie. Hydrologic Units 04100012 through 04110003 drain to the Central Basin of Lake Erie

NLCD 2001 Level I	Ohio Lake Erie Tributaries	Maumee Basin	St. Joseph	St. Marys	Upper Maumee	Tiffin/ Bean
Hydrologic Unit	**Aggregate of HUCs**	**Aggregate of HUCs**	**04100003**	**04100004**	**04100005**	**04100006**
Area (sq. mi.)	**13,643**	**6,587**	**1,074**	**823**	**383**	**782**
Agriculture	65%	78%	70%	78%	78%	78%
Urban	16%	11%	10%	13%	14%	8%
Forest	13%	7%	11%	6%	5%	7%
Wetlands	3%	2%	8%	1%	1%	6%
Grassland	1%	1%	1%	1%	1%	0%
Barren	0%	0%	0%	0%	0%	0%
Shrub	0%	0%	1%	0%	0%	0%

NLCD 2001 Level I	Auglaize	Blanchard	Lower Maumee	Ottawa	Toussaint/ Portage	Sandusky
Hydrologic Unit Code	**04100007**	**04100008**	**04100009**	**04100001**	**04100010**	**04100011**
Area (sq. mi.)	**1,666**	**786**	**1,074**	**402**	**973**	**1,878**
Agriculture	82%	82%	76%	54%	76%	76%
Urban	11%	10%	14%	32%	13%	10%
Forest	5%	6%	7%	10%	4%	8%
Wetlands	0%	0%	1%	2%	4%	2%
Grassland	1%	2%	1%	1%	1%	1%
Barren	0%	0%	0%	0%	1%	0%
Shrub	0%	0%	0%	0%	0%	0%

NLCD 2001 Level I	Huron +	Vermilion/ Black/Rocky	Cuyahoga	Chagrin +	Grand	Ashtabula +
Hydrologic Unit Code	**04100012**	**04110001**	**04110002**	**04110003**	**04110004**	**04110003**
Area (sq. mi.)	**759**	**899**	**801**	**380**	**712**	**252**
Agriculture	69%	36%	16%	6%	33%	28%
Urban	9%	31%	45%	56%	11%	21%
Forest	19%	25%	31%	31%	43%	43%
Wetlands	1%	6%	3%	1%	6%	3%
Grassland	0%	1%	3%	5%	4%	3%
Barren	0%	0%	0%	0%	0%	0%
Shrub	0%	0%	0%	0%	2%	2%

Appendix B — Ohio Lake Erie Phosphorus Task Force Recommended Agricultural Best Management Practices for Reducing Phosphorus, Nitrogen and Sediment Loading to Lake Erie*

Nutrient Management (590) and Waste Utilization (633)

Nutrient management is the use of approved and proper prescriptions for fertilizer amounts and application methods and timing, based on proper soil testing and crop yield goals. Nutrient management is one of the most important practices for reducing the export of dissolved reactive phosphorous from the watershed. Nutrient management takes two forms:

- *Traditional nutrient management* involves traditional soil testing methods; and
- *Precision nutrient management* incorporates Global Positioning (GPS) Technology, combined with yield monitor maps, and Geo-referenced application methods to more precisely apply only what the crop needs and can use and only where it is needed. Precision nutrient management is state of the art conservation.

Develop and/or update Comprehensive Nutrient Management Plans Comprehensive Nutrient Management Plans (CNMPs) are documents developed to provide nutrient managers (especially manure managers in Ohio) an environmentally sound plan for proper nutrient storage, application, and agronomic utilization. CNMPs in and of themselves do not reduce nutrient losses in runoff, unless they are well-written, regularly updated and implemented. Water quality can incrementally improve based upon the extent that the following actions occur: CNMPs and/or Waste Utilization plans are well written and regularly updated per changes to recommendations and USDA-NRCS practice codes; a commitment to implement the CNMP exists on behalf of the nutrient manager (through training, monitoring, record keeping); and the degree with which the plan is fully implemented.

Fully Implement Waste Utilization and Nutrient Management practice standards

Waste utilization is the planning of a system to store, test, and apply animal waste in a manner that minimizes environmental risks and impacts. A waste utilization plan is a component of a *comprehensive nutrient management plan* and specifies the time, placement, and amounts of waste applied. It incorporates soil testing, waste testing, nutrient application prescriptions, application setbacks and restrictions, and timing prescriptions AND record keeping.

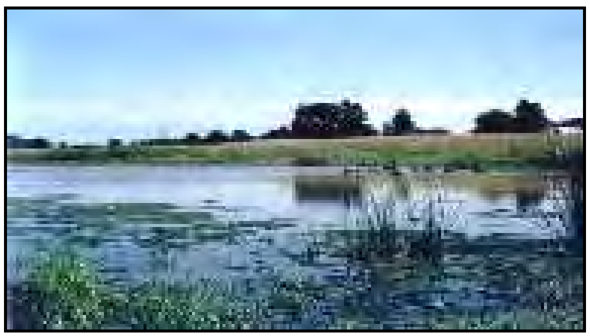
Management Practice: Necessitates increased time spent for planning, oversight, and commencement of nutrient application, which can raise cost associated with additional labor, equipment, and fuel, but can reduce cost of fertilizer inputs.

Appendix B — Ohio Lake Erie Phosphorus Task Force Recommended Agricultural Best Management Practices for Reducing Phosphorus, Nitrogen and Sediment Loading to Lake Erie*

Riparian Forested Buffers (391) and Herbaceous Riparian Cover (390)

Riparian Forested Buffers are areas of native trees maintained along water courses to: control bank erosion; provide shading to keep water temperatures down and inhibit algal growth; reduce runoff rate and amount; intercept and assimilate nutrients; sequester carbon; and provide habitat. Riparian forested buffers may be the most effective buffer to protect and restore natural stream ecosystems. Herbaceous Riparian Cover buffers have similar but less effective conservation effects for water quality protection.

Buffer Practice: Generally, a cropland retirement action, which involves a Farm Bill program easement or lease payment to compensate landowner.



Wetlands: Restoration (657), Creation (658), Constructed (656), Enhancement (659)

Wetland restoration involves converting cropland and other drained areas into wetlands. Wetlands act as a buffer by providing the benefits of flow attenuation, reduced runoff, filtering of nutrients, and provide habitat.

Buffer Practice: Generally, a cropland retirement action, which involves a Farm Bill program easement or lease payment to compensate landowner.

Appendix B — Ohio Lake Erie Phosphorus Task Force Recommended Agricultural Best Management Practices for Reducing Phosphorus, Nitrogen and Sediment Loading to Lake Erie*

Drainage Water Management (554) and Structures for Water Control (587)

Drainage water management utilizes water control structures in tile drainage systems to raise the water table in crop fields during the non-crop period when improved drainage is not needed. The elevated water table reduces nutrient losses to surface waters by reducing the overall volume of water released from the tile drainage system over time.

Management Practice: Success of drainage water management is dependent upon the degree and timing with which the land-owner/operator utilizes and adjusts the structure.

Structural Practice: A permanent structure that must be installed. Costs include cost of material, labor, and any land that may be removed from production.

Filter Areas/Filter Strips (393)

Filter Areas and Filter Strips are areas that are generally placed adjacent to watercourses that are planted into perennial grasses, legumes and forbs. These areas reduce erosion, trap pollutants and nutrients, improve water quality and provide habitat.

It is important to recognize that sheet flow of runoff from field to watercourse is rare in the landscape. Therefore, filter areas that are designed to intercept and disperse runoff through the entirety of the filter area are much needed, and should become a priority for conservation planners in Lake Erie watershed county offices in Ohio. Fixed-width buffers can be improved with this rationale in mind.

There are numerous instances in Ohio where streamside buffers are called "filter strips," but in fact, do not meet the specifications in the Filter Strip/Area practice NRCS fField Office Technical Guide standard because runoff is not dispersed through the filter, but enters surface water via concentrated flow paths and/or subsurface tiles. In these cases (e.g., where the filter strip elevation is higher than the crop field), the "filter strip" is more properly called "conservation cover."

Buffer Practice: Generally, a cropland retirement action, which involves a Farm Bill program easement or lease payment to compensate landowner.

Appendix B — Ohio Lake Erie Phosphorus Task Force Recommended Agricultural Best Management Practices for Reducing Phosphorus, Nitrogen and Sediment Loading to Lake Erie*

Conservation Crop Rotations (328)

Conservation crop rotations improve soil structure and soil tilth by incorporating more high residue crops in the rotation, use of cover crops, and by minimizing oxidation of crop residue by tillage. Improved crop rotations decrease surface runoff volumes through better infiltrative and water holding capacities of the soil resulting in decreased runoff amounts and reduced soil erosion losses.

Management Practice: Necessitates increased time spent for planning, oversight, and commencement of land practices, which can raise cost associated with additional labor, equipment, and fuel, but can reduce cost of fertilizer inputs.

Residue and Tillage Management (Conservation Tillage): No till/strip till/direct seed (329), Mulch Till (345)

Conservation tillage is the use of crop production methods that maintain protective crop residue on the soil surface. Conservation tillage practices such as No-till, strip till and direct seed are the most effective conservation practices to control soil erosion in the Western Lake Erie Basin. Compared to traditional moldboard plow tillage, conservation tillage reduces volume and intensity of surface runoff, sequesters carbon in soil profile, and provides wildlife habitat in winter.

Management Practice: Necessitates increased time spent for planning, oversight, and commencement of land practices, which can raise cost associated with additional labor, equipment, and fuel, but can reduce cost of fertilizer inputs.

Appendix B — Ohio Lake Erie Phosphorus Task Force Recommended Agricultural Best Management Practices for Reducing Phosphorus, Nitrogen and Sediment Loading to Lake Erie*

Cover Crops (340)

Cover crops are grasses, small grains, or legumes planted after harvest to protect the soil and sequester nutrients until the next crop is planted. Cover crops prevent nutrients from leaching or leaving in runoff waters, reduce discharge volume, improve soil tilth and quality, and reduce erosion. Cover crops work in union with conservation cropping systems, and conservation tillage. Further, the benefits to water quality are multiplicative with the adoption of each practice for as long as the land continues in row crop production.

Management Practice: Necessitates increased time spent for planning, oversight, and commencement of land practices, which can raise cost associated with additional labor, equipment, and fuel, but can reduce cost of fertilizer inputs.

Grassed Waterway (412) and associated Grade Control Structures (410)

Grassed waterways control ephemeral gully erosion. They reduce sediment delivery to receiving waters and eventually to the harbor and Lake Erie. Grade stabilization structures control bank and gully erosion to improve water quality and allow for drainage water management. They are often used in the installation of grassed waterway.

Buffer Practice: Generally, a cropland retirement action which involves a Farm Bill program easement or lease payment to compensate land owner.

Structural Practice: A permanent structure that must be installed. Costs include cost of material, labor, and any land that may be removed from production.

Appendix B — Ohio Lake Erie Phosphorus Task Force Recommended Agricultural Best Management Practices for Reducing Phosphorus, Nitrogen and Sediment Loading to Lake Erie*

Field Border (386), Vegetative Barrier (601), Contour Buffer Strips (332), and Conservation Cover (327)

Field borders are plantings of perennial grasses, forbs, and legumes around the perimeters of crop fields. These plantings capture and filter nutrients in runoff, provide food and nectar for crop pollinators, and provide habitat and nesting.

Conservation covers establish perennial vegetative cover to protect soil and water resources on land retired from agricultural protection. As mentioned above, countless acres of conservation cover along streams and water courses are mistaken for and often referred to as "filter strips." Where possible these systems conservation cover should be re-evaluated and redesigned to meet the "filter area" definition described above for more effective water quality protection.

The practices described above may also be applied as in-field buffers to reduce the rate and quantity of surface runoff by acting as a physical barrier to reduce runoff velocity/energy,

Buffer Practice: Generally, a cropland retirement action which involves a Farm Bill program easement or lease payment to compensate land owner.

Diversion (362): *in Association with Filter Areas (above)*

A diversion is a channel constructed across the slope generally with a supporting ridge on the lower side. That is installed to break up concentrations of water on long slopes, on undulating land surfaces, and to intercept surface and shallow subsurface flow. A diversion can be an important practice to achieve more effective benefit of designed filter areas or strips.

Structural Practice: A permanent structure that must be installed. Costs include cost of material, labor, and any land that may be removed from production.

Appendix B — Ohio Lake Erie Phosphorus Task Force Recommended Agricultural Best Management Practices for Reducing Phosphorus, Nitrogen and Sediment Loading to Lake Erie*

Waste Transfer (634)

Waste transfer is a management practice that involves a system using structures, conduits or equipment (usually manure hauling vehicles) to convey byproducts (manure and other material) from agricultural operations to alternative points of storage or usage. This practice is especially important in regions or farmsteads where there is a nutrient surplus in the soil, and where there is no agronomic necessity for application of additional manure or other nutrients to the land.

Management Practice: Necessitates increased time spent for planning, oversight, and commencement of waste transfer, which can raise cost associated with additional labor, equipment, and fuel, but can reduce cost of fertilizer inputs.

Controlled Traffic System

Controlled traffic confines heavy traffic from tractor drive wheels/tracks, combine wheels, fertilizer or manure spreaders and grain carts to specific lanes in crop fields year after year. Controlled traffic systems will reduce soil compaction, increase infiltration and improve crop yields. Additional benefits include reductions in erosion, runoff and sedimentation as well as energy savings as the need for sub-soiling decreases and firm traffic tracks form for better traction. Implementation of this practice includes: limiting wheel/track traffic to no more 50% of the rows or a maximum of 50% of the trafficked area of the field; keeping wheel/track traffic the same for all passes, all equipment and years; and ensuring no track row that is greater than 20 inches wide.

Equipment Enhancement and Management Practice: For full width tillage Geographic Positioning System (GPS) is required to maintain the designated traffic lanes. For narrow width or drilled crops, a skip row system or GPS is required. Some systems use GPS to steer tractor and are accurate to within an inch.

Appendix B — Ohio Lake Erie Phosphorus Task Force Recommended Agricultural Best Management Practices for Reducing Phosphorus, Nitrogen and Sediment Loading to Lake Erie*

Other recommended practices that can affect water quality improvement where applied to address farm specific concerns:

The following practices are included on this list because they have been documented to provide water quality benefit, but it is recognized that there may be limited participation in the Lake Erie Basin, or on acres where site specific needs dictate their adoption:

1. **Critical Area Planting (342):** Planting vegetation such as trees, shrubs, vines, grasses, or legumes on highly erodible or critically eroding areas with the purpose to: stabilize sheet, rill, and gully erosion, minimize sedimentation on and offsite, and improve wildlife habitat and visual resources.
2. **Pasture and Hay Planting (512):** Establishing and re-establishing long-term stands of adapted species of perennial, biennial, or reseeding forage plants for the purpose of reducing erosion, to produce high quality forage and to adjust land use on existing pasture and hayland or on land that is converted from other uses.
3. **Prescribed Grazing (528):** Managing the harvest of vegetation with grazing and/or browsing animals for the purpose of improving or maintaining surface and/or subsurface water quality and quantity, improving or maintaining riparian and watershed function, reducing accelerated soil erosion, and maintaining or improving soil condition.

* Photographs obtained from USDA-NRCS and lftseed.com. Numbers refer to specific NRCS practice standards listed in the NRCS Field Office Technical Guide. (Ohio NRCS, 2001)

Cover Image:
Lake Erie, Sept. 4, 2009
Thomas Archer, Columbus, Ohio

Ohio Environmental Protection Agency
Division of Surface Water
P.O. Box 1049
Columbus, Ohio 43216-1049
www.epa.ohio.gov
(614) 644-2001

EXHIBIT 13

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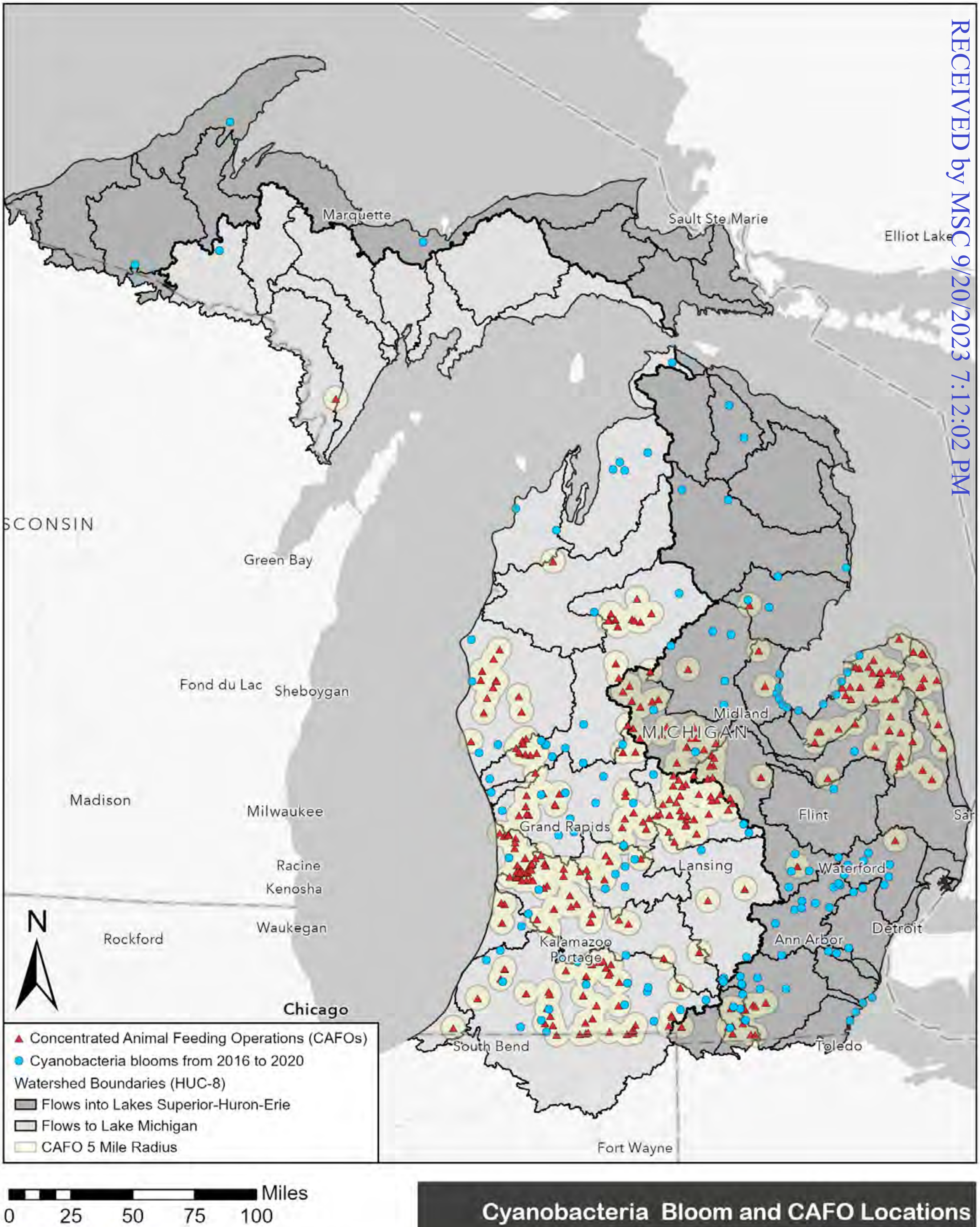

Cyanobacteria Bloom and CAFO Locations

Water Resources Division

EGLE MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

Date Created: 1/11/2021

EXHIBIT 14

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Published November, 2000

Potential of Earthworm Burrows to Transmit Injected Animal Wastes to Tile Drains

Martin J. Shipitalo* and Frank Gibbs

ABSTRACT

Subsurface injection of animal manure is a best management practice (BMP) that reduces odors and promotes efficient nutrient usage. In tile-drained fields, however, injected wastes have been observed emerging from tile outlets shortly after application. This appears to be a particular concern in no-till fields where *Lumbricus terrestris* L. are often numerous. Our objective was to determine if burrows created by this earthworm species can contribute to rapid movement of injected wastes to tile drains. A turbine blower was used to force smoke into a 0.6 m-deep tile line in a no-till field and 20 burrows 0.02 to 0.5 m from the tile that emitted smoke, and 18 burrows 0.8 to 4.7 m from the tile that did not produce smoke were flagged. A Mariotte device filled with dyed water was then used to measure infiltration rate for each burrow. Afterwards, plastic replicas of the burrows were made so their proximity to the tile and geometrical properties could be determined. Average infiltration rate for smoke-emitting burrows (128 mL min^{-1}) was twice that of the more distant burrows. Moreover, dyed water was observed in the tile when added to smoke-emitting burrows, but not when added to burrows that did not produce smoke. Thus, earthworm burrows in close proximity to tile lines may expedite transmission of injected wastes offsite. Movement of injected wastes to tiles via earthworm burrows and other preferential flow paths may be reduced by using precision farming to avoid waste application near tile lines or by modifying application procedures.

Confined feeding operations for animal production generate large amounts of manure. Frequently these wastes are stored as slurries in aerobic or anaerobic lagoons and land-applied as a nutrient source for crop production. These liquid wastes can be applied on the soil surface or incorporated with tillage or by direct injection. Because of concerns with odor and nutrient losses in surface runoff, subsurface injection is currently advocated as a BMP in Ohio (Johnson and Eckert, 1995) and elsewhere (Hilborn, 1992). Injection is accomplished using either portable tanks or flexible hose systems with vertical knives or horizontal sweeps that introduce pressurized slurry 10 to 30 cm below ground. Proper installation and maintenance of surface and subsurface drainage systems reportedly reduce the potential losses of manure to streams (Johnson and Eckert, 1995). In Ohio, however, the NRCS and the Ohio Department of Natural Resources have received numerous reports of animal wastes being found in tile outlets and streams shortly after injection, with the problem more frequently observed in no-till than in tilled fields (Widman, 1998).

No-till soils often have more continuous macropores than tilled soils (Ehlers, 1975; Shipitalo and Protz, 1987; Drees et al., 1994; Pagliai et al., 1995), and this might contribute to the rapid movement of injected wastes to tile drains. Preferential flow in macropores has been shown to contribute to rapid movement of pesticides and nutrients to tile drains (Magesan et al., 1995; Kladivko et al., 1999). Cracks have also been implicated in the rapid movement of pesticides to tile lines (Harris et al., 1994) and may also play a similar role with injected animal wastes. In Ontario, movement of liquid animal wastes through soil cracks to tile drains has been identified as significant source of bacterial contamination leading to beach closure (Hilborn, 1992). In the incidents reported in Ohio, however, cracks were not visible nor did application rates exceed the water holding capacity of the soil (Widman, 1998), which could lead to saturated soil conditions and flow of effluent to the tile through the soil matrix porosity.

No-till soils, nevertheless, often have higher earthworm populations, hence more earthworm-formed macropores, than tilled soils. The increased populations are often attributed to the increased amount of surface residue that provides a greater supply of food as well as a cooler, wetter environment more favorable for earthworm survival (Edwards and Bohlen, 1996, p. 271). Applications of slurried animal wastes to soils can further increase the amount of food available to earthworms and have been shown to increase earthworm populations up to 53% (Curry, 1976) and lead to increased burrow numbers (Haraldsen et al., 1994). Lack of tillage can increase the persistence of earthworm burrows, which also increases the total number of earthworm-formed macropores in no-till soils. Furthermore, greater earthworm populations have been noted in tiled fields than in similar undrained fields (Carter et al., 1982), presumably due to improved soil aeration.

Earthworm-formed macropores can have a major influence on water and chemical movement in soil (McCoy et al., 1994; Shipitalo et al., 2000). Unlike cracks, which can close under wet soil conditions, earthworm burrows can continue to function as preferential flow paths (Friend and Chan, 1995). Moreover, studies conducted in Czechoslovakia suggest that earthworm burrows are more numerous in the backfill around tiles and can be hydraulically connected to the drain (Urbánek and Doležal, 1992). Macropores formed by the anecic, earthworm *L. terrestris* can have a particularly large impact on hydrology because of their relatively large diameter, up to 12 mm, and depth of penetration, up to 240 cm (Edwards and Bohlen, 1996, p. 198). Average infiltration rates for *L. terrestris* burrows in an undrained, no-till, corn (*Zea mays* L.) field in Coshocton, OH, ranged from 41 to 1005 mL min^{-1} burrow^{-1} (Shipitalo and Butt, 1999), whereas Wang et al. (1994) reported steady-state infiltration rates of 37 to 284 mL min^{-1} for *L. terrestris* burrows in a Wisconsin corn field. *Lumbricus terrestris* also appears to respond more favor-

M.J. Shipitalo, USDA-ARS, North Appalachian Experimental Watershed, P.O. Box 488, Coshocton, OH 43812-0488; and F. Gibbs, USDA-NRCS, Findlay, OH 45840. Received 29 Nov. 1999. *Corresponding author (shipitalo.1@osu.edu).

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Abbreviation: BMP, best management practice.

ably to a reduction in tillage frequency than other earthworm species (Edwards and Bohlen, 1996, p. 272).

Thus, no-till, slurry application, and tile drainage can increase earthworm populations and the number of earthworm-formed macropores. These macropores have been implicated in the rapid movement of nutrients and pesticides through soils and may play a role in the rapid movement of injected animal wastes to tile drains. Therefore, our objective was to determine if burrows formed by *L. terrestris* in a no-till, tile-drained field can contribute to the movement of injected animal wastes through the soil and if their effectiveness diminishes with distance from the tile. Furthermore, we investigated if earthworm populations, hence the number of burrows, varied with distance from the tile.

MATERIALS AND METHODS

A tile-drained field at a commercial swine (*Sus scrofa*) production facility near Bucyrus, Ohio, was selected for study. Plastic drain tile (10-cm diam.) was installed in this field by trench excavation ≈10 years ago at a depth of 0.6 m and spacing of 9 m. The field was in the fifth year of a 3 yr, corn–soybean [*Glycine max* (L.) Merr.]–wheat [*Triticum aestivum* L.] rotation. Mulch tillage with a straight-shank chisel was used in the spring of the corn years. The soybean and wheat crops were planted no-till. Anaerobic swine lagoon effluent (≈1% solids) was injected ≈20 cm deep once each year at a rate of 37 400 L ha^{-1}. Preliminary investigations by local NRCS and Crawford County Soil and Water Conservation District personnel indicated that swine lagoon effluent applied with either a flexible hose system or a tank wagon injection unit appeared in the tile outlet only a few minutes after the applicator passed over a tile line.

Field experiments were conducted 19 to 20 May 1999, shortly after soybean was planted. In the portion of the field investigated, the soil is Tiro silt loam 2 to 6% slope (fine-silty, mixed, mesic Aeric Epiaqualfs), a somewhat poorly drained soil formed in Wisconsinan glacial lake sediment with calcareous glacial till making up the lower portions of the solum. The permeability of the upper meter of this soil series ranges from 1.5 to 5.1 cm h^{-1}, and decreases to 0.15 to 1.5 cm h^{-1} in the next meter (Steiger et al., 1979).

In order to determine if earthworm burrows could have contributed to the rapid movement of injected effluent to the tile drains, a pit was opened to expose a short segment of tile that was subsequently severed. The upstream portion of the tile was connected to a gasoline engine-powered turbine blower constructed using a turbocharger salvaged from a transport truck (Fig. 1). After the blower was started, an ignited smoke cartridge (Smoke #3C, Superior Signal Company, Spotswood, NJ) that generates ≈1100 m^3 of smoke in 3 min was placed on the intake.[1] Twenty *L. terrestris* burrows with middens that emitted smoke at a distance of 12 to 25 m from the point of smoke introduction were flagged. An additional 18 *L. terrestris* burrows outside of the zone that produced smoke, but not beyond the midpoint between tile lines, were flagged. These burrows were in two transects perpendicular to the tile line that were 22 and 25 m from the point of smoke introduction.

Infiltration rates in individual flagged burrows were measured using the procedures and equipment described and de-

Fig. 1. Turbine blower used to force smoke into the tile line.

picted in Shipitalo and Butt (1999). Briefly, the middens were removed and an intake funnel with a flexible spout was firmly inserted into the burrow entrance. A Mariotte-type infiltrometer with a capacity of 6.8 L was used to maintain a constant head of water within the funnel. In order to distinguish which burrows contributed flow to the tile, water added to the smoke-emitting burrows contained Brilliant Blue FCF dye (Flury and Flühler, 1994), in the form of the commercial product Aquashade (Applied Biochemists, Milwaukee, WI), whereas fluorescein dye was used in the water added to the burrows that did not emit smoke. The water level in the infiltrometer was recorded every minute for the first 2 min then every 2 min thereafter for a total of 30 min, or until the water supply was exhausted. Immediately afterwards, dilute formalin (0.08 mol kg^{-1}) was injected into the burrow to expel the resident earthworm. Species, sexual condition, and fresh, live weights of all specimens were noted.

One day after measuring infiltration rates, commercial-grade fiberglass resin (no. 58020, U.S. Chemical & Plastics, Canton, OH) was poured into the burrows. After hardening, the burrows were excavated and burrow depth was obtained by measuring the distance from the base of the burrow to the soil surface. Burrow length was total length of the plastic replica, and volume was obtained by weighing the replicas and dividing by the density of the hardened resin. Average diameter was calculated based on burrow volume and length. The minimum distance between the tile line and the burrows was determined by measuring the closest approach of the plastic replicas to the buried tile as observed in the pits during burrow removal. In the case of the burrows that did not produce smoke, however, the buried tile was too distant to be observed in the pits during removal of the burrow replicas. Therefore, this parameter was taken as the shortest distance from the entrance of the burrow to the tile at the soil surface.

[1] Names are necessary to report factually on available data; however, the USDA neither guarantees nor warrants the standard of the product, and the use of the name by USDA implies no approval of the product to the exclusion of others that may also be suitable.

Fig. 2. Smoke emerging from middens in an ≈1 m wide band above the buried tile.

Earthworm populations were measured in five locations in each of two transects perpendicular to the tile line that were 19 and 20 m from the point of smoke introduction. Earthworms were extracted from the soil by slowly sprinkling 8 L of dilute formalin (0.08 mol kg^{-1}) on the soil surface inside 0.5 by 0.5 m quadrats (Baker and Lee, 1993). The first quadrat was adjacent to the tile line and subsequent quadrant were spaced in 1.2-m intervals. A composite fresh, live weight was obtained for all specimens from individual quadrat and the samples were then preserved in formalin prior to species identification.

Data analysis was performed using the Statistical Analysis System (SAS Institute, 1989), with a 0.05 probability level selected as the minimum acceptable for all comparisons.

RESULTS AND DISCUSSION

General Observations

Blowing smoke into the tile was a very effective means of delineating the position of the buried line and associated *L. terrestris* burrows. Smoke was observed emerging from burrow middens in a band about 1 m wide by 35 m long, the presumed end of the tile (Fig. 2). The rate at which smoke was emitted from individual burrows was highly variable, but this was not quantified. Given the short length of time available to mark the burrows (3 min) it was impossible to determine the percentage of burrows within the 1-m-wide band that were emitting smoke. Regardless, many more burrows were observed emitting smoke than were flagged, and only burrows ≥30 cm apart were selected for further investigation. The entrances of many of the smoke-emitting burrows were beyond the approximately 20-cm-wide zone of soil disturbed by tile installation about 10 years earlier.

The fact that smoke emerged from the burrows indicates that they provided a pathway for the movement of air from the tile to the soil surface. Our original plan was to conduct the experiment when the tile line was flowing to determine if dyed water introduced to burrows with the infiltrometer would be carried to the tile outlet, indicating a direct pathway for the movement of water from individual burrows to the tile. Due to a dry spring season, however, the tile was no longer discharging at the time the experiment was conducted. Nevertheless, we began our infiltration tests with the smoke-emitting burrow closest to the outlet (12.4 m), and continued progressively upstream from the outlet. Fourteen minutes after beginning the infiltration test on the second burrow from the outlet (12.6 m), and after a total of only 9.3 L of water had been added to the burrows, Brilliant Blue-dyed water began to emerge from the outlet. Given the distance of the burrows from the outlet, a substantial portion of the dyed water must have entered the tile. Moreover, the permeability rating of the Tiro series (Steiger et al., 1979) suggests it should have taken 12 to 40 h for the water to reach the tile.

We continued to observe dyed water emerging from the outlet during the remainder of the infiltration tests on the smoke-emitting burrows, with the flow rate apparently fluctuating with the infiltration rate in the burrows. It was impossible, however, to confirm if each of the 20 smoke-emitting burrows contributed to the flow in the tile. Next, infiltration tests with fluorescein-dyed water were conducted on the 18 burrows 0.8 to 4.7 m from the tile that did not produce smoke. The tile ceased flowing and no dyed water was observed, indicating that none of this water migrated to the tile line through these macropores.

Live earthworms were expelled from 42% (16 of 38) of the burrows following completion of the infiltration tests. Only one earthworm was retrieved per burrow, all were *L. terrestris*, and 81% were clitellate adults. In eight other instances a dead *L. terrestris* was found blocking the penetration of the resin upon excavation of the impregnated burrows. This combined with entrapment of air and blockage by debris contributed to a success rate of 45% for making complete plastic replicas of the burrows. This was somewhat lower than the 60% success rate reported when Shipitalo and Butt (1999) used this technique, but was substantially higher than the 20% rate reported by McKenzie and Dexter (1993) when using a grid system and excavation to determine the geometrical properties of earthworm burrows.

Most of the burrows were single, nearly vertical channels, but three of the smoke-emitting burrows were Y-shaped with secondary channels intersecting the main channels at depths of 31 to 69 cm. Similarly, at the two sites investigated by Shipitalo and Butt (1999), an average of 5% of the *L. terrestris* were Y-shaped (see their Fig. 3 for a photograph of typical burrow types). The auxiliary channels were included when the geometrical properties of the burrows were determined and contributed to the greater length and significantly greater volume of the smoke-emitting burrows compared to those that did not produce smoke (Table 1). Presumably the entire length and volume of the combined channels would have contributed to the measured infiltration rates. Depth, average diameter, and weight of the resident earthworm were similar among burrows that did and did not emit smoke (Table 1).

Infiltration Capacity and Rate

Cumulative infiltration was highly variable, but the mean was twice as high for smoke-emitting burrows

Table 1. Infiltration and general characteristics of the burrows.

	Cumulative Infiltration	Infiltration rate 2 min	Infiltration rate Final	Infiltration rate Avg.†	Worm weight	Burrow Depth	Burrow Length	Burrow Volume	Burrow Avg. Diam.
	mL	mL min^{-1}	mL min^{-1}	mL min^{-1}	g	cm	cm	cm^3	mm
					Smoke-emitting				
Mean	3541**	158	109*	128**	4.9	84	110	47*	7.5
Range	888–6736	38–416	0–302	30–353	2.6–6.6	63–95	73–188	30–65	6.4–8.6
					No smoke				
Mean	1714	97	52	62	5.0	78	89	30	6.5
Range	189–6653	8–397	4–199	6–256	4.4–5.9	64–92	83–100	22–44	5.7–8.1

*, **, Smoke-emitting means significantly different from no smoke means at $P = 0.05$ and 0.01 levels, respectively.
† Based on actual length of infiltration measurement when <30 min.

than that for those further distance from the tile that did not produce smoke (Table 1). The volume of the infiltrometer (6.8 L), however, was insufficient to supply three of the smoke-emitting and one of the burrows that didn't produce smoke for the full 30 min, with the dyed water being exhausted in as little as 19 min. Therefore, 2-min, final, and average infiltration rates were calculated in order to compare the infiltration characteristics of the two burrow types. The 2-min reading represents the first measurement of infiltration rate since the 1-min reading included the volume required to initially fill the burrow and intake funnel. The final infiltration rate was calculated using the last reading taken for each burrow. Similarly, average infiltration rate was based on the actual length of the infiltration measurement for each burrow when <30 min.

All three measures of infiltration rate were higher for the smoke-emitting burrows than for those that did not produce smoke (Table 1). Although the mean 2-min rate for the smoke-emitting burrows was 1.6 times that of the burrows that did not produce smoke, the means were not significantly different. Mean infiltration rate, however, declined more rapidly from the 2-min to the final reading for burrows that did not emit smoke (46% decrease) than for those that did (31% decrease). This resulted in mean final and average rates for the smoke-emitting burrows that were more than twice that of the burrows that did not produce smoke (Table 1). Regression analysis for individual burrows indicated that infiltration rate declined significantly with time in most instances (26 of 38). No relationship of infiltration rate to time was detected for the remaining 12 burrows.

In general, the geometrical properties of the burrows were poor predictors of their infiltration characteristics as was also the case in the study of Shipitalo and Butt (1999). The only significant correlations noted were for the 2-min infiltration rate with burrow length and volume (Table 2). The weight of the worm that occupied the burrow was also a poor indicator of infiltration rate (Table 2). In contrast, distance from the tile line was highly related to infiltration rate (Fig 3).

Average infiltration rate for individual burrows declined rapidly with distance from the tile line. This rapid decline was mainly attributable to a rapid decrease in infiltration rate for the smoke-emitting burrows, as infiltration rate for the burrows that did not produce smoke varied little (Fig. 3). Thus, production of smoke, although it indicated linkage of the burrow to the tile line, was not a quantitative measure of how closely the burrows were associated with the tile and was not a good predictor of infiltration rate.

The plastic replicas of the burrows revealed that none of the earthworms entered the openings in the tile, but they burrowed as close as 2 cm from the tile (Fig. 3 and

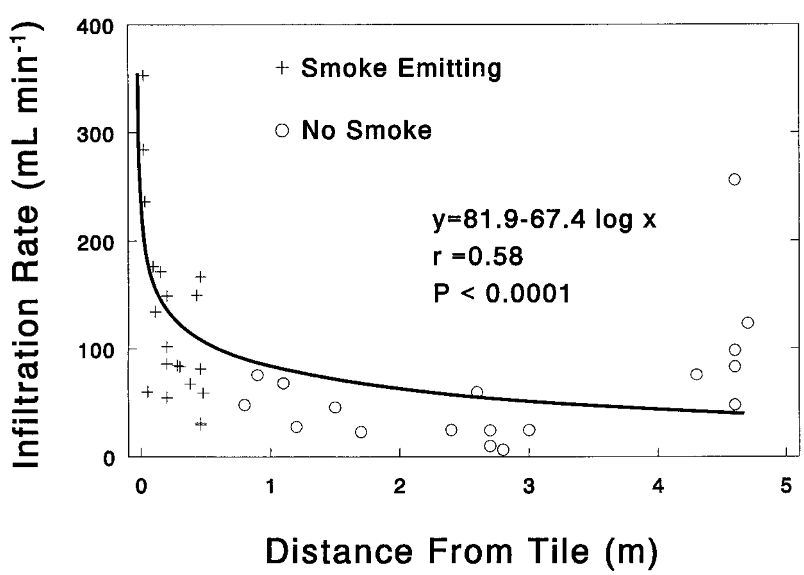

Fig. 3. Average infiltration rate in individual earthworm burrows as a function of distance from the buried tile.

Table 2. Correlation (Pearson's *r*) of infiltration rates with burrow geometrical properties and worm weight.

Variable	Burrow Depth	Burrow Length	Burrow Volume	Burrow Avg. Diam.	Worm weight
Infiltration rate (2 min)	0.12	0.53*	0.49*	0.10	−0.19
Infiltration rate (Final)	−0.09	0.20	0.42	0.35	−0.07
Infiltration rate (Average)	−0.01	0.27	0.48	0.36	−0.10
n	18	18	17	17	16

* Correlation coefficient significant at $P = 0.05$.

4). Therefore, smoke blown into the tile and dyed water used in the burrow infiltration tests must have passed through a portion of the soil matrix porosity. In the case of the dyed water even a short distance of travel through the matrix porosity was sufficient to substantially reduce infiltration rate. One of the burrows at the midpoint between tile lines (4.6 m), however, had an average infiltration rate (256 mL min^{-1}), that was similar to those for burrows nearest the tile that produced smoke (Fig. 3). The plastic replica of this burrow was incomplete because it terminated in a mass of resin-impregnated soil. Excavation of this burrow also revealed that the subsoil in this area was coarser-textured, and gleyed colors were less evident than the soil surrounding the other burrows. This may have been the result of previous disturbance of the soil by burrowing rodents as has been reported by Bouma et al. (1982) and Shipitalo and Butt (1999), or a sedimentological feature. Sand lenses at the contact of the lake deposits with the glacial till have been noted in the Tiro series (Stieger et al., 1979).

Earthworm Populations

There were no detectable trends in earthworm abundance or biomass with distance from the tile line (Table 3). The mean population of 50 earthworms m^{-2} was on the low side of that typically reported for arable fields (Edwards and Bohlen, 1996, p. 96) and the numbers measured by Kladivko et al. (1997) in no-till fields in Indiana and Illinois with soils similar to the Tiro soil we investigated. This may have been related to the dry spring conditions we previously noted. Bohlen et al. (1995) found that measured earthworm populations can decline dramatically in response to drought conditions.

The distribution of *L. terrestris* closely followed that of the total population and their numbers were not influenced by the presence of the tile line (Table 3). Thus, it is unlikely that the number of macropores formed by this earthworm would vary with distance from the tile. *Lumbricus terrestris* comprised an average of 82% of the total earthworm population, and 78% of the specimens were juveniles. The relatively high proportion of *L. terrestris* in the population may have been an artifact of the sampling method or due to the fact that it is more drought-tolerant than other species (Bohlen et al., 1995). Formalin reportedly does not extract all species equally and is most effective on species with wide and deep burrows, such as *L. terrestris* (Baker and Lee, 1993; Edwards and Bohlen, 1996, p. 93). Nevertheless, formalin extraction is useful for comparing relative abundances and is more efficient in no-till than in plowed soils (Baker and Lee, 1993).

Fig. 4. Earthworm burrow closely associated with the buried tile. This burrow approached within 3 cm of the tile and had an average infiltration rate of 236 mL min^{-1}.

SUMMARY AND CONCLUSIONS

Our results indicate that some *L. terrestris* burrows rapidly transmitted water to the buried tile. The rate at which water entered the burrows declined with the log of their distance from the drain tile. Beyond a distance of about 0.5 m, the tile had no apparent effect on the infiltration rate in the burrows, and water added to

Table 3. Total earthworm population, number of *L. terrestris*, and total earthworm biomass as a function of distance from the tile drain as measured in two transects using 0.5 × 0.5 m quadrats.†

	Distance from tile line (m) 0–0.5	1.2–1.7	2.4–2.9	3.6–4.1	4.8–5.3	Avg.
	Total earthworm population (no. m^{-2})					
Transect 1	72	16	100	44	24	51
Transect 2	72	44	68	28	36	50
Mean	72	30	84	36	30	50
	L. terrestris (no. m^{-2})					
Transect 1	64	12	76	32	24	42
Transect 2	56	32	56	28	32	41
Mean	60	22	66	30	28	41
	Total earthworm biomass (g m^{-2})					
Transect 1	130	24	120	85	61	84
Transect 2	88	83	93	38	93	79
Mean	109	54	107	62	77	82

† No significant differences in means among distances detected at $P = 0.05$.

these burrows did not enter the drain, although the geometrical properties of these burrows were similar to those closer to the tile. Furthermore, the number of earthworms, hence the potential number of earthworm-formed macropores, was not affected by distance from the tile line. The infiltration characteristics of the burrows were poorly correlated to the geometrical properties of the burrows, thus models of infiltration based on these characteristics without taking into account distance to the tile would not accurately predict intake of injected animal manure. Models that simulate the fate of injected animal manure could be improved, however, by incorporating a macropore flow component (Bakhsh et al., 1999).

The infiltration tests were conducted without regard to whether earthworms occupied the burrows, although in most cases (24 of 38) we were able to confirm that a single *L. terrestris* occupied each burrow. Earthworms would probably be present in most burrows when animal manure is injected, therefore these conditions simulate those likely to occur during waste application. Regardless, Shipitalo and Butt (1999) demonstrated that the presence of a live *L. terrestris* had no significant effect on infiltration in their burrows.

It is uncertain how much injected manure can be transmitted to buried tile in *L. terrestris* burrows, or if these are the only type of macropore that contributed to the rapid movement of injected swine lagoon effluent to the tile observed during actual field operations. The highest average infiltration rate we measured for a single burrow was 353 mL min^{-1}. Even at this rate the amount of effluent transmitted to the tile during the short time an injector is in contact with a single burrow would probably be quite small. Nevertheless, since the effluent is injected under pressure the infiltration rates might be much higher, and with an average of 41 *L. terrestris* m^{-2}, the aggregate effect of their burrows may be substantial. Even if the amount of animal waste directly transmitted to the tile might be small in terms of the total application and of no agronomic consequence, their potential to contribute to microbial contamination of surface water might be high enough to be of concern. Furthermore, these burrows might also contribute to rapid movement of pesticides and nutrients to the tile drain when these materials are applied in the vicinity of the tile.

The fact that direct transfer of water from *L. terrestris* burrows to the tile was limited, in this instance, to 0.5 m either side of the tile, suggests several potential solutions that warrant further investigation. If the position of tile lines can be accurately determined, the techniques of precision agriculture might be used to avoid waste application in the immediate vicinity of the tile. This might not be practical in many locations, however, given the layout and spacing of the tile lines relative to the size of the injection equipment. Additionally, this would result in untreated zones in the field that might have lower fertility levels and crop yields. Tillage might also be used to disrupt the burrows in the zone above the tile prior to waste application, and is recommended in Ontario prior to application of liquid wastes to soils with visible cracks (Hilborn, 1992). Tillage has been shown to reduce pesticide losses in tile (Rothstein et al., 1996) and mole drains (Brown et al., 1999). Disruption of the soil, however, would eliminate the benefits of no-till in this zone and would probably reduce the effectiveness of the tile in removing excess water from the field (Patni et al., 1996). Another alternative would be to use shut-off valves to inhibit flow from the tile lines when animal manure is being injected for a long enough period to allow any wastes that enter the tile sufficient time to reenter the soil. This remedy is currently being used in Ohio with cost sharing available through the Ohio Department of Natural Resources. Catch basins could also be installed so that effluent that enters the tile could be collected and reinjected. These techniques should be useful even if macropores other than those formed by *L. terrestris* contribute to rapid movement of injected wastes to tile lines.

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Biomass and Residue Cover Relationships of Fresh and Decomposing Small Grain Residue

J. L. Steiner,* H. H. Schomberg, P. W. Unger, and J. Cresap

ABSTRACT

Maintaining residue cover provides diverse conservation benefits. Exponential relationships have been developed to estimate cover from biomass of randomly distributed, flat residues, but a large portion of crop biomass remains standing after harvest. Our objective was to determine how relationships between biomass and soil cover change in no-tillage small grain fields as residues decompose and shift from standing to flat. Winter and spring wheat (*Triticum aestivum* L.), winter barley (*Hordeum vulgare* L.), and spring oat (*Avena sativa* L.) were grown at Bushland, TX, on Pullman clay loam (fine, mixed thermic Torrertic Paleustoll) in 12 field plots in three randomized complete blocks. For each crop, differential seeding rate, fertilization, and irrigation produced a range of biomass. During decomposition, differential irrigation increased environmental variability (13, 5, and 0 applications to sub-sub-plots). Ash-free residue biomass was measured seven times in 14 mo, after taking photographs to determine soil cover of 1-m^2 sites. For crop-date combinations, coefficients were determined from total (k_t, m^2 g^{-1}) or flat (k_f, m^2 g^{-1}) biomass. Regression indicated k_t increased with time ($P < 0.0001$ for all crops, except spring wheat with $P < 0.0041$). Across crops, the relationship $k_t = 0.0037 + 0.000047 \cdot DAH$ ($r^2 = 0.54$, $P < 0.0001$) indicated that decomposition affects cover provided by total biomass. Across crops, the weak relationship $k_f = 0.0136 + 0.000023 \cdot DAH$ ($r^2 = 0.17$, $P < 0.016$) indicated that cover could be estimated from flat biomass with $k_f \approx 0.0175$ for extended periods. These findings can improve estimation of residue cover for no-tillage fields and indicate that residue orientation should be considered in biomass-to-cover relationships.

J.L. Steiner and H.H. Schomberg, USDA-ARS, 1420 Experiment Station Road, Watkinsville, GA 30677; P.W. Unger and J. Cresap, USDA-ARS, P.O. Drawer 10, Bushland, TX 79012. Received 14 May 1999. *Corresponding author (jsteiner@arches.uga.edu).

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Conservation tillage systems are adopted for a wide variety of reasons, including decreased production costs, decreased labor, and resource conservation. Many natural resource conservation benefits are attained by retaining increased crop residue cover over longer periods of time, including increased infiltration, reduced evaporation, and reduced soil erosion in the short term as well as long-term enhancements in soil organic matter and structure (Steiner, 1994).

Maintaining surface residue cover is often recommended to reduce erosion by water and wind. Residues contribute to erosion control both through sheltering the soil with a nonerodible material (cover) or through changing the surface conformation in ways that change the flow of water and wind across the surface (roughness or resistence). Both aspects are important for both wind and water erosion. The fraction of soil covered by crop residue also influences raindrop impact on soil surface properties (aggregation, crusting, etc.) and on the surface aerodynamic properties (Hagen, 1991). The processes of wind and water erosion are interactive—changes in soil or residue surface properties by either wind or water impacts the erodibility of that surface when exposed to future wind or water erosive forces.

In spite of this complexity, where erosion is primarily by water, the required amount of residue has been based on surface cover (with 30% cover required after planting

Abbreviations: DAH, days after harvest; k_f, flat biomass cover coefficient (m^2 g^{-1}); k_t, total biomass cover coefficient (m^2 g^{-1}); M, residue biomass (g m^{-2}).

EXHIBIT 15

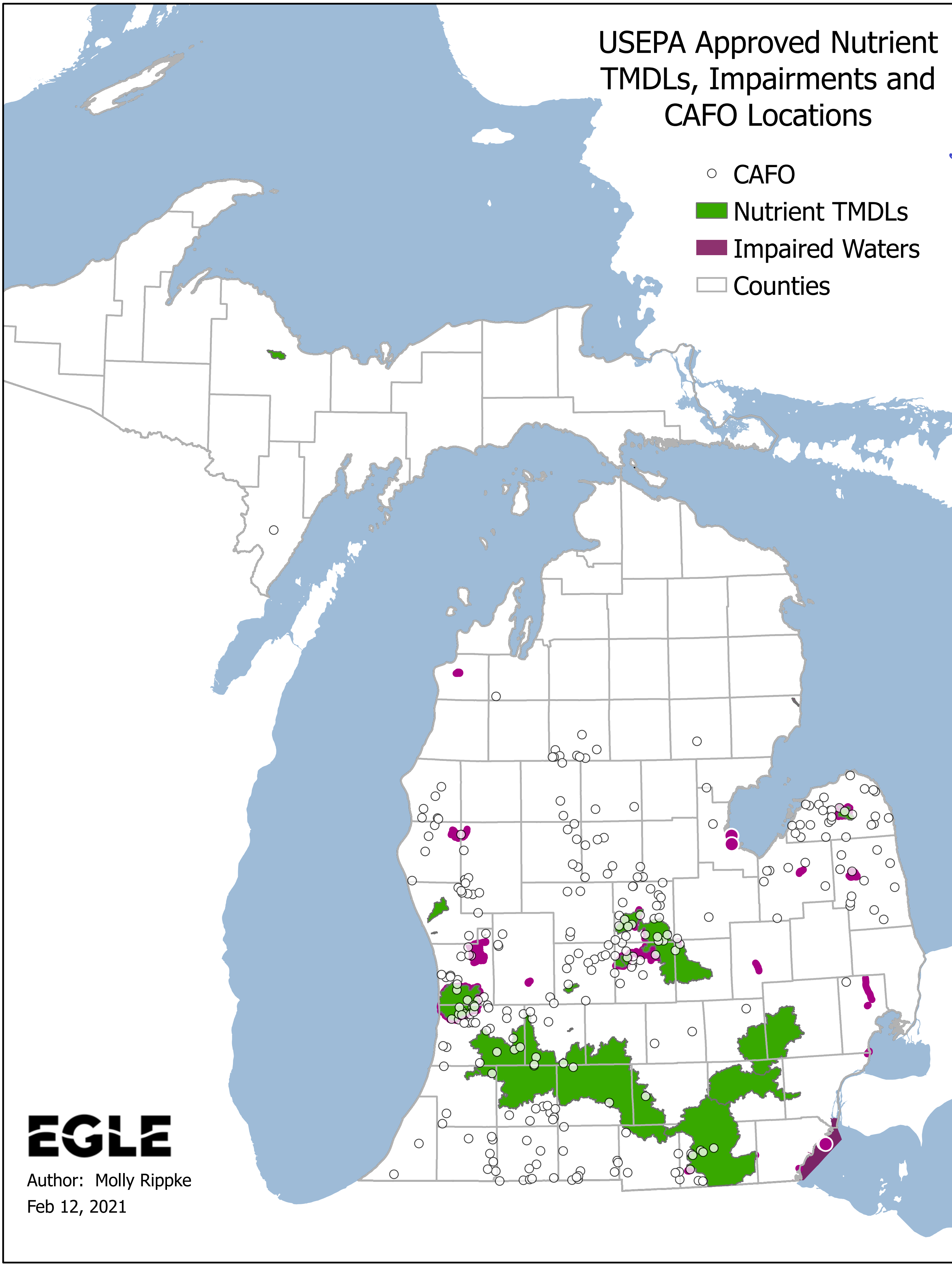

USEPA Approved Nutrient TMDLs, Impairments and CAFO Locations
CAFO
Nutrient TMDLs
Impaired Waters
Counties
EGLE
Author: Molly Rippke
Feb 12, 2021

EXHIBIT 16

Testimony Excerpt of EGLE Environmental Quality Specialist; Sarah Holden

STATE OF MICHIGAN

MICHIGAN ADMINISTRATION HEARING SYSTEM

In the matter of:	Docket No.:	20-009773
Petition of Michigan Farm Bureau; Michigan Milk Producers Association; Michigan Allied Poultry Industries; Foremost Farms USA; Michigan Pork Producers Association; Dairy Farmers of America; Select Milk Producers, Inc.; and 126 Identified Livestock Farms /	Permit No.:	MIG010000
	Part:	Part 31, Water Resources Protection
	Agency:	Department of Environment, Great Lakes and Energy
	Case Type:	Water Resources Division

HEARING - VOLUME NO. VI

BEFORE DANIEL PULTER, ADMINISTRATIVE LAW JUDGE

Via Microsoft Teams Meeting

Monday, December 13, 2021, 9:00 a.m.

APPEARANCES:

For the Petitioners:
MR. ZACHARY CHAD LARSEN (P72189)
MR. MICHAEL JOHN PATTWELL (P72419)
Clark Hill, PLC
212 East Cesar E. Chavez Avenue
Lansing, Michigan 48906
(517) 318-3053

For the Respondent:
MS. ELIZABETH ANNE MORRISSEAU (P81899)
MS. JENNIFER A. ROSA (P58226)
Assistant Attorneys General
Department of Attorney General
525 West Ottawa Street
G. Mennen Building, 6th Floor
Lansing, Michigan 48933
(517) 373-7540

Q Based on your education, training, and experience, do you have an opinion about whether CAFOs contribute to phosphorus pollution in Michigan?

A Yes.

Q What is that opinion?

A CAFOs contribute to phosphorus pollution in Michigan. Animals in CAFOs general a large amount of waste in a small area. That waste contains a large amount of nutrients. Spreading animal waste on agricultural fields can contribute to the amount of nutrients moving from fields to surface water when conditions exist that prevent absorption of the nutrients into the soil.

Q Are you familiar with the 2051 CAFO General Permit?

A Yes, I am generally familiar with the 2015 CAFO General Permit, but I could not recite details from the document.

Q Based upon your education, experience, and expertise in water quality, do you believe the 2015 CAFO General Permit is sufficient to control nutrient pollution from CAFOs?

A No.

Q Why not?

A The 2015 CAFO General Permit was part of the first steps of working to reduce pollution from land-based agricultural sources of pollution and does not contain best practices that we now know reduce pollution runoff from farm fields. We also know that primary productivity is expected to

increase in lakes and streams due to higher temperatures and increased storm frequency and intensity resulting from climate change. Significant advances in pollution reduction will be required to maintain or reduce the current level of productivity in Michigan surface waters. To protect the value of our aquatic systems in the next 50 years, we will need additional reductions in nutrient inputs from agricultural and urban land uses. This will likely include adding nutrient reduction measures to NPDES facilities.

Q Based upon your education, experience, and expertise in water quality, do you believe the 2020 CAFO General Permit is sufficient to control nutrient pollution from CAFOs?

A **It is a step in the right direction, but may not be sufficient to control nutrient pollution as technology improves and water quality protection needs to be increased in the future. The 2020 CAFO General Permit is similar to other types of permits that have had additional requirements added to their permits when a new permit is issued in order to reduce nutrient pollution. For example, we know that the appropriate soil concentration of phosphorus that maximizes crop productivity and prevents nutrient runoff needs to be reduced. These reduced concentrations need to be determined for future permits. As technology improves and our understanding of how nutrients move from fields to surface waters becomes more detailed, additional treatment**

JUDGE PULTER: Sure.
MS. ROSA: Great. Thank you.
JUDGE PULTER: Let's come back at 3:40.
(Off the record)
JUDGE PULTER: Let's go back on the record. Ms. Rosa?
MS. ROSA: Thank you, your Honor. Good afternoon, Ms. Holden.

REDIRECT EXAMINATION

BY MS. ROSA:
Q Mr. Pattwell on cross-examination talked about CAFOs, that there was a lack of CAFOs in a particular TMDL area of the nutrient TMDL map. Do you remember that conversation?
A Yes.
Q And is there -- do you need to make any clarification about that discussion?
A I was just going to add that the areas where we don't have nutrient TMDLs may be areas that we have not done assessments to make a decision on nutrient impairment or not. We -- because we don't have numeric nutrient criteria focusing on making nutrient water quality standard attainment is more complicated and we've been more recently developing our assessment methodology to make those -- more of those determinations around the state. And so in the future we will likely have more TMDL watersheds as we begin

conducting or developing TMDLs for the impairments that we identify.

Q Mr. Pattwell also asked you a lot of questions stating facts that you did not have the answers to or your responses were "I don't know." Why is that?

A **I didn't necessarily really know the source of the information or they were topics that I don't have detailed information on so I don't know. I just didn't know.**

Q So do you know if any of the things that he was saying was true?

MR. PATTWELL: Objection; over broad.

JUDGE PULTER: Overruled. Go ahead.

A **Nothing -- I'm not aware of anything that was incorrect, but I wouldn't be able to identify necessarily if something was correct or not.**

Q And in the beginning of your testimony there were questions about your expertise. Do you have to know about soil science or geology or groundwater flow in order to understand impacts to aquatic biology?

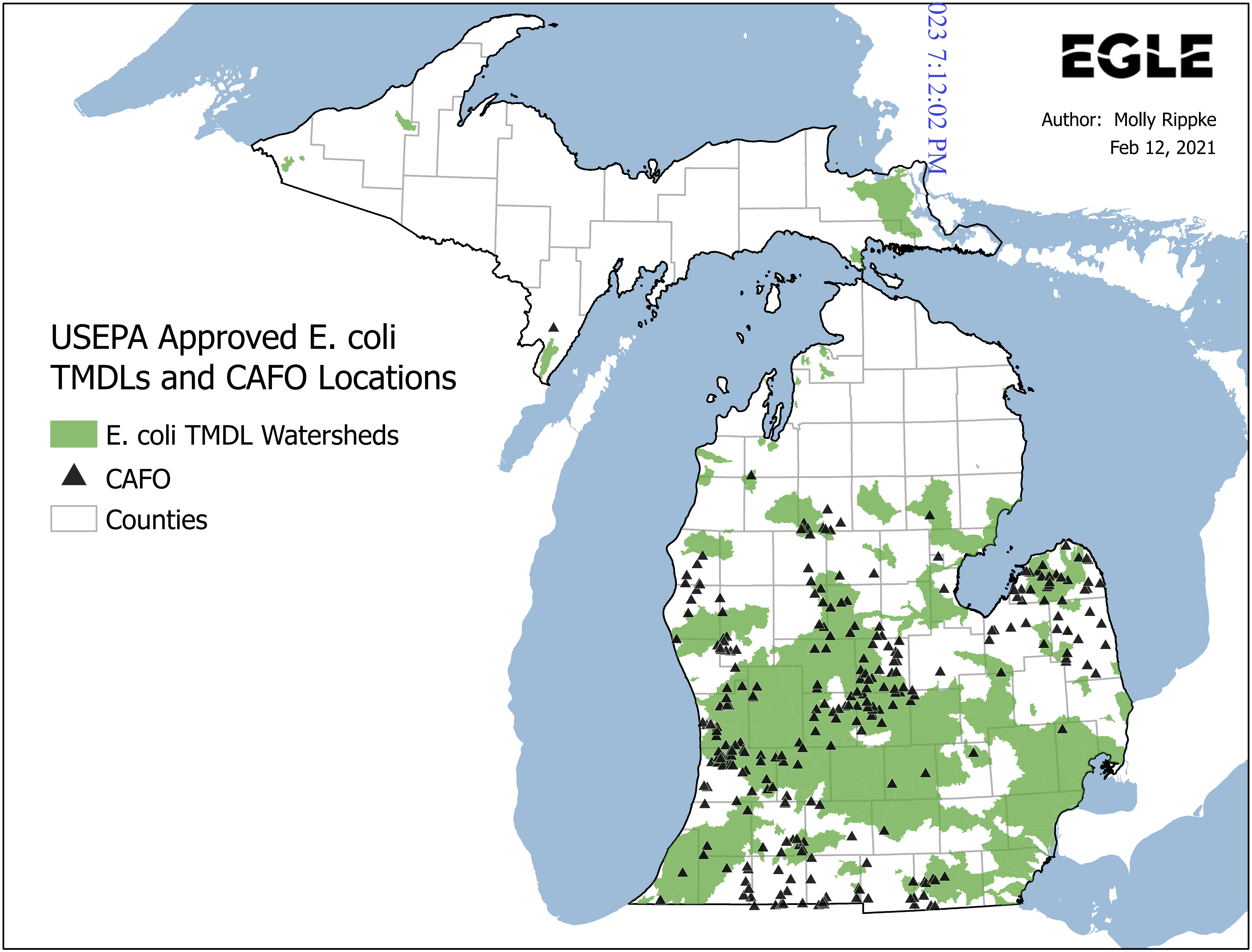
A **Some general knowledge, yes.**

Q And do you have that general knowledge?

A **Yes.**

Q Specifically referring you to the CSO reports that Mr. Pattwell was referring to -- you to, I won't ask you to read parts of them because that can be addressed on briefing.

EXHIBIT 17

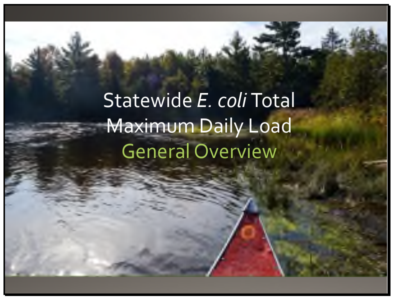


USEPA Approved E. coli
TMDLs and CAFO Locations
E. coli TMDL Watersheds
CAFO
Counties
EGLE
Author: Molly Rippke
Feb 12, 2021

Feb 4, 2021

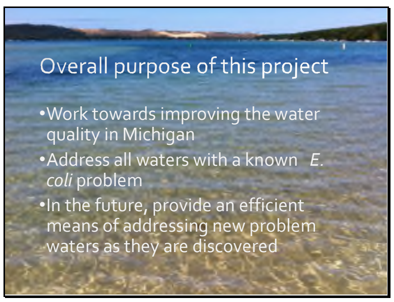
EXHIBIT 18

Slide 1



My name is Molly Rippke,
I am with the Department of Environmental Quality, Water Resources Division
And I am hear today via webinar to give you a general overview of the statewide E. coli TMDL and online mapping system.

Slide 2



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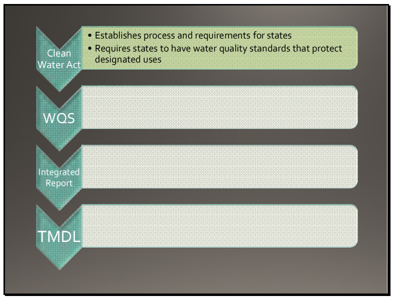
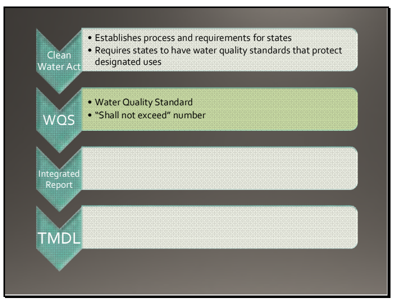


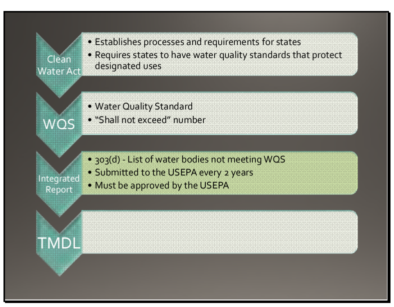
First we have the federal clean water act which….
Designated uses are the ways in which the SOM has decided that it wants to USE its water or why we want to protect it (eg. Total body recreation - Swimming)

Slide 5



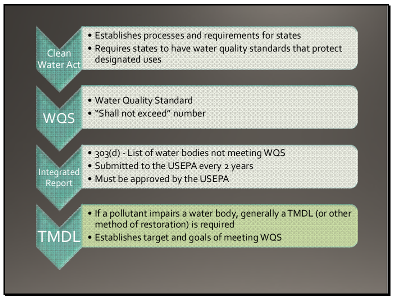
States then come up with water quality standards to protect water. These are often concentrations of pollutants that we aren't supposed to exceed

Slide 6



When the WQS aren't being met, we are required to notify the USEPA and the public of that.
We do this through the Section 303(d) and 305(b) lists (spelled out in the Clean water act)
Submitted to the USEPA and public noticed for comment every two years in the form of the "integrated report"

Slide 7



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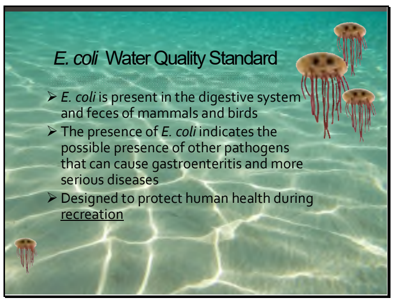
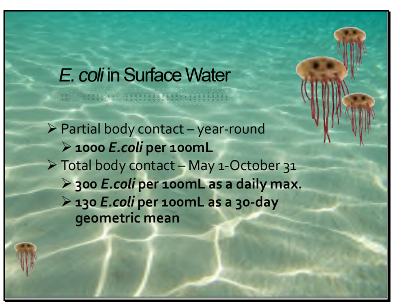


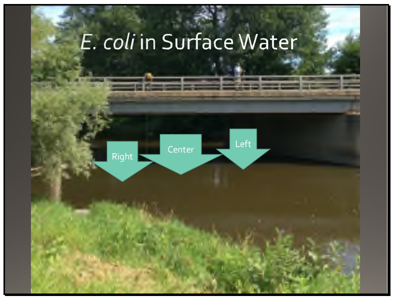
Michigan uses E. coli as an indicator of all fecal pollution

Slide 9



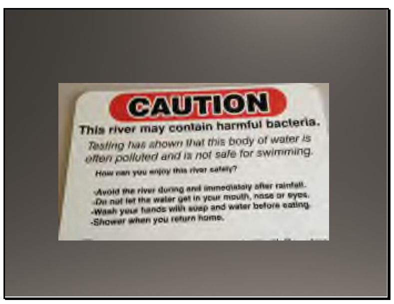
Target is equal to the WQS

Slide 10



A quick summary of how we sample for E. coli.
If you want the DEQ to compare the E. coli results with the E. coli Water Quality Standard,
We use three samples per site, which is written into our rules.
These should be taken in locations that represent the waterbody fairly.
Generally we divide the river up like you see here, and we call these are called 'left, center, and right'. Avoiding the stagnant edges.
We then calculate the geometric mean of those three results
Then we compare to the daily standard

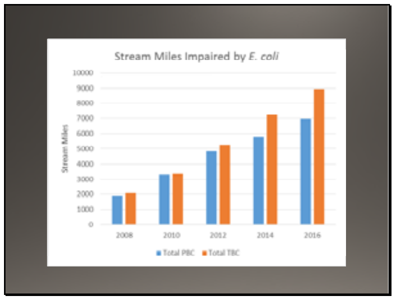
Slide 11



The MDEQ estimates that approximately 50 percent of our rivers and streams are not meeting the Michigan's WQS for *E. coli* bacteria and rough 20 percent of monitored beaches have had closures due to bacterial pollution.

While the MDEQ does do some testing and determines if the designated uses are being met,
In Michigan, it is the local health departments responsibility to post a warning if they feel it is warranted.
This is written in Michigan laws and regulations.

Slide 12

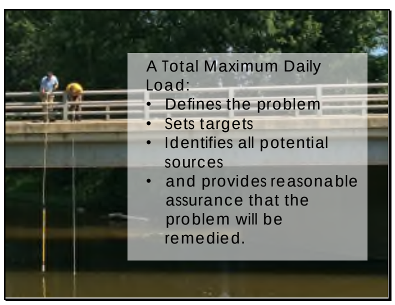


This is a chart showing the number of waterbodies (by year) that are listed in the IR as impaired by E. coli (either having a TMDL or needing one).
In 2016 we had 4,500 miles needing a TMDL, and 9,000 that if you include waters that already have a TMDL.

The increase over the years is NOT because of worsening water quality as far as we know. But every year we monitor waters that have never been monitored before and find new problems.

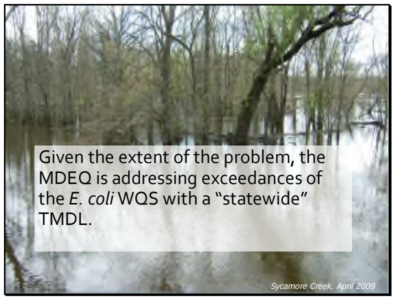
We have only assessed 11% of our river miles.
And we estimate that about half of our river miles will be listed as impaired

Slide 13



So, we have 4,500 stream miles that need a TMDL.
What is a TMDL? It is a document that

Slide 14



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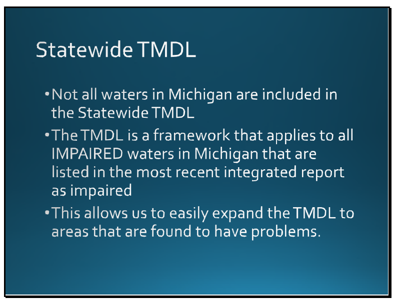

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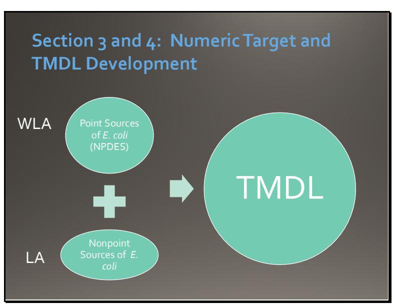
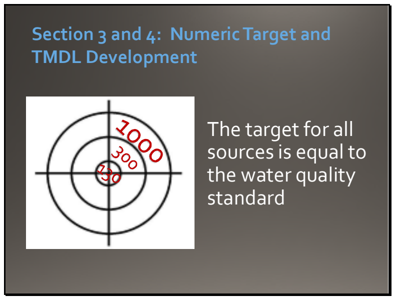


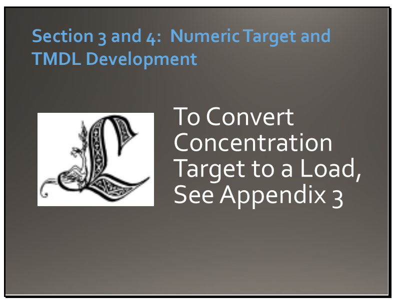
A TMDL is the sum of all pollution that can go into a waterbody, and still have it meet the standards
A TMDL is a TARGET we should achieve
There are two parts here, the waste load allocation and the load allocation. Illegal sources get an allocation of zero.
The WLA is for point sources, or National Pollutant Discharge Elimination System Permits.
The LA is for non NPDES sources, or "nonpoint sources"
Sections 3 and 4 of the TMDL discuss the target and the allocations.

Slide 17



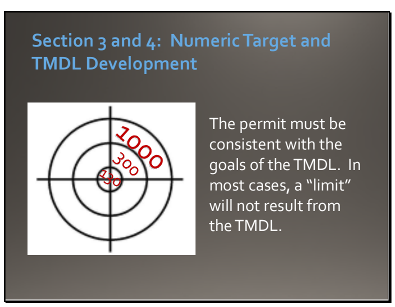
Our target is not a load in this TMDL. We use a concentration based target (not a load) because it is easier to understand, communicate, and measure.

Slide 18



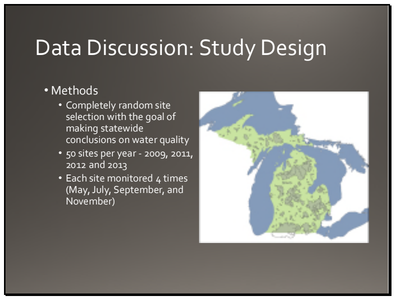
If you are interested in a load based target rather than a concentration, please see appendix 3.

Slide 19



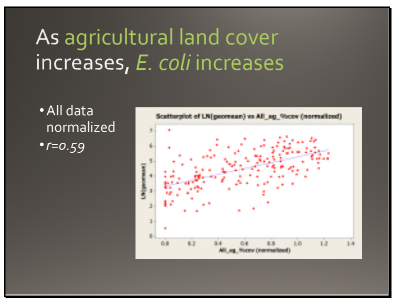
The permit must be consistent with the goals of the TMDL. But in most cases, a "limit" will not result from the TMDL. Please keep in mind that WWTPs already have a limit, and generally discharge permits contain language that prohibits the discharge from causing an exceedance of the WQS.
However, permit specific language may be added to the permits in a TMDL to meet the goal of the TMDL.

Slide 20



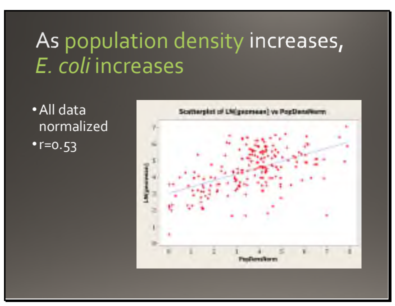
To support the conclusions of this TMDL, an analysis of existing data was conducted.
We looked at the characteristics of the watershed above each site and the e. coli data to draw conclusions.

Slide 21



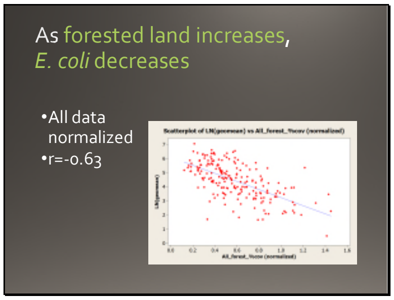
All these were statistically significant relationships.
E. Coli is on the vertical axis, and landcover is on the horizontal axis.
Reminder that correlation does not equal causation
Livestock may not be the only issue
Could be septic systems!

Slide 22



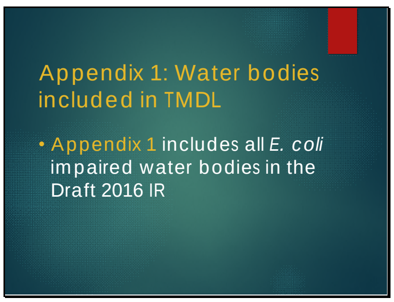
More people equal more septic systems, more illicit connections, more pets, nuisance wildlife

Slide 23



This was the strongest correlation that we found.
As forested land increases, *E. coli* decreases.

Slide 24



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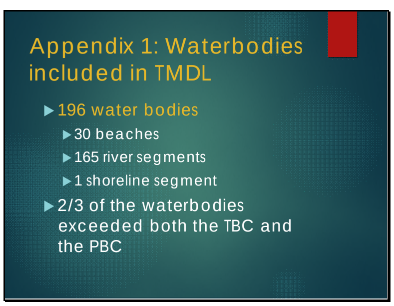

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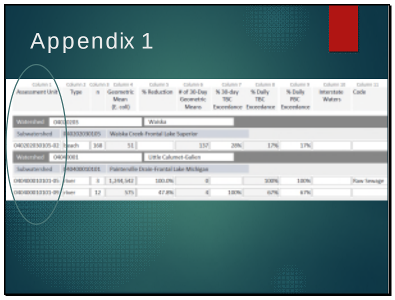
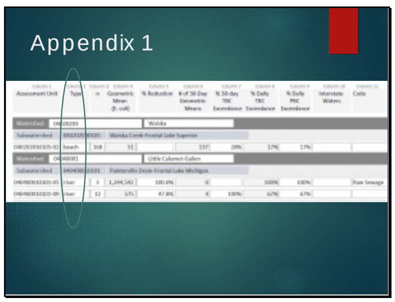


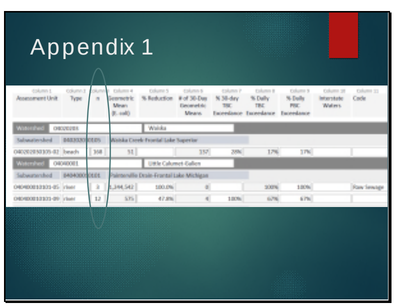
Assessment Unit Identifier (AUID) is a unique identifier
Based on subwatershed number (12-digit hydrologic unit code)
This number will allow you to look up the water body in the Integrated Report

Slide 27



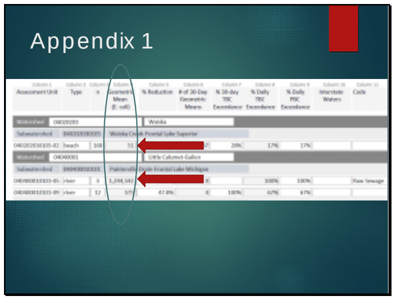
Each waterbody is marked as a river segment, beach, lake, etc.

Slide 28



Total number of daily geometric means in the water body.
Could be one or more sites combined

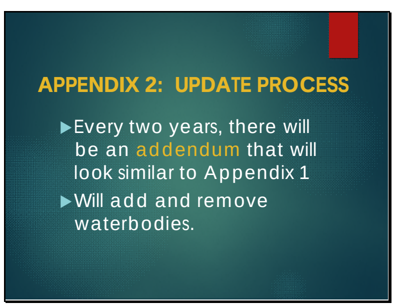
Slide 29



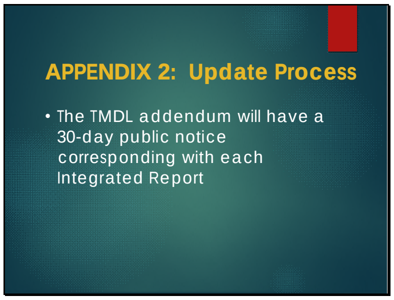
Geometric mean of all data that we have for the stream/beach segment
This number is not used for deciding if the water body is impaired.
It cannot be compared to the WQS.
But is provided to give you an idea of the scope of the problem.
For example, compare this river segment near lake Michigan (more than 1 million), with this beach on Lake superior

Slide 30

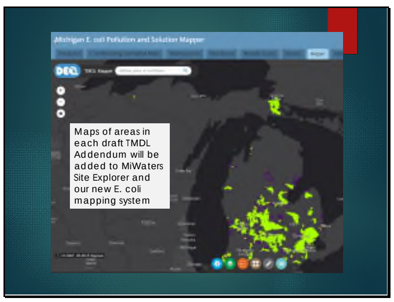
Slide 31



Slide 32

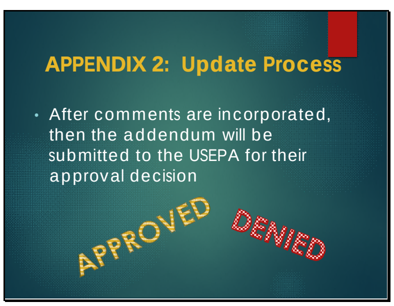


Slide 33



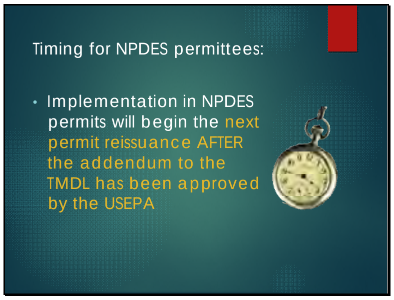
Maps of areas in each DRAFT TMDL Addendum will be added to MiWaters Site Explorer and our new E. coli mapping system

Slide 34



After public comments have been considered, the Addendum and Integrated Report will be submitted to the USEPA for their approval decision

Slide 35



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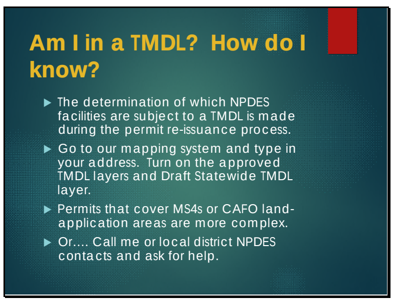

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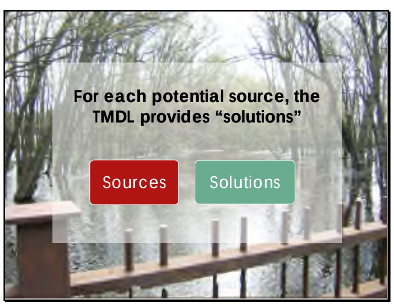
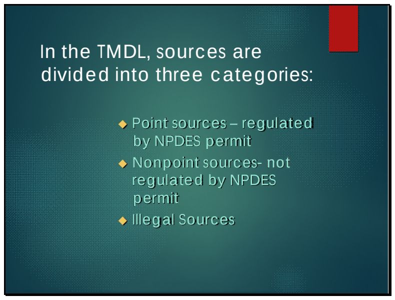


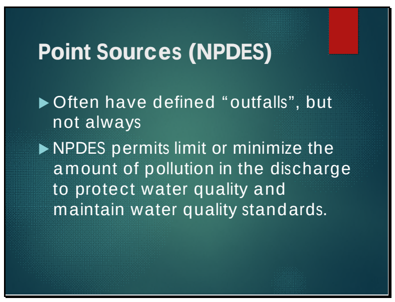
This section of the TMDL is 30 pages long!

Slide 38



National Pollutant Discharge Elimination System permits

Slide 39



Slide 40

Regulated MS4 are separate storm sewers or publicly owned infrastructure that drains into surface water through the storm sewers, such as roads, roadside ditches, and publicly owned parking lots. Combined sewers and sanitary sewers aren’t included.

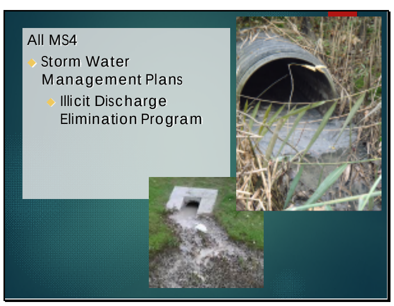
These permits are required in areas identified by the DEQ using the U.S. Census Bureaus Urbanized area data. These are the highly urbanized areas. A map of this area is available on our new E. coli mapping system.

Storm water can become contaminated from issues like illicit connections, trash, pet and wildlife waste.

Slide 41

All MS4 permittess must produce and implement Storm Water Management Plans.
Storm Water Management Plans have 6 minimum control measures they must address,
Which includes planning and implementing best management practices to reduce pollutants in new and redevelopment.

Slide 42

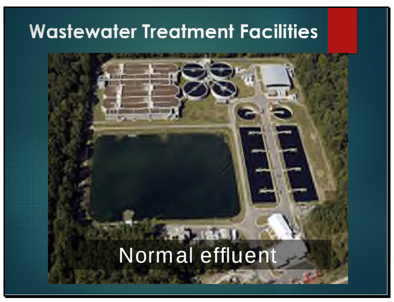


Storm Water Management Plans also must include Illicit Discharge Elimination Programs (IDEP).
This is perhaps one of the most significant parts of the permit, with the most potential to reduce E. coli.
Through this, permittees work to find and eliminate raw sewage discharges to their systems.

Slide 43

Additionally, if part of a EPA approved TMDL, MS4s permits include a requirement to develop a TMDL Implementation plan.
The purpose of these plans is to make progress towards achieving the pollutant reduction goal in the TMDL.
Permittees can do this by focusing and adding to existing programs, such as the IDEP.
Permittees must also monitor or model to demonstrate that they are making progress towards the goal of the TMDL

Slide 44



Another potential point source is WWTP effluent, or treated sewage water.
Wastewater Treatment Facilities can be lagoon systems or treatment plants. They can be private or public.
They collect sanitary waste and treat it to reduce pollutants to levels specified in their permits before discharging to surface water.
There are 542 in Michigan discharging to surface water.

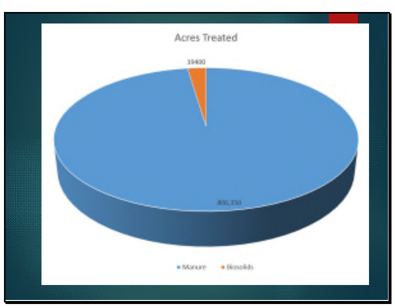
Slide 45

WWTPs have strict disinfection and discharge requirements, so in practical terms, their normal discharges are not a source.
Their limits are expressed in terms of fecal coliform, which is in our rules and can be confusing,
but the fecal coliform limits are protective of the E. coli WQS.

Slide 46

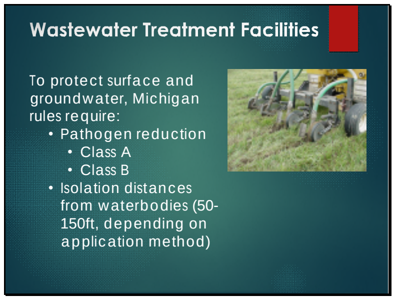
Biosolids are solids left over after sewage treatment process, and can be land applied as a fertilizer after treatment.
We have 263 sewage treatment facilities in Michigan that are permitted to land-apply biosolids as a fertilizer.
Almost 6000 sites statewide, and these are shown in the interactive mapping system.

Slide 47



It is important to note, that There are far fewer acres of land that are treated with biosolids, than are fertilized with livestock manure!

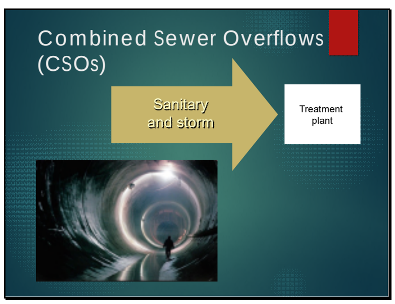
Slide 48



Biosolids land application is HIGHLY REGULATED
To protect surface and groundwater, Michigan rules require:
Isolation distances from waterbodies (50-150ft, depending on application method)
Pathogen reduction (composting)
Class A biosolids have no detectable levels of pathogens.
Class B are treated but still contain detectable levels of pathogens.

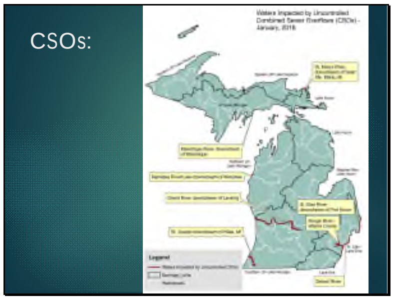
Site restrictions on applications to frozen, highly sloped or saturated ground.

Slide 49



In a combined sewer system…..Sanitary and storm water are carried by the same pipes, and this mix goes into the WWTP for treatments.
Problems occur after big rain storms or snow melt when the WWTP cannot handle the influx of storm water.
Raw or partially treated sewage then is diverted around the WWTP and into surface waters.

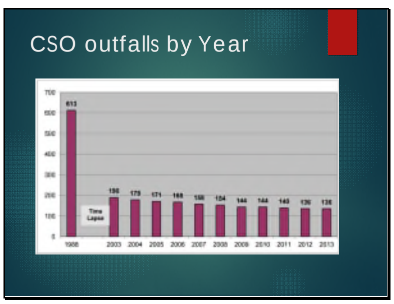
Slide 50



Two types of CSOs:
-Controlled CSO discharges are disinfected and skimmed before discharge.
-Uncontrolled CSO discharges receive no treatment and contain raw sewage
This map shows the areas of the state that are still impacted by uncontrolled CSO discharges.
Some CSOs discharge more often than others, and some discharge only every few years.
CSOs are regulated under the NPDES permit of the responsible facility.

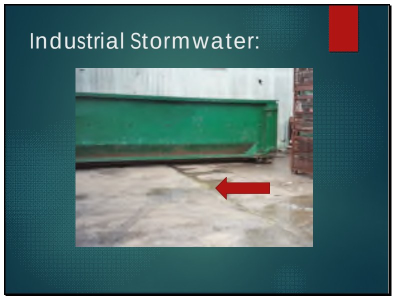
In the mapping system, you will find a layer of waters that still receive uncontrolled CSO discharges

Slide 51



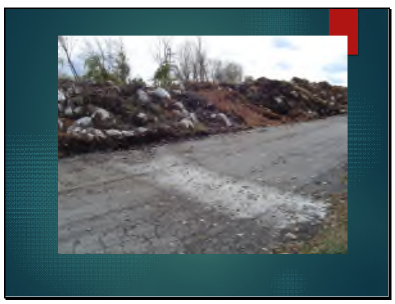
78% of Michigans CSO outfalls have been eliminated or controlled by our communities and facilities, since 1988. All remaining uncontrolled CSOs in Michigan have DEQ approved Control Plans, which work towards either controlling CSOs through treatment, or separating storm sewers from sanitary sewers.

Slide 52



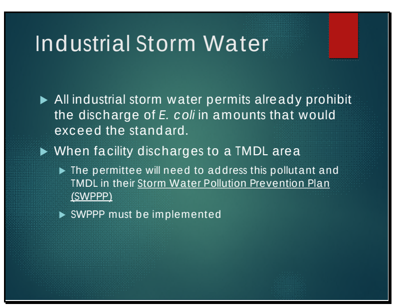
There are 2,900 industrial stormwater NPDES permits in Michigan, but that number fluctuates almost daily.
Industrial storm water permits are required when stormwater enters waters of the state after coming into contact with industrial materials or areas of activity.
Any industrial facility can be a source of E. coli if there are issues like you see here in this image. A leaking rollaway dumpster. When it rains this mysterious liquid will enter surface water

Slide 53



Most often industrial stormwater sites are probably not a significant source of e. coli, but there are particular types of facilities that might be especially prone to issues.
These include facilities related to the transport and storage of trash, recycling, or composting.
This is a composting site with runoff issues. Issues like this can be fixed using structural controls like berms.

Slide 54



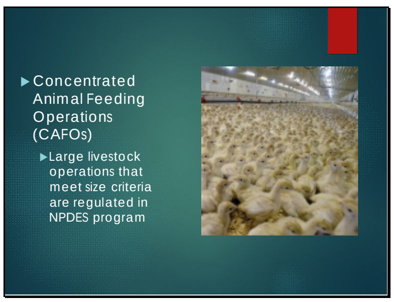
We will talk more about this at the industrial stormwater webinar.

Slide 55

Large CAFOs are required to obtain NPDES permits under Michigan Rules (No. 323.2196.)
The size criteria vary by animal type, and depends upon the volume and type of manure produced:
For example:

- A farm with 700 mature dairy cattle (whether milked or dry cows) would need a CAFO permit.

Slide 56



- For poultry it is more complicated. The threshold for broiler chickens is 30 to 125 thousand, and depends on whether the manure is handled in liquid or solid form.

Slide 57

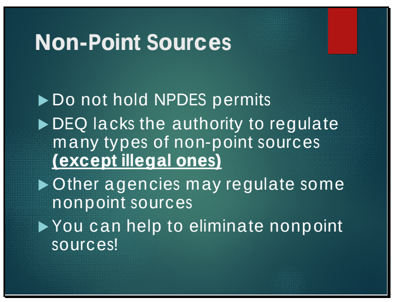
To prevent discharges to surface water, all CAFOs must design and construct facilities properly. This storage was built after the facility had a discharge. It is built to catch contaminated runoff, and built to the standards required by the permit. It is fully lined with concrete and has a depth gauge in the middle.

CAFO facilities also must develop a CNMP. The CNMP is designed to protect waters from nutrient issues, but practices that impact nutrients in a good way, also tend to reduce e. coli.

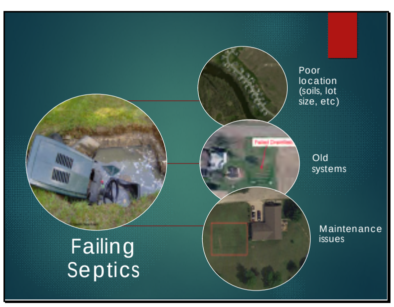
Slide 58

All CAFOs must:
Avoid manure spreading in sensitive areas and near water bodies
There is also a Restriction on where and how winter spreading can occur
There are more requirements for CAFOs intended to reduce E. coli contamination of our waters.
These are detailed in the TMDL beginning on page 36.

Slide 59



Slide 60

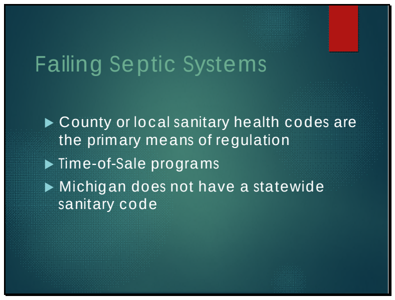


Failing or poorly designed septic systems are a major nonpoint source of E. coli in Michigans waters.

1.4 million septic systems in Michigan and between 17-25% may be failing to adequately treat waste for reasons such as lack of maintenance, poor location, and age.

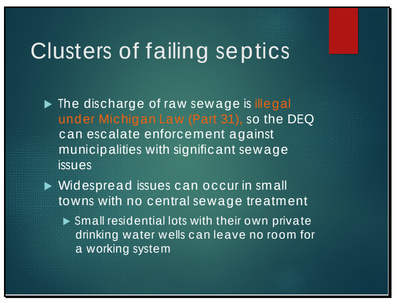
Failing septic systems means raw human sewage is getting into surface waters. Yuck!

Slide 61



Michigan does not have a statewide sanitary code, and a statewide inspection program for existing systems would be very beneficial in finding and solving problems.

Slide 62



So how do we fix failing septic systems statewide? That's a big problem.
We start by locating problem areas, and working together with local agencies.

Slide 63

We have assembled a list of funding sources on the next 2 slides. Each one has its own qualification requirements which are sometimes very specific. They are competitive programs and the timing of applications and funding availability varies. We are presenting this to you in order to help you find resources that may be available.

All of the grants and low interest loan programs on this page are intended to provide assistance to communities that need financial help with infrastructure improvements, such as sewage treatment, storm water, or drinking water infrastructure.

Slide 64

There are a couple of programs that we were able to find that help to fund septic system replacements on private property! Households must meet income and other requirements to qualify.

- Property Improvement Loans to replace EXISTING SEPTIC Tanks
- Neighborhood Impact Program issues grants of up to $7,500 for qualifying homeowners

We will post these slides on our e. coli TMDL website.

Slide 65

Septage is a term for the solids from a septic tank.
Pumping septic systems is a good thing!
When pumped the waste needs to be taken to a licensed facility or land applied as an ag. fertilizer

Slide 66

2004 PA 381, which amended Part 117, Septage Waste Servicers, of the NREPA

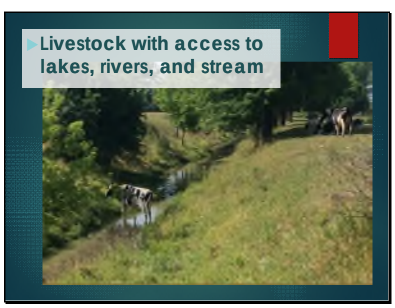
The regulations are designed to protect surface water and human health. .

And the mapping system shows areas of the state where septage is land applied, and also where it is prohibited by local ordinance.
The locations in our map are general due to data limitations.

Slide 67

If done properly and timed right, manure makes a great fertilizer. However, unfortunately it doesn't take much to go wrong.
In this case, the manure was applied on frozen ground. The field has only a slight slope, but it was enough to cause the field to overflow into a ditch, then into a creek. The E. coli levels as it entered the ditch were in the 200 times the partial body contact standard.

Slide 68



Livestock with access to surface waters are another common nonpoint source issue.
This a beautiful image but just downstream of this, we get

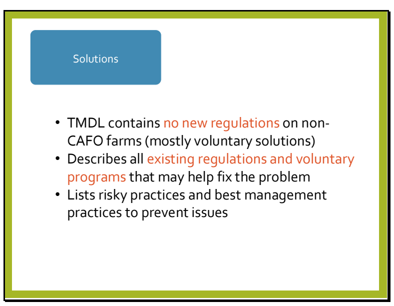
Slide 69

Evidence that isn't so pretty. Since this photo was taken, the cattle have been fenced out of the stream.

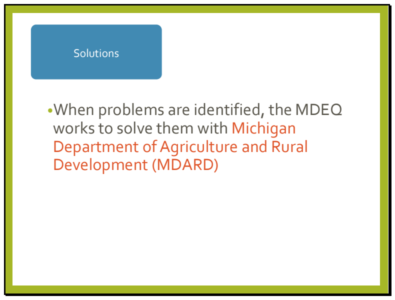
Slide 70

This image shows overgrazing in a pasture that is highly sloped, over-grazed, and has a swale going through it.
So how do with fix this? It's a big topic. Here are some key points….

Slide 71



Slide 72

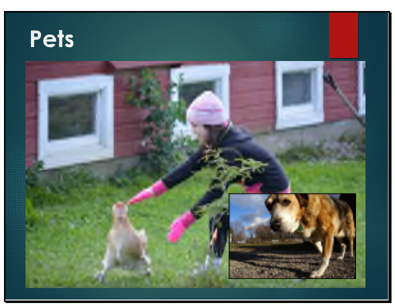


This is a very large and detailed part of the TMDL document, I urge you to attend the nonpoint source webinar to learn more.
This section of the TMDL starts on page 48

Slide 73

USDA Natural Resources Conservation Service - financial and technical assistance to implement structural and land management conservation practices on eligible agricultural land.

Slide 74



Dogs, cats, chickens, you name it.
Pet waste left on lawns or in public parks, kennels, etc can contaminate water especially during and following wet weather.
Rainwater flows over the ground, downhill, and into lakes, rivers and wetlands.
If you live in an urban area, it may enter the storm sewers, then most likely go into a river.

Slide 75

The solution here is good housekeeping. Densely vegetated buffers between pet areas and water bodies also work.
Some areas have established local ordinances aimed toward protecting water quality and human health.

Slide 76

Nuisance Wildlife is the last of the nonpoint sources.
Flocks of geese, raccoons in sewers, etc.
While deer can certainly contribute to local problems, there are many bigger issues.
Calhoun county has 44,000 deer, the most in Michigan. Compared with 136,000 humans and 46,000 cattle/hogs.

Slide 77

This can be a difficult problem to solve, particularly in urban areas.
The solutions here are varied depending on the problem.
Good housekeeping such as proper trash storage can reduce some problems, and ordinances against feeding wildlife.
And geese can be frightened away with trained dogs or decoys of predators.
Geese like open areas, so leaving unmowed areas of tall vegetation near waterbodies is possibly the best way to discourage them.

Slide 78

- Federal pass-through grants administered by the DEQ that can be used to fund implementation of best management practices, E. coli monitoring, and educational activities. Limited to areas with approved plans. $2 million per year
- Implementation of best management practices……$2 million per year
- GLRI funding is generally targeted to specific subjects each time they release an RFP, so this is something to keep an eye out for.

Slide 79

Community Block Grants for identified low and moderate income communities, if you are applying for one of these Block grants for a big project (like infrastructure), you may ALSO include work to reduce pollution through rain gardens, green strips, dog clean-up stations. But these are generally part of a larger project.

Urban Waters grants are available only to designated locations, which includes the western basin of lake erie and Grand Rapids.
The mission of Urban Waters Program is to help residents and organizations to restore their urban waters in ways that also benefit community and economic revitalization.

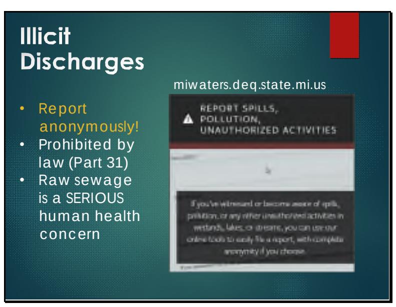
Slide 80

Illicit connections to storm sewers and surface water.
Illicit Connections bypass the sewage treatment system (either a septic system or the wwtp)
This image shows a 'cheater pipe' from a septic tank to a creek bank. The smell and flies and tomato seedlings made it obvious what was coming out of the pipe.

Slide 81

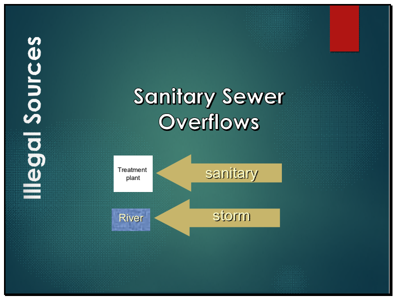
Barn wash water is another type of illicit discharge that Contains high amounts of manure. Black stinky mud is common any type of untreated fecal pollution that has been occurring for a while.

Slide 82



The DEQs new MiWaters website allows for anonymous reporting

Slide 83

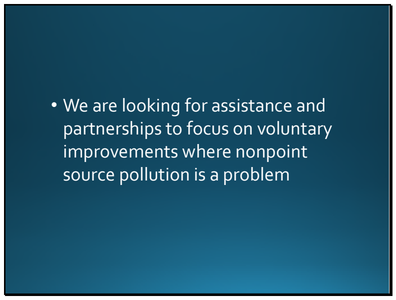


In addition to illicit connections and illegal discharges from private farms and residences, Municipal or private Sanitary Sewers sometimes spill raw human sewage onto land or into surface water.
These occur in systems where the storm water is separate from the sanitary waste.
Usually these are isolated events, and often due to power outages, weather, or other disasters, But there are also systems that have chronic recurring problems.

Slide 84

For chronic issues, the MDEQ requires the responsible municipality to implement corrective actions with a formal schedule (target dates)
All SSOs must be reported to the DEQ and local health departments.
Failing infrastructure was recently brought into the spotlight by the Frasier Sinkhole which resulted in raw sewage being spilled in the Clinton River and terrible loss of property.
Funding is needed to fix our aging infrastructure.
We have an online CSO/SSO database that allows anyone to search for events by location or responsible party.

Slide 85



So how do we fix all of these problems?
The DEQ will focus on NPDES permitted discharges and facilities, as well as illegal activities.
But we need you!
We are looking for assistance and partnerships with local agencies and interested groups to focus on voluntary improvements

Slide 86

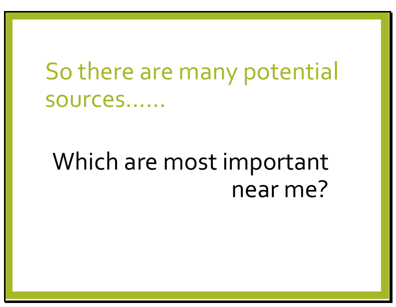
You can help reduce E. coli by maintaining your septic system if you have one,
cleaning up after pet waste,
avoid feeding wildlife,
allowing tall vegetation to grow along waterways,
And join a watershed council or environmental group.
If you are a farmer, contact your local conservation district office for help. Ask them for information about becoming environmentally verified!

Slide 87

Slide 88

Slide 89

Slide 90



End of presentation. Interactive mapping demonstration.

EXHIBIT 19

Published January 25, 2018

Journal of Environmental Quality

TECHNICAL REPORTS

SURFACE WATER QUALITY

Solid Cattle Manure Less Prone to Phosphorus Loss in Tile Drainage Water

Y. T. Wang, T. Q. Zhang,* C. S. Tan, Z. M. Qi, and T. Welacky

Abstract

Forms (e.g., liquid and solid) of manure influence the risk of P loss after land application. The objective of this study was to investigate the effects of P-based application of various forms of cattle manure (liquid, LCM; or solid, SCM) or inorganic P as triple superphosphate (IP) on soil P losses in tile drainage water. A 4-yr field experiment was conducted in a clay loam soil with a corn (*Zea mays* L.)–soybean [*Glycine max* (L.) Merr.] rotation in the Lake Erie basin. Over the 4 yr, the dissolved reactive P (DRP) flow-weighted mean concentration (FWMC) in tile drainage water was greater under SCM fertilization than under either IP or LCM fertilization. Despite its lower value on an annual basis, DRP FWMC rose dramatically immediately after LCM application. However, the differences in DRP FWMC did not result in detectable differences in DRP loads. Regarding particulate P and total P losses during the 4 yr, they were 68 and 47%, respectively, lower in the soils amended with SCM than in those with IP, whereas both values were similar between IP and LCM treatments. Overall, the P contained in solid cattle manure was less prone to P loss after land application. Accordingly, the present results can provide a basis for manure storage and application of best management practices designed to reduce P losses and improve crop growth.

Core Ideas

- Phosphorus-based addition of liquid and solid manure was evaluated on P loss.
- Liquid manure increased dissolved P loss immediately after application.
- Solid and liquid manures had long-term dissolved P loss similar to fertilizer P.
- Solid manure reduced particulate P and total P loss over the long term.

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*Corresponding author (Tiequan.Zhang@agr.gc.ca).

Phosphorus losses from agricultural lands have long been identified as a major contributor to the degradation of surface waters (USEPA, 2000). Given the unfavorable N/P ratio of manure relative to most crops' N and P uptake rates, manure application rates based on crop N requirements result in excessive P application, raising the risk of P losses to surface waters (Sharpley et al., 1994; Sims et al., 2000). To mitigate P losses from cropland with soils at high risk of P loss, a manure application rate based on P status is encouraged (Sharpley and Moyer, 2000). Currently, application rates are typically estimated on the basis of total P (TP) concentration in manures (Barnett, 1994; Sharpley and Moyer, 2000; Kumaragamage et al., 2011). Liquid and solid manure storage systems currently in use produce manures with contrasting chemical and physical characteristics, leading to different pathways and magnitudes of P losses after their application (Statistics Canada, 2003; Hansen et al., 2004). The limited information currently available regarding differences in soil P losses after liquid and solid manure application presents an impediment to developing improved manure storage and application protocols that ensure lower P losses and greater surface water quality while promoting crop growth.

Many studies suggest that the water extractable P (WEP) concentration of inorganic and organic P sources recently applied to soils is a consistent indicator of P loss potential (Hodgkinson et al., 2002; Kleinman et al., 2005; Kang et al., 2011). A survey of WEP in livestock manures showed variability resulting from handling and storage systems, with solid manures bearing less WEP (3.9 g kg^{-1}) than liquid ones (5.4 g kg^{-1}) (Kleinman et al., 2005). Tarkalson and Leytem (2009) reported that WEP accounted for 32 to 43% of TP in solid dairy manure and 57 to 70% in liquid manure. If manure application rates were determined on the basis of their TP, one might expect greater P losses from soils amended with liquid rather than solid manure. Such a hypothesis was partially confirmed by Tarkalson and Leytem (2009), who observed greater TP loss in leachate from liquid rather than solid dairy manure amended soils. However, greater manure P solubility in water may not necessarily result in greater long-term losses (Withers et al., 2003). Indeed, although the increase in dissolved

Y.T. Wang, T.Q. Zhang, C.S. Tan, and T. Welacky, Harrow Research and Development Center, Agriculture and Agri-Food Canada, Harrow, ON, Canada, N0R 1G0; Z.M. Qi, Dep. of Bioresource Engineering, McGill Univ., 21,111 Lakeshore Rd., Sainte-Anne-de-Bellevue, QC H9X 3V9. Assigned to Associate Editor Douglas Smith.

Abbreviations: DRP, dissolved reactive phosphorus; FWMC, flow-weighted mean concentration; IP, inorganic phosphorus; LCM, liquid cattle manure; PP, particulate phosphorus; SCM, solid cattle manure; TN, total nitrogen; TP, total phosphorus; WEP, water extractable phosphorus.

reactive P (DRP) loss via surface runoff linked to solid manure application occurred 28 d later than that under a liquid manure application, Smith et al. (2001) found no significant difference in DRP loss over the full period of 4 Feb. 1994 to 13 June 1994.

Given the high mobility of liquid manure P in the soil profile, studies have generally shown greater soil P losses through subsurface runoff after liquid (vs. solid) manure applications. Tarkalson and Leytem (2009) reported that, after application, the P in solid dairy manure remained within the soil's top 0.05 m, whereas the P in liquid manure or monoammonium phosphate ($NH_4H_2PO_4$) leached down to lower soil depths. Soils that received annual applications of solid or liquid dairy manures for >10 yr showed similar TP in the 0.01-m soil layer, but at a depth of 0.45 to 0.65 m, liquid-manure-amended soils had TP nearly double that of solid-manure-amended soils (Hansen et al., 2004). The water in liquid manure may be an important factor contributing to the greater leaching of P from liquid-manure-amended soils than from solid-manure-amended soils (Hansen et al., 2004). Unlike solid manure, liquid manure has the potential to remain in soil macropores and be flushed down to lower soil layers or into tile drainage within the first few drainage events (Hodgkinson et al., 2002). In comparison, the P in solid manure may have more time to react with minerals in soil surface layers, providing some protection against P mobilization (Hodgkinson et al., 2002; Hansen et al., 2004).

The actual effects of solid and liquid manure on soil P loss through subsurface runoff require further investigation under long-term field conditions, particularly in Ontario, where eutrophication of the Lake Erie is a growing public concern. In Ontario, ~1.65×10^6 ha, or 63% of the cropland excluding pastures, has been tile drained and may become a potentially significant source for agricultural P loss (Tan and Zhang, 2011; Wang et al., 2012; King et al., 2015). Therefore, the objective of this study was to investigate the effects of P-based application of various forms of cattle manure (liquid or solid) or inorganic P (IP) on soil P losses in tile drainage water.

Materials and Methods

Experimental Site and Design

The experiment was conducted at the Honorable Eugene F. Whalen Experimental Farm, Woodslee, ON (42°13′ N, 82°44′ W) from 1 May 2008 to 30 Apr. 2012. The soil was a Brookston clay loam and classified as a fine-loamy, mixed, mesic, Typic Argiaquoll (Soil Survey Staff, 1999) or as an Orthic Humic Gleysol (Soil Classification Working Group, 1998). A composite soil sample was collected across the field site for particle size distribution analysis using the hydrometer method (Kroetsch and Wang, 2008). In spring 2008 before treatments were implemented, four composite soil samples were also collected for measuring TP and total N (TN) using the concentrated sulfuric acid and hydrogen peroxide digestion method (Thomas et al., 1967), soil organic carbon (a dry combustion method with a Leco CN2000 [Leco Corporation] analyzer; Nelson and Sommers, 1996), and Olsen P (0.5 M $NaHCO_3$, pH = 8.5; Schoenau and O'Halloran, 2008).

The climate is humid and temperate, with a mean annual air temperature of 8.9°C and precipitation of 830 mm (Zhang et al., 2015). Monthly and annual precipitation data collected during the study within 0.5 km of the site are presented by cropping year (i.e., from 1 May to 30 April the following year) (Table 1). As one of the three major intensive manure production regions in Canada, southwestern Ontario's cattle production generates 63% of the total volume of manure in Ontario (Fraser et al., 2006; Statistics Canada, 2008). Accordingly, in the present experimental setting, cattle manure was selected to determine the influence of manure forms (i.e., liquid vs. solid) on P losses in tile drainage water, relative to IP fertilizer.

The experiment was arranged in a factorial randomized complete block design with two replicates. Treatments were combinations of two water table management practices (free drainage vs. controlled drainage with subirrigation) with four P sources, including IP fertilizer as triple superphosphate, liquid cattle manure (LCM), solid cattle manure (SCM), and soil P drawdown (i.e., use of legacy P by ceasing P addition). In the current study, three treatments (i.e., IP, LCM, and SCM) under standard free drainage were selected to compare the effects of various P sources on soil P loss in tile drainage water. Liquid cattle manure and SCM were collected separately from two local cattle farms situated in southwestern Ontario. Wheat (*Triticum aestivum* L.) straw was used as bedding material for SCM. Two or three days before application, composite representative manure samples were collected and analyzed for determining moisture and TP concentrations, which were then used to calculate the actual manure application rates. The TN and TP in manure were determined using the concentrated sulfuric acid and hydrogen peroxide digestion method of Thomas et al. (1967).

Some 15 m wide × 67 m long (≈0.1 ha), each plot was delimited on its north, south, and west sides by a 0.30-m-tall berm preventing entry or loss of surface water from and to other plots. To prevent any potential between-plot cross contamination from movement of surface sheet flow and the lateral flow in the soil profile, a tile-drained buffer strip (7.5 × 67 m each) was established between plots, with a 1.2-m-deep vertical plastic sheet barrier installed between the buffer strip and the adjacent plot. In each plot, three drainage tiles (0.10 m i.d.) were installed to run parallel to the length of the plot (4.2-m spacing, 0.85-m depth). The spacing and depth values are within the ranges typically used for tile installations in Eastern Canada, Ontario, and Quebec, in

Table 1. Monthly precipitation from 1 May 2008 to 30 Apr. 2012 at Woodslee, ON.

Month	Precipitation (1 May–30 April)			
	2008–2009	2009–2010	2010–2011	2011–2012
	mm			
May	54.4	45.0	107.8	193.0
June	186.2	85.6	113.2	62.6
July	85.6	62.8	148.4	120.0
August	12.8	90.6	9.2	104.8
September	124.6	20.8	90.4	180.6
October	28.8	75.8	63.0	112.0
November	94.8	17.4	85.2	179.0
December	78.4	53.8	25.2	77.2
January	15.0	16.8	30.8	55.2
February	63.6	21.4	61.4	33.0
March	96.8	36.4	84.8	63.4
April	114.0	61.2	128.4	32.4
Annual total	955.0	587.6	947.8	1213.2

particular. Tile water from each full plot was delivered to a single collection sump, installed in a central automated monitoring station.

Crop Management

A corn (*Zea mays* L.)–soybean [*Glycine max* (L.) Merr.] rotation was used at the experimental site. Both manure and inorganic fertilizer applications occurred only in the corn years (i.e., 2008 and 2010) of the rotation. For each of the treatments selected for the current study, P was applied at a rate of 50 kg ha^{-1}. Manure applications were complemented with the application of inorganic N and K fertilizers (NH_4NO_3 and KCl) to achieve an overall available N and K fertilization rates of 200 and 100 kg ha^{-1}, respectively. Pesticides and herbicides were applied in consequence of the season's prevalent pests, and rates were based on local recommendations.

All nutrients (i.e., N, P, and K) were broadcast on the soil surface at the preplanting stage (spring) of the corn cropping years and were incorporated immediately or once weather conditions allowed. Shortly after harvest in the fall, plots were disked to a depth of 0.20 m prior to spring planting and then were harrowed to the same depth with a chisel plow. In 2008, corn was planted and harvested on 18 June and 12 November, respectively, with manure and chemical fertilizer surface applied on 2 to 9 June and then incorporated into the soil on 17 June. In 2009, soybean was planted and harvested on 12 May and 20 Oct., respectively. In 2010, corn was planted and harvested on 26 June and 8 Nov., respectively, with nutrients surface applied on 11 to 26 June and then incorporated into the soil on 26 June. In 2011, soybean was planted and harvested on 15 June and 13 Dec., respectively. Corn and soybean were seeded at the local recommended rates of 76,800 and 486,700 seeds ha^{-1}, respectively.

Water Sampling and Analysis

Tile drainage water in each collection sump was pumped through a water meter (Neptune T-10, Neptune Technology Group) to an outlet drain. A multichannel data-logger was used to continuously record the water meter's analog signal to monitor, measure, and store volumes of water discharge. Autosamplers (CALPSO 2000S, Buhler Gmbh & Company) were instrumented to automatically take one sample of 250 mL per 1000 L of flow during the growing seasons and per 3000 L of flow during the nongrowing seasons. Every four samples collected in sequence were automatically combined to form a composite sample for laboratory analysis. In the laboratory, a portion of each composite water sample was filtered through a 0.45-µm filter, and DRP and dissolved TP were then measured by a Flow Injection Auto-Analyzer (QuikChem FIA + 8000 series, Lachat Instruments) using the ammonium molybdate ascorbic acid reduction method (Murphy and Riley, 1962). Unfiltered water samples were analyzed for TP using the sulfuric acid-hydrogen peroxide digestion method (Thomas et al., 1967). Particulate P (PP) was calculated as the difference between TP and dissolved TP. Dissolved reactive P flow-weighted mean concentrations (FWMC) in tile drainage water were calculated on an annual basis or for the entire 4-yr study period.

Data Analysis

All statistical analyses were performed using SAS (SAS Institute, 2009). All the data were tested for normality using a UNIVARIATE procedure, with natural logarithm transformations performed when necessary. Significance of the differences in tile drainage volume and concentration and loads of DRP, PP, and TP in flow water between IP, LCM, and SCM fertilization treatments was tested by repeated measures ANOVA using a MIXED procedure, where between-subject was P sources, within-subject (repeated) was cropping year, and variance components were selected as the covariance structure among the repeated measures. Tukey's test was used to test the significance of means of flow volume and DRP, PP, and TP concentrations and loads between IP, LCM, and SCM fertilization treatments.

Results and Discussion

Soil and Manure Properties

The soil at the study site contained 280, 350, and 370 g kg^{-1} of sand, silt, and clay in the Ap horizon, respectively. Before the treatments were applied in spring 2008, the soil contained 594 mg TP kg^{-1} and 2083 TN mg kg^{-1} with SE of 22 and 209 mg kg^{-1}, respectively. Soil organic carbon was 22.7 g kg^{-1} (SE = 2.8 g kg^{-1}). Soil-test P (Olsen P) was 31.8 mg kg^{-1} (SE = 7.3 mg kg^{-1}). The TN contents were 35.1 g kg^{-1} for LCM and 13.5 g kg^{-1} for SCM in 2008 and 63.3 g kg^{-1} for LCM and 16.5 g kg^{-1} for SCM in 2010. The TP contents of LCM and SCM were 4.8 and 2.3 g kg^{-1} in 2008 and 13.1 and 6.6 g kg^{-1} in 2010, respectively.

Flow Volume of Tile Drainage Water

Precipitation drives the production of tile drainage flow. Ranging between 345 and 420 mm yr^{-1}, mean tile drainage flow accounted for 37 to 45% of mean annual precipitation over the 4 yr (Tables 1 and 2). These observations fell within the range previously reported by Zhang et al. (2015) for this site's Brookston clay soil, namely, 96 to 319 mm yr^{-1} for precipitation ranging from 729 to 875 mm yr^{-1}.

Compared with the IP fertilization amendment, the SCM amendment had significantly lower flow volume of tile drainage over the period of the study (420 vs. 345 mm yr^{-1}, Table 2). No significant difference in tile drainage flow volume was observed between LCM and either IP or SCM amendment regimes (Table 2). Overall, our results are consistent with the observations that solid manure application significantly reduced the hydraulic conductivity measured on the saturated undisturbed columns of a silt loam soil, whereas liquid manure did not have a significant impact on it (Unc and Goss, 2006). In our study, the differences in flow volume were mainly caused by the extreme rainfall of 1213 mm received during the very rainy 2011–2012 cropping year. The amount of rainfall in 2011–2012 was 46% greater than the average during the rest of the study (Table 1). Given that very intense or frequent rainfall events can result in surface ponding and saturated soil conditions, under which macropore flow may dominate overall infiltration (Miller et al., 2002), the greatest risk of such conditions leading to macropore flow occurred in the 2011–2012 production season. To explain the observed differences in the hydraulic conductivity, Unc and Goss (2006) suggested that due to the resulting differences in

Table 2. Mean annual flow volume, flow-weighted mean concentrations of dissolved reactive P (DRP), particulate P (PP), and total P (TP), and their respective loads in tile drainage water for the period of 1 May 2008 to 30 Apr. 2012.

Source of P applied	Flow volume	Concentration			Load		
		DRP	PP	TP	DRP	PP	TP
	mm	mg L^{-1}			g ha^{-1}		
Inorganic P	420a†	0.189ab	0.424a	0.631a	826a	1942a	2839a
Liquid cattle manure	407ab	0.158b	0.334a	0.512ab	703a	1468ab	2242ab
Solid cattle manure	345b	0.227a	0.159b	0.405b	833a	614b	1511b
				ANOVA			
PA‡	0.0424	0.0183	0.0030	0.0260	0.4686	0.0060	0.0198
Time	<0.0001	0.0093	0.0380	0.0201	<0.0001	0.0024	0.0004
PA*Time	0.0679	0.1049	0.4363	0.3155	0.0718	0.1758	0.1164

† Means within a column followed by same letter are not significantly different at $P = 0.05$.

‡ PA, source of phosphorus applied.

organic C input, liquid manure application favors accelerated flow through macropores, whereas solid manure application limits the fast macropore flow. Previous studies have shown that solid manure contains more organic C than liquid manure (Fraser et al., 2006; Hao et al., 2015). In contrast with IP and LCM amendments, SCM amendments may also improve soil physical properties (e.g., soil structure, aggregate stability, and mechanical resilience) through long-term inputs of organic C, thereby reducing the chances of macropore (e.g., crack) formation and decreasing preferential flow (Zhang et al., 2005; Fraser et al., 2006). Zhang et al. (2005) reported that the fraction of fine soil pores (<6 μm) increased with increasing organic C application rates during dry–wet cycles, whereas the coarse pore fraction (>50 μm) decreased.

Tile Drainage Dissolved Reactive Phosphorus

Across the three tested P sources and 4 yr of the study, the LCM fertilization regime showed the highest peak DRP FWMC in tile drainage water in the sampling periods of 1 May 2008 to 16 June 2008 and 12 June 2010 to 5 Aug. 2010 (Fig. 1A). The different forms of P were applied to the soil surface in early June 2008 and in middle and late June 2010. Liquid manure's greater water content affords its soluble P a greater potential to remain in soil macropores and be flushed to lower soil depths or into tile drainage within the first few drainage events (Hodgkinson et al., 2002). Such a process is likely what contributed to the observed peak in DRP FWMC with LCM fertilization. An increased DRP FWMC in tile drainage water after a liquid manure application was previously reported, especially for fine-textured soils (Geohring et al., 2001; Hodgkinson et al., 2002; Schelde et al., 2006; Liu et al., 2012). In the case of IP and SCM fertilization regimes, rainfall led to recently applied soluble P being easily lost to runoff water, thereby contributing to the peak DRP FWMC between 12 June 2010 and 5 Aug. 2010. Compared with liquid manure, the P in solid manure might have had more time to react with minerals in the topsoil, providing some protection against P mobilization (Hodgkinson et al., 2002; Hansen et al., 2004). Accordingly, the peak DRP FWMC in tile drainage water was higher under the LCM fertilization regime than under either the SCM or IP regimes (Fig. 1A, 12 June 2010–5 Aug. 2010).

For IP and SCM amendments, no peak DRP FWMC was observed between 1 May 2008 and 16 June 2008, although both were applied to the soil in early June. Instead, their peak DRP FWMC in tile drainage water occurred between 17 June 2008 and 17 July 2008 (Fig. 1A). Smith et al. (2001) reported similar DRP concentration peaks in surface runoff immediately after cattle slurry application, whereas the rise in DRP concentration after cattle farmyard manure application did not occur until ~28 d later. Whether or not the peak FWM DRP concentration in tile drainage water is delayed after P applications might depend on the dominant water infiltration pathway and the amount of soluble P available in the soil. After liquid manure application, large quantities of soluble P remain in soil macropores that can be easily flushed to tile drains by the first few drainage events, thereby yielding an immediate peak in FWM DRP concentration. In contrast, most of the P contained in SCM is not immediately soluble after

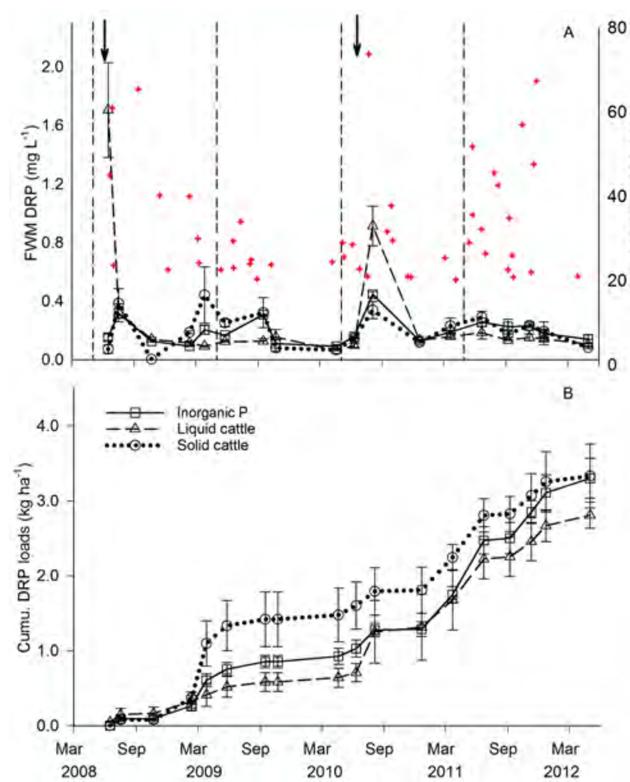

Fig. 1. Effects of inorganic P fertilizer, liquid cattle manure, and solid cattle manure application on (A) flow-weighted mean dissolved reactive P concentration (FWMC DRP) in tile drainage water, and (B) cumulative (Cumu.) tile drainage DRP loads from a Brookston clay loam soil over 4 yr. Vertical bars are standard errors (*n* = 2), the arrows show the dates of P application, dashed vertical lines represent 1 May each year (i.e., 2008, 2009, 2010, and 2011), and "+" represents daily precipitation with >20 mm d^{-1}.

land applications and may have to experience a range of desorption, dissolution, and/or mineralization to become available to release to drainage water (Kleinman et al., 2005). Overall, SCM application brings less soluble P to the soil within a short period of time. Enhanced by SCM application, soluble P in the matrix flow also tends to be retained in the soil due to the longer travel time in the soil and the large contact area between soil components and the flowing water (Unc and Goss, 2006). These are likely what prevented peak DRP concentration in tile drainage from occurring between 1 May 2008 and 16 June 2008. Daily precipitation data showed that compared with the period of 1 May 2008 to 16 June 2008, the period of 17 June 2008 to 17 July 2008 received much greater rainfall (on average 2.5 vs. 5.9 mm d^{-1}). Moreover, heavy rainfall events of 45, 61, and 24 mm occurred in the latter period, compared with the absence of any rainfall event >20 mm during the former period (Fig. 1A). Such heavy rainfall events may have saturated (or brought close to saturation) a portion of the soil matrix in the plots amended with SCM, thus initiating macropore flow while exceeding its infiltration potential. This, along with the increased soluble P caused by desorption, dissolution, and/or mineralization, would raise DRP concentration in tile drainage water. Vidon and Cuadra (2011) reported that macropore flow represented 43 to 50% of total tile drain flow during large storms (>60 mm), but only 11 to 17% during smaller tile-flow events (<30 mm).

Generally, liquid manure contains greater WEP than solid manure (Kleinman et al., 2005). Accordingly, the higher peak in DRP concentration observed in our study, occurring immediately after the LCM application was made, supported the idea that manure P solubility in water is an indicator of DRP loss for recently applied soil P (Kleinman et al., 2005). However, greater solubility of manure P in water does not necessarily result in greater postapplication DRP loss over the long term. Except for peak DRP FWMC after P application, most of the time, DRP FWMC in tile drainage water was lower under the LCM fertilization regime than under either the SCM or IP regimes (Fig. 1A). This may be related to what was discussed previously: compared with LCM, more P in SCM and IP tends to be retained in the soil and will then slowly become soluble through desorption, dissolution, and mineralization, leading to more P available to release to tile drainage water. Over the 4 yr, annual DRP FWMC in tile drainage water was significantly lower under the LCM fertilization regime (0.158 mg L^{-1}) than under the SCM regime (0.227 mg L^{-1}) (Table 2). Tarkalson and Leytem (2009) indicated that most of the P in solid manure remained in the top 51 mm of the soil after land application, whereas P in liquid manure or inorganic fertilizer was leached to much lower soil depths. Generally, P leaching loss risks are positively related to P levels in the topsoil (Wang et al., 2012). Accordingly, it is consistent with this observation that a greater annual DRP FWMC was observed in tile drainage water from the SCM-amended soil. Given our results, it seems that LCM application may result in a dramatic increase in DRP loss immediately after fertilizer application, whereas SCM application tends to become a long-term P source for DRP loss.

Across the 4 yr, annual DRP loads (0.7–0.8 kg ha^{-1} yr^{-1}) in tile drainage water were similar across the three forms of applied P (Table 2, Fig. 1B). This is consistent with the SCM fertilization regime generating greater DRP concentration on an annual basis, but lower annual tile flow. The annual DRP loads fell within the range of such loads reported by Gentry et al. (2007) and King et al. (2015): 0.05 to 1.01 kg ha^{-1} yr^{-1}. However, based on the temporal pattern of DRP FWMC, one could expect to achieve a reduction in DRP losses if the LCM application could be arranged to avoid major rainfall events for a short period of time after application. In addition, peak DRP FWMC after liquid manure application was mainly the result of macropore flow in the soil; accordingly, by destroying the soil's macropore network, preapplication tillage (applying liquid manure to the soil surface after disturbing the top soil layer) or tilling the soil surface immediately after liquid manure application might be another way of decreasing DRP losses through tile drainage water. However, this needs to be investigated in further studies.

Tile Drainage Particulate Phosphorus

Over the 4 yr, annual mean PP FWMC in tile drainage water from the SCM-amended soil (0.159 mg L^{-1}) was significantly lower than in IP-amended soil (0.424 mg L^{-1}), and marginally lower than in LCM-amended soil (0.334 mg L^{-1}) (Table 2). The reduction in sediment and thus PP loss caused by SCM application could be due to improved soil structure (Whalen et al., 2003). As shown in Fig. 2A, the temporal pattern of PP FWMC in tile drainage water from IP-amended plots was characterized by six peaks, which corresponded to the periods of 17 June 2008 to 17 July 2008, 11 Feb. 2009 to 27 Mar. 2009, 27 May 2009 to 16 Sept. 2009, 21 Apr. 2010 to 11 June 2010, 23 Mar. 2011 to 22 June 2011, and 10 Nov. 2011 to 22 Dec. 2011, respectively. The peak PP FWMC between 17 June 2008 and 17 July 2008 occurred immediately after P incorporation into the soil and is consistent with previous reports that disturbing the soil surface increased PP losses (Schelde et al., 2006). Scrutiny of rainfall records over the 4 yr showed that peak PP FWMC in tile drainage waters occurred in periods of frequent rainfall events, especially if these were particularly intense (>20 mm d^{-1}, Fig. 2A). Across the 4 yr, annual PP FWMC was significantly correlated with annual precipitation in the IP-amended soil ($P = 0.04$). These results are consistent with the report that PP losses in tile drainage largely occurred during storm events (Grant et al., 1996). In the current study, however, intense rainfall events did not necessarily cause peak PP FWMC in tile drainage water such as during the periods of 17 July 2008 to 11 Feb. 2009 and 11 June 2010 to 22 Mar. 2011 (Fig. 2A). The reason for the lack of peak PP concentrations might have been related to crop protection against soil erosion: the two low PP periods were during the seasons when either corn was growing or corn residue remained on the soil surface. The peaks observed with IP treatment did not appear during the period of 11 Feb. 2009 to 27 Mar. 2009 for LCM-amended soil, and during the period of 27 May 2009 to 16 Sept. 2009 for both LCM- and SCM-amended soil. The reasons for the disappearance of peak PP FWMC remain unclear. In addition, a comparison of PP FWMC and DRP FWMC in tile drainage water showed the former to be more temporally variable than the latter (Fig. 1A and 2A), suggesting that PP FWMC in tile drainage water was influenced by more factors (e.g., P application rate, rainfall intensity, tillage practices) than DRP FWMC, which was mainly tied to the rate of P application.

Across the 4 yr, annual PP loads in tile drainage water from SCM-amended soil (0.6 kg ha^{-1} yr^{-1}) were significantly ($P \leq 0.05$) lower than in IP-amended soils (1.9 kg ha^{-1} yr^{-1}), and

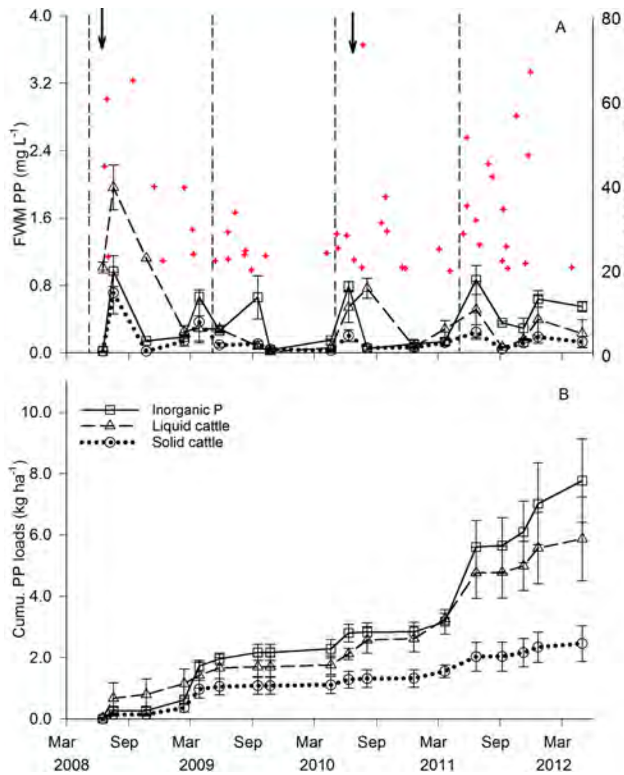

Fig. 2. Effects of inorganic P fertilizer, liquid cattle manure, and solid cattle manure application on (A) flow-weighted mean particulate P concentration (FWMC PP) in tile drainage, and (B) cumulative (Cumu.) tile drainage PP loads from a Brookston clay loam soil over 4 yr. Vertical bars are standard errors (n = 2), the arrows show the dates of P application, dashed vertical lines represent 1 May each year (i.e., 2008, 2009, 2010, and 2011), and "+" represents daily precipitation with >20 mm d^{-1}.

subtly lower ($P \leq 0.08$) than in LCM-amended soils (1.5 kg ha^{-1} yr^{-1}) (Table 2, Fig. 2B). Our annual PP loads in tile drainage water were comparable with the values of 0.24 to 2.52 kg ha^{-1} yr^{-1} reported for a clay loam soil under a corn–soybean rotation, also situated at the Honorable Eugene F. Whalen Experimental Farm (Zhang et al., 2015). The 68.4% reduction in PP loads with solid manure relative to IP amendment was the consequence of both a 17.9% reduction in annual tile drainage flow volume and a 62.5% reduction in annual PP FWMC (Table 2). This emphasizes the fact that selecting appropriate sources to provide P for crop growth promises to be an effective method to reduce PP losses to surface waters.

Tile Drainage Total Phosphorus

On average, the combination of DRP and PP accounted for 94.8% of TP in tile drainage water (data not shown). Compared with the LCM soil amendment, the SCM soil amendment had higher tile drainage DRP FWMC, but lower PP FWMC (Table 2). It is therefore reasonable to have observed similar annual TP FWMC in tile drainage water for both LCM- and SCM-amended soils (0.41 and 0.51 mg L^{-1}, respectively). As with annual PP FWMC, annual TP FWMC in drainage water was significantly greater with the IP soil amendment than with the SCM amendment, but not significantly different than the LCM amendment (Table 2). Given that annual DRP loads were similar among all three amendment sources (Table 2), it would come as no surprise that differences in TP loads were mainly caused by differences between treatments in PP loads. Compared with the IP amendment, the TP loads of the SCM treatment decreased by 46.8%, which was the consequence of a 17.9% reduction in tile drainage flow volume and a 35.8% reduction in TP concentration.

Over the 4 yr, cumulative tile drainage TP losses under the IP, LCM, and SCM soil amendments represented 11.4, 9.0, and 6.0%, respectively, of TP (i.e., 50 + 50 = 100 kg P ha^{-1}) applied to the soil. It has been estimated that a loss of 1% of the P applied annually to a catchment was sufficient to impair surface water quality (Withers et al., 2003). The annual TP FWMC (0.41–0.63 mg L^{-1}, Table 2) in tile drainage water was much higher than the critical threshold of 0.03 mg TP L^{-1} for triggering eutrophic effects in lakes (Environment Canada, 2004). Thus, under the conditions of our study, P fertilizer application at a rate approximate to that of crop P removal was not sufficient to reduce TP losses to an environmentally acceptable level. Nevertheless, from an environmental perspective, SCM soil amendment is the preferred method to provide P for crop growth whenever it is available.

Percentage of Dissolved Reactive Phosphorus in Total Phosphorus in Tile Drainage Water

During the first cropping year monitored, on a cumulative basis, the ratio of DRP to TP loads in tile drainage water declined from 88 to 25% for the IP-amended soil, and from 61 to 21% for the LCM-amended soil, whereas for SCM-amended soil, it dropped from 63 to 35%, and then rose back up to 50% (Fig. 3). The peak DRP/TP ratio in the tile drainage water occurred in the period from 1 May 2008 to 16 July 2008, showing the substantial effects of surface P application on promoting DRP loss within a short period of time after application. Similarly, Kleinman et al. (2009) observed that dairy manure application increased the percentage of DRP in leachate TP from 25 to 37% in an intact soil column leaching study. Starting at the end of the first cropping year, the percentage of cumulative DRP to TP loads in tile drainage water remained relatively stable: SCM (53–56%) > IP (26–34%) ≈ LCM (22–32%). Overall, DRP loss represented a smaller fraction of TP loss in tile drainage water from both IP- and LCM-amended plots, as previously reported (Toor et al., 2004; Schelde et al., 2006; Kleinman et al., 2009). For example, Schelde et al. (2006) observed that on a well-structured soil, >80% of leachate TP was particle bound when cattle slurry had not been recently applied. The main reason for higher DRP/TP ratios with SCM amendment was that this treatment, while having similar DRP loads to the IP and LCM amendment treatments, had significantly lower PP loads in tile drainage water.

Conclusions

Inorganic P, LCM, and SCM amendments had different effects on P losses in tile drainage water after land application. Although the LCM amendment resulted in dramatically higher DRP FWMC soon after application, on an annual basis, SCM application resulted in higher DRP FWMC in tile drainage water. Across the 4 yr, annual DRP loads were similar among the three P sources due to flow volume compensating for DRP concentration. However, it might be reasonable to expect a reduction in DRP loss in tile drainage water if LCM amendment application can be arranged to avoid rainfall events immediately after application. In contrast with

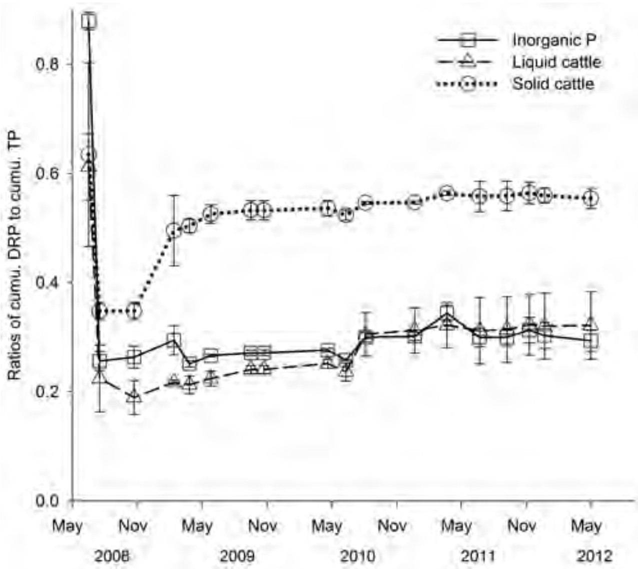

Fig. 3. Effects of inorganic P fertilizer, liquid cattle manure, and solid cattle manure application on ratios of cumulative dissolved reactive P (cumu. DRP) loads to cumulative total P (cumu. TP) loads (i.e., DRP/TP ratio) in tile drainage water. Vertical bars are standard errors (*n* = 2).

annual DRP FWMC, annual PP FWMC was lower under the SCM treatment than under either IP or LCM treatment. This may indicate that even if one selects appropriate P sources for land application, it will remain challenging to simultaneously reduce both DRP and PP losses. Along with reduced tile drainage flow volume, reduced PP and TP FWMC led to a 68% reduction in PP loads and a 47% reduction in TP loads from the SCM-amended soil, relative to the IP-amended soil. Overall, SCM is a more environmentally friendly source than the LCM to provide P for crop growth. However, we should point out that the results from the current study were based on broadcast application, which is a dominant practice in the Lake Erie basin. Further study is needed to confirm if the results are also applicable to the manure injection scenarios.

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EXHIBIT 20

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PHOSPHORUS FATE, MANAGEMENT, AND MODELING IN ARTIFICIALLY DRAINED SYSTEMS

Phosphorus Fate, Management, and Modeling in Artificially Drained Systems

Peter J. A. Kleinman,* Douglas R. Smith, Carl H. Bolster, and Zachary M. Easton

Abstract

Phosphorus (P) losses in agricultural drainage waters, both surface and subsurface, are among the most difficult form of nonpoint source pollution to mitigate. This special collection of papers on P in drainage waters documents the range of field conditions leading to P loss in drainage water, the potential for drainage and nutrient management practices to control drainage losses of P, and the ability of models to represent P loss to drainage systems. A review of P in tile drainage and case studies from North America, Europe, and New Zealand highlight the potential for artificial drainage to exacerbate watershed loads of dissolved and particulate P via rapid, bypass flow and shorter flow path distances. Trade-offs are identified in association with drainage intensification, tillage, cover crops, and manure management. While P in drainage waters tends to be tied to surface sources of P (soil, amendments or vegetation) that are in highest concentration, legacy sources of P may occur at deeper depths or other points along drainage flow paths. Most startling, none of the major fate-and-transport models used to predict management impacts on watershed P losses simulate the dominant processes of P loss to drainage waters. Because P losses to drainage waters can be so difficult to manage and to model, major investment are needed (i) in systems that can provide necessary drainage for agronomic production while detaining peak flows and promoting P retention and (ii) in models that can adequately describe P loss to drainage waters.

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*Corresponding author (peter.kleinman@ars.usda.gov).

PHOSPHORUS in drainage waters, particularly subsurface drains such as tile lines, is often mistakenly assumed to be a minor contributor of P losses from agricultural fields. However, it has been the focus of scientific inquiry and management concern for nearly four decades (Sharpley and Seyers, 1979). Around the world, P loss via artificial drainage has been shown to contribute to the accelerated eutrophication of rivers, lakes, estuaries and even coastal waters, including some of the most challenging cases of agriculturally derived eutrophication. High-profile cases of watershed P loss via drainage networks, such as in Western Lake Erie in the United States, have served to bring broader attention to the subject, even raising calls for moratoria on new drainage in agriculture.

Artificial drainage is an essential component of agricultural management in humid regions, where excessive water can limit trafficability and crop production. Even in arid regions, artificial drainage can be an important component to irrigation infrastructure, routing "return flows" away from irrigated lands. In most areas, today's base drainage infrastructure was established or defined by the initial reclamation of land for agricultural production. It should not be surprising, therefore, that modern drainage systems continue to prioritize hydraulic function over water quality management. For instance, in many US states, a local governmental entity, often the county drainage board, is charged with ensuring drainage networks (i.e., agricultural ditches and some large subsurface tile maintained by the drainage board) adequately drain land for agricultural productivity. When these boards were chartered (often more than 100 yr ago), their charge was to remove the water as quickly and efficiently as possible, not to balance nonpoint source pollution and water conservation concerns with drainage concerns.

Two primary methods are used to drain water from agricultural fields, recognizing that variations and combinations of these methods are common and that historical, or outdated drainage methods are also used (e.g., rock drains, mole drains). In finer-textured soils, drainage typically occurs through *subsurface drainage tiles*, originally made of porous ceramic material (hence the name *tile*) but today constructed of perforated plastic pipes. In very flat landscapes with coarser-textured soils that tend to have higher lateral hydraulic conductivity, *open ditches* often

P.J.A. Kleinman, USDA–ARS, Pasture Systems and Watershed Management Research Unit, University Park, PA 16802; D.R. Smith, USDA–ARS, Grassland, Soil and Water Research Lab., Temple, TX 76502; C.H. Bolster, USDA–ARS, Food Animal Environmental Systems Research Unit, Bowling Green, KY 42104; Z.M. Easton, Dep. of Biological Systems Engineering, Virginia Tech, Blacksburg, VA 24061.

Abbreviations: BMP, best management practice.

serve as the primary drainage conveyance (Needelman et al., 2007). Water is transported away from the fields via a series of increasingly larger tiles or ditches. Drainage intensity, defined by the spacing, depth, and size of the drains (Blann et al., 2009), generally increases with decreasing soil hydraulic conductivity. Drainage can vary from ephemeral (e.g., shallow, field tiles and ditches, often installed at depths <1 m), to seasonal or perennial flows in deeper ditches.

Despite periodic reviews of leaching and subsurface drainage research on agricultural P loss (Sims et al., 1998; Chardon and Van Faassen, 1999), systematic generalizations regarding the contexts, management, and modeling of P loss in drainage waters remain uneven. This collection of 16 papers seeks to establish a new benchmark in our understanding of the science, management, and modeling of P in drainage waters. The compendium represents the culmination of a symposium arranged by the Organization to Minimize P Loss from Agriculture (Southeastern Regional Information Exchange Group 17, SERA-17) and the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America held at a joint 2013 conference of these organizations in Tampa, FL. This collection of papers includes case studies, field and laboratory experiments, and reviews of P in tile drainage and modeling of P in artificially drained systems authored by researchers from North America, Europe, and New Zealand (Fig. 1).

Contexts of Phosphorus Loss to Drainage Waters

One of the broad goals of this special section is to synthesize the recent contributions to drainage water management and P loss. In that context, King et al. (2015b) provide as part of this special section an extensive review of P losses in drained landscapes. Phosphorus in drainage water occurs in all forms (dissolved, particulate, organic), and during storm flow, the concentrations and forms of P in drainage water are often similar to those in surface runoff, even when discharged from a tile drain. It is well established that soil macropores serve as major conduits for P movement through the soil profile, routing P in the soil or on the soil surface to tile drains (Jensen et al., 1998; Stamm et al., 1998; Simard et al., 2000). Frequently, macropores (earthworm burrows, root channels) serve to bypass the P buffering capacity of the soil matrix (e.g., Shipitalo and Gibbs, 2000).

The concept of hydrologic "connectivity" is key to nonpoint source P concern, with storm water flows driving the majority of P lost in runoff from agricultural soils. Hydraulic engineers, hydrologists, and biogeochemists have found it difficult to

Fig. 1. Locations of case studies and experiments compiled in the special collection on P loss in artificial drainage.

determine and quantify the importance of bypass flows on nonpoint source P loss from agricultural fields. The installation of artificial drainage not only increases peak flows, which accounts for the majority of P loss, but also connects areas of the landscape with plumbing and channels where flows were previously more diffuse (King et al., 2015a; Smith et al., 2015). In the process, P that is entrained in drainage water is concentrated along pathways where there is little interaction with the extensive P buffers found in matrix flows or retention times associated with lower hydraulic conductivities (King et al., 2015b).

Trade-offs between P transport in overland versus subsurface flow are frequently highlighted in areas where agricultural P loss is a concern (i.e., do the benefits of reduced surface runoff P losses outweigh the costs of increased P losses in drainage discharge?). In Western Lake Erie, United States, blooms of the cyanobacterium *Microsystis* temporarily overwhelmed the drinking water treatment facilities of the city of Toledo, OH, in the summer of 2014. Two of the case studies in this collection focus on drainage related P losses in the Western Lake Erie Basin. Conducted in intensively cropped areas of Indiana and Ohio, these studies document P losses from lake plain and glacial till soils that are drained by surface inlets, tile drains, and ditches (Smith et al., 2015; King et al., 2015a). Smith et al. (2015) conclude that as much as 50% of the P loads in a tributary of Indiana's St. Joe's watershed may be derived from tile drainage. King et al. (2015a) illustrate the similarities in P loss in tile drainage and surface runoff, with strong correlations between storm hydrographs and chemographs.

Ontario, Canada, borders North America's Great Lakes and is home to intensively tile drained lake plain and till landscapes comparable to those found in the Western Lake Erie Basin. Zhang et al. (2015a) summarize the results of a long-term (>40 yr) cropping systems study in which dissolved forms of P comprised the majority (72%) of total P in tile drainage. Their findings indicate that grassed systems have the potential to lose as much as three times more P through tiled systems than a cropped system (e.g., continuous corn). Differences in P loss in tile drainage between grassed and tilled systems are consistent with greater connectivity between the soil surface and the tile for the no-till grassed system through the preservation of macropores in perennial or no-till crops (Kleinman et al., 2007). In addition, the contribution of dissolved P from lysed plant tissues in the grass systems would be expected to increase loss (Bechmann et al., 2005).

The previously glaciated landscapes of northern Europe are the focus of some of the most extensive long-term studies of P losses via artificial drainage. Bergström et al. (2015) in this issue provide an overview of Swedish research with more than 50 yr of field trial data and more than 25 yr small catchment data. At the catchment scale, soil properties and weather were found to have a greater influence on P loss to drainage waters than did placement of conservation practices. Previous research by Djodjic et al. (2004), determined that P transmission through Swedish soils was greater in leachate from finer-textured soils with strong structural integrity, than in sandier soils. These generalizations are borne out by Kleinman et al. (2015), this issue, who determine that leaching of applied P (from poultry litter) through soils of the mid-Atlantic coastal plain in the United States is greater in fine-textured soils than in coarse-textured soils.

Swedish research also points to the potential for P in the subsoil to contribute to dissolved P losses in leaching waters that contribute to tile drainage. Andersson et al.'s (2015) work in the current issue highlights the potential that subsoil properties (subsoil P concentration, degree of P sorption saturation, and P sorption capacity) can contribute to P loss in leachate from both structured, fine-textured soils and unstructured, coarse-textured soils. Even though the Swedish research focuses on moderately fertilized systems, their findings are consistent with those of Kleinman et al. (2015) in intensively manured soils of the coastal plain region of the mid-Atlantic United States, where historical application of poultry litter has produced much higher levels of P sorption saturation. Kleinman et al. (2015) report significant, positive relationships between P in surface soils (0–5 cm) and P concentrations in leachate but also find subsoil P (45–50 cm), which was lower than P at the surface, to also relate to P concentrations in leachate. Correlation between surface and subsoil P made it difficult to discriminate between the effects of these sources on leachate P concentrations.

With studies dating back to the 1970s (e.g., Sharpley and Seyers, 1979), New Zealand also has a long history of research on P loss in artificial drainage. In the current issue, McDowell and Monaghan (2015) describe recent experiences with the expansion of drainage (open ditch and mole drain) on dairy farms located on marginal lands of the south island of New Zealand. Despite moderate soil P levels, drainage from an organic soil resulted in some of the highest P loads on record (87 kg P ha^{-1} over 18 mo, nearly 60 kg P ha^{-1} yr^{-1}). In comparison, Kleinman et al. (2007) reported loads of 20 to 30 kg P ha^{-1} yr^{-1} in drainage ditches from coastal plain soils of the mid-Atlantic, with a large "legacy P" source (soil P that had accumulated following 30 yr of poultry litter application in excess of crop P requirement). McDowell and Monaghan's (2015) points to the potential for recently applied sources of P to contribute to P in drainage waters from organic soils with low P buffering ability, consistent with the findings of Cogger and Duxbury (1984).

In semiarid environments, return flows from irrigated fields to drainage networks can be source of P to downstream water bodies. However, in the Upper Snake Rock watershed (Idaho) case study described by Bjorneberg et al. (2015) in this issue, water diverted from the Snake River annually supplied 1.1 kg ha^{-1} of total P to the 82,000-ha irrigation tract, while irrigation return flows contributed only 0.71 kg ha^{-1} of total back to the Snake River. The significant reduction of P in the return flows shows the potential for conservation practices to improve water quality in artificial drainage, particularly under highly regulated irrigated systems. For instance, in the Upper Snake Rock watershed, there has been a gradual conversion of irrigation systems from furrow irrigation to sprinkler irrigation. Furrow irrigation contributes high concentrations of sediment and P in return flow (Bjorneberg et al., 2006). In addition, "water quality" ponds designed to mitigate sediment and P losses from the watershed were shown to reduce total P in influent from 36 to 75%, although they had little effect on dissolved P.

Management of Phosphorus Losses to Drainage Waters

It is well recognized that the successful management of artificial drainage requires a systems-level approach in which all aspects of an operation are considered and managed in concert (Strock et al., 2010). The management of P loss in artificial drainage includes the panoply of practices affecting nonpoint source P loss, from balancing P inputs and outputs at catchment, farm and field scales to minimize legacy sources of P (Kleinman et al., 2011) to managing applied sources of P to fields (King et al., 2015b), to agronomic management (Bergström et al., 2015; Han et al., 2015), to drainage water management and filtration (Buda et al., 2012; Nash et al., 2015; Zhang et al., 2015b). While most management studies included in this special section focus on individual practices, it is recognized that the performance of these practices is decidedly site specific. Even so, many of the practices that have been tested show broad promise for mitigating P losses to drainage waters.

Controlling Phosphorus Sources to Drainage Waters

Sources of P to drainage water include recently applied sources (manure, fertilizer), soils, sediments and even vegetation. Growing awareness exists of the role of legacy sources of P to nonpoint source pollutions (Jarvie et al., 2013; Sharpley et al., 2013). In areas where P accumulates due to the concentration of livestock or high value-horticulture and/or vegetable production, accumulation of P in soils and sediments over the long term can create a source of P to drainage water that is extremely difficult to manage. Bergström et al. (2015) review long-term soil fertility trials in Sweden, revealing strong positive relationships between soil P concentrations and dissolved P concentrations in leachate. Strategies are needed to draw down higher levels of soil P so that this legacy source of P to drainage water can be minimized.

Tillage has been proposed as one means of addressing legacy P, by diluting high P concentrations at the soil surface, bringing sources of P sorption capacity from the subsoil to the surface, and breaking macropores that connect the high concentrations at the surface with drainage conduits (Sharpley, 2003; Shipitalo et al., 2000). The results of Han et al. (2015) presented here suggest that in soils with deeper sources of legacy sources, mitigation strategies that address these sources are required to curb P losses in subsurface drainage. They performed simulated tillage (to 20 cm) on 50-cm-deep columns of mid-Atlantic (United States) coastal plain soils with varying textures (from sand to silt-loam) and varying, albeit high, levels of antecedent soil P (Mehlich-3 P at 0–2 cm was 124–283 mg kg^{-1}). Mixing the upper 20 cm of soil to simulate tillage did not substantially reduce soil P concentrations for most of the soils, compared with a control with no mixing. Based on N dynamics in leachate, Han et al. (2015) determined that the simulated tillage did indeed help to decrease solute transfers from the soil surface through macropores and promote matrix flow (applied urea-N leaching was significantly reduced). Therefore, in heavily P saturated soils with legacy sources of P in the subsoil (>20 cm), deeper forms of tillage may be required to see a benefit from this practice.

Recently applied sources of P can serve as acute sources of P in drainage waters. Zhang et al. (2015b) in the current issue evaluated differences in P loss from tile drains following the application of different composts (derived from yard waste or swine manure) to a fine-textured soil over a 4-yr period in Ontario. Substantially greater concentrations (mg L^{-1}) and losses (kg ha^{-1}) of dissolved and particulate P in tile drainage occurred with swine manure compost than with the unamended control or yard waste compost. Elsewhere, Kleinman et al. (2015) point to the soil-specific nature of P leaching from applied sources to shallow groundwater. They broadcast poultry litter (4.5 Mg ha^{-1}) to different agricultural soils of the mid-Atlantic coastal plain. Leachate P losses increased most with poultry litter addition for the finest-textured soils, contributing 41 and 76% of total P loss in leachate from these soils. As noted above, Djodjic et al. (2004) also found that finer-textured soils that preserve structural attributes such as macropores transmit more P from the soil surface than do coarse-textured soils with lesser structural integrity.

Agronomic Management

Considerable opportunities exist to modify agronomic management or to implement practices aimed at curtailing P loss to drainage waters. Bergström et al. (2015) reviewed Swedish studies evaluating best management practices (BMPs) to reduce P leaching losses including catch crops (i.e., cover crops), constructed wetlands, structure liming of clay soils, and manure management. At field and plot scales, the effects of BMPs on drainage P losses could be quite pronounced. For instance, loads of total P in drainage water were reduced by 36% with wetland installation, by 39 to 55% with structure liming [addition of CaO or $Ca(OH)_2$, which improves structure and promotes Ca-P precipitation], and by 50% with incorporation of liquid swine manure into a clay soil instead of leaving the broadcast manure unincorporated. In contrast, experiments with eight different catch crops revealed no clear pattern in P concentrations with practice implementation. At broader, catchment scales, the beneficial effects of BMPs on P losses have been even more elusive to quantify. Long-term trend analysis of water quality from small Swedish catchments in which various BMPs have been implemented since the 1980s revealed no clear pattern with practice implementation.

Control and Treatment of Tile Drainage

Controlled drainage utilizes coffer dams to more precisely regulate artificial drainage and has been shown to dramatically reduce annual drainage losses of N, primarily due to lesser discharge. However, concern has existed over the potential for greater dissolved P losses with controlled drainage due to the reductive dissolution of Fe-P during periods of water stagnation. Indeed, based on simulated conditions in a laboratory study, Sanchez Valero et al. (2007) concluded that elevated water tables produced by drainage water management could increase P export in subsurface drainage following the reductive dissolution of Fe-bound P in waterlogged soils. While issues remain over the timing of discharges under controlled drainage (drains are typically free flowing in the spring, when concern over P discharges is often greatest), field trials with controlled drainage have documented some significant benefits, including reduced P loss and improved yields.

Nash et al. (2015) evaluated the effects of controlled drainage on P loss in tile drains from soils under corn production where seasonal perching of water above a claypan was a concern in New Zealand. They found that flow-weighted dissolved P concentrations from controlled drainage were significantly lower (0.09 mg L^{-1}) than with conventional, free tile drainage (0.15 mg L^{-1}). Dissolved P losses, which were admittedly low compared with some of the other studies reported in this special collection, were reduced by 80% compared with free drainage, consistent with literature reports on nitrogen. Notably, and in contrast with previous research, the lesser dissolved P losses were not solely due to lesser flows from tiles with controlled drainage (63% less than free draining tiles). In particular, during the spring period, when coffer dams were open and flow between controlled drainage and conventional tile drains was similar, concentration of dissolved P in drainage water from the controlled drainage tiles were lower than with conventional, free draining tiles. Nash et al. (2015) speculate that better conservation of controlled drainage water during dry summer months increased crop uptake of water and P, decreasing field sources of P available to drainage later in the year.

Zhang et al. (2015b) compare controlled drainage combined with subirrigation and free drainage on P losses from tile drains in Ontario. Subirrigation is increasingly practiced in the region using tile networks. Zhang et al. (2015b) determined that this creative use of controlled drainage could be an effective means of curtailing all forms of P loss (dissolved and particulate) from tile drainage, both by decreasing flows and by lowering P concentrations. However, these benefits were overwhelmed by the addition of swine compost, pointing to the need to pair nutrient management with drainage management. In addition, monitoring of tile drains across Quebec by Stämpfli and Madramootoo (2006) suggests that subirrigation can substantially increase dissolved P concentrations in tile discharge. Therefore, careful consideration is needed when pairing practices such as subirrigation and tile drainage.

Tile risers are open inlets that connect subsurface tile lines with depressions or internally drained areas of agricultural fields providing a direct conduit for runoff carrying sediment and solutes to surface waters. Feyereisen et al. (2015) herein describe research with "blind" inlets in which previously open surface inlets were capped with soil and gravel to promote filtration without severely restricting drainage. Over 7 yr of paired comparisons between open and blind inlets in Indiana, total P and dissolved P loads were 66 and 50% lower from blind inlets than from open inlets. Total suspended solids loads were 64% lower from the blind inlets than from the open inlets. In Minnesota, the conversion of an open inlet to blind inlets resulted in a decline in median total suspended solids concentrations from 97 to 8.3 mg L^{-1} and a decline of median dissolved P concentrations from 0.099 and 0.064 mg L^{-1}. This promising new technology has an expected service life of at least 10 yr, based on results from the Indiana study.

The treatment of P sources and P in drainage waters to trap or capture particulate and dissolved forms of P has received great attention over the past decade. In parallel, denitrifying bioreactors have emerged as a practice for removing nitrate from tile drainage. In this issue, Bock et al. (2015) evaluated alternative bioreactor designs to couple denitrification with P removal. Nine laboratory-scale bioreactors were evaluated with and without biochar derived from different hardwood and pine materials. The use of biochars in the bioreactors lowered dissolved P concentrations by 65% over 18 h compared with an 8% increase in dissolved P concentrations within the bioreactor with no biochar after 72 h. In addition, these biochars decreased nitrate concentrations, on average, by 86% after 18 h and 97% after 72 h, compared with only 13% at 18 h and 75% at 72 h in the control. While the results of Bock et al. (2015) clearly point to the potential for biochar to expand the benefits of bioreactors to remove P and reduce the design residence time by enhancing nutrient removal rates, it is important to point out that the biochar feedstocks were materials with low antecedent P concentrations. Increasingly, biochars derived from manure are being tested as value-added products for livestock farms. Undoubtedly, the results of Bock et al. (2015) would be different if biochars derived from poultry litter or other high P byproducts were used.

Drainage Ditches

While the focus of this special issue is on tile-drained fields, drainage ditches are also an important and commonly used management practice for removing excess water from agricultural fields. The management of drainage ditches for water quality protection is, however, distinctly different than the management of tile drains. The geometry, or channel characteristics, of a ditch is key to its function in conveying water, sediment, and P. Two-stage ditches, which use a trapezoidal geometry to support a stable bench within the ditch, help to reduce the velocity of drainage flows by widening the ditch and promoting sedimentation on the bench (Powell et al., 2007; Strock et al., 2010). Vegetation also plays an important role through bank stabilization and physical trapping of sediment (Moore et al., 2010; Liu et al., 2013), although vegetation can adversely affect the hydraulic function of a ditch by creating impoundments during peak flows thereby reducing drainage flows.

A growing body of research examines the potential to establish impoundments and diversions in drainage ditches that promote processes of sedimentation and hyporheic exchange that may diminish particulate and dissolved P losses (Pierce and R. Kröger, 2011). Some of these practices fall under the category of constructed wetlands, as many argue that drainage ditches should be considered "entrained wetlands." Indeed, in the Lake Erie region where very small loads of agricultural P in drainage water discharge are of critical concern (<2 kg ha^{-1}), in-ditch and in-stream options for nonpoint source P mitigation have become a priority focus.

Ditch dredging is frequently cited as a management practice of concern, due to the severe disturbance caused by the activity and instability of banks following dredging. This can result in increased bank erosion (hence particulate P loss) and removal of bed materials with a high P sorption capacity leading to ditches becoming a P source rather than a P sink (Needelman et al., 2007; Sharpley et al., 2007; Smith and Pappas, 2007; Shigaki et al., 2008). In some instances, however, short-term increases in P retention have been observed following ditch dredging (Smith and Huang, 2010). As is the case with tile-drained fields, many questions are still to be answered regarding the use of drainage ditches for effectively removing water from agricultural fields without significantly increasing risks of P loss.

Modeling of Phosphorus Loss to Drainage Waters

Despite the mounting evidence that artificially drained agroecosystems can be significant sources of P loading to P-sensitive water bodies, the development, implementation, and evaluation of P fate and transport models in these systems is lacking. For models to be effective tools, they must accurately capture the important processes governing P fate and transport in the system of interest. It is important, therefore, that research be directed at better understanding the processes controlling P in artificially drained agroecosystems and that models specifically designed for these systems are developed and tested. In addition to these priorities, there remains a need for more data to calibrate and test models in artificially drained systems and for reasonable estimates of uncertainties in model predictions (Radcliffe et al., 2015).

In the current issue, Radcliffe et al. (2015) first identify the critical processes controlling P loss in artificially drained systems (Fig. 2), then review the following models that have been used, or have the potential to be used, for modeling P losses in artificially drained fields: the P Index, ADAPT, APEX, DRAINMOD, HSPF, HYDRUS, ICECREAMDB, PLEASE, and SWAT. With the exception of the ICECREAMDB model, the models reviewed by Radcliffe et al. (2015) were not developed specifically for predicting P loss in artificially drained agroecosystems. Not surprisingly, ICECREAMDB is deemed by the authors as the best option for modeling P losses in artificially drained systems. In addition, some important limitations in applying the remaining models to artificially drained systems are highlighted and recommendations are given on how some of these models could be improved. Several of the models do not directly account for artificial drainage but rather simulate drainage indirectly (APEX and HSPF). Important limitations in the P routines are also noted for most of the models, including omission of important P loss pathways such as leaching through the soil matrix (SWAT), transport through macropores (APEX, PLEASE, SWAT, and nearly all versions of the Phosphorus Index), and particulate P losses in surface runoff or through the soil matrix (HSPF, HYDRUS, PLEASE); DRAINMOD and HYDRUS currently lack P specific routines. P Indices were deemed too simplistic to adequately represent fate and transport of P in artificially drained systems.

Also in this issue, Que et al. (2015) present results from their study using the Annualized Agricultural Nonpoint Source model (AnnAGNPS) to predict effects of controlled drainage on nutrient and sediment loads in a 3900-km^2 agricultural river basin in Ontario. While the model-predicted changes in runoff due to controlled drainage were generally consistent with changes in runoff measured from small (250 and 470 ha) paired watersheds within the basin under controlled and conventional drainage, the model-predicted changes in P loading only agreed with observed changes from the paired watersheds 50% or less of the time. The authors hypothesize that the ability of AnnAGNPS to predict P losses in flat tile-drained landscapes could be improved by modifying the model to account for P transport in the subsurface and in tile drainage; they caution,

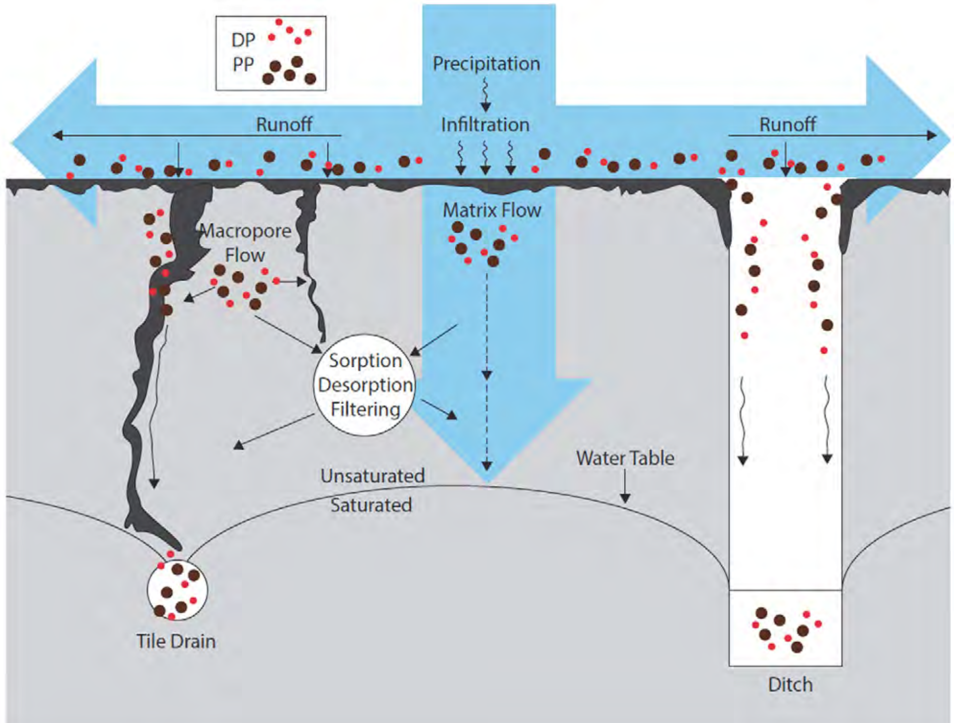

Fig. 2. Representation of processes controlling P losses in artificially drained systems. DP, dissolved phosphorus; PP, particulate phosphorus. Adapted from Radcliffe et al. (2015).

however, that modeling at large spatial scales, particularly in mixed-use watersheds, requires parsimonious parameterization.

Improving the Science, Management, and Modeling of Phosphorus in Drainage Waters

Artificial drainage in agricultural landscapes is fundamental to the productivity of agriculture in many areas of the world, but it increases the connectivity of fields to downstream water bodies and can increase P losses from agriculture. Strategies to mitigate P loss through artificial drainage must weigh trade-offs between increased production and potential increases in P loss. Following roughly four decades of research on P in drainage waters, a solid foundation of knowledge exists on factors controlling the fate and transport of P in artificial drainage. Even so, the site-specific nature of P mobility can confound generalizations regarding P in drainage waters. By the same token, trade-offs associated with drainage must be better documented to inform farmers, action agencies, and watershed management organizations. For instance, trade-offs between greater connectivity of agricultural fields with intensification of tile drainage and lesser contribution of surface runoff to watershed discharge must be better quantified. From this collection of papers, we have identified the following priorities for improving the science, management, and modeling of P in drainage waters.

Knowledge Priorities

- Decisions on whether to intensify drainage require a clear understanding of the trade-offs between P losses in overland flow versus losses in tile or ditch flow. Techniques that discriminate between surface and subsurface sources of P in drainage water are needed to better target management practices.

Management Priorities

- Determining the trade-offs of cover crops on different forms of P loss in artificially drained systems is needed to ensure benefits in particulate P control are not overwhelmed by greater dissolved P losses.
- Quantifying trade-offs of tillage management on P sources and P transport in artificial drainage (no-till, strip till, conventional tillage) is necessary to define the correct mix of practices.
- Developing filters that maintain hydraulic function of drainage systems but remove P (particulate and sediment) that can be widely adopted.
- Irrigation systems need to be developed that minimize P loss to drainage waters.

Modeling Priorities

- Field studies designed to increase our understanding of the mechanisms controlling P fate and transport in artificially drained systems are needed to correctly formulate and parameterize models.
- Watershed- and field-scale models for artificially drained systems must be tested against measured P losses in drainage waters.

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EXHIBIT 21

BENNETT & WILLIAMS

ENVIRONMENTAL CONSULTANTS, INC.

98 COUNTY LINE ROAD WEST • SUITE C • WESTERVILLE, OHIO 43082
TELEPHONE: (614) 882-9122 • FAX: (614) 882-4260 • 1-800-635-3810

March 7, 2023

Robert Michaels, Senior Attorney
Environmental Law and Policy Center
35 East Wacker Drive, Suite 1600
Chicago, IL 60601

Dear Mr. Michaels:

Privileged and Confidential
Attorney Work Product

As requested, we have prepared the following discussion about the impact of applying liquid waste derived from concentrated animal feeding operations (CAFOs) to farm fields in the Maumee River Basin that drains into the Western Lake Erie Basin. We have focused on the application of these waste products to tile-drained fields used for the production of corn and soybeans, as is common in the three state (Indiana, Michigan and Ohio) Maumee River Basin.

As discussed in this letter, we have the following conclusions:

- Fields in the Maumee River Basin are usually drained using subsurface tile drains;
- The soils in the Maumee River Basin are prone to fracturing resulting in the rapid transport of dissolved reactive phosphorus (DRP) to tile drains and drainage ditches;
- Liquid animal manures are widely applied in this watershed;
- When liquid manures are applied to the surface, they pool on the field, then drain through macropores to the subsurface and/or are washed offsite as runoff;
- DRP moves through the subsurface with water and will enter the tile drains or recharge baseflow of the streams;
- Tile drains and baseflow discharge to drainage ditches or streams, transporting the DRP to the Western Lake Erie Basin;
- We have known since 2013, that over 90% of DRP delivered to the Western Basin of Lake Erie came from agricultural practices (including the application of liquid manures); and
- Standard BMPs and the 4Rs (right source, right rate, right time and right place) have not been effective at reducing DRP impact to the Western Lake Erie Basin.

The resumes for the authors are provided in Attachment A. Dr. Julie Weatherington-Rice is a soil scientist with extensive experience in the Western Lake Erie Basin over the last forty years. Dr. Weatherington-Rice has been a pioneer in the science and applications relating to water flow in soils, specifically as it relates to secondary porosity and fracture flow. Dr. Kerry Zwierschke is a Professional Engineer in the state of Ohio with extensive experience in environmental and agricultural engineering. Dr. Zwierschke has over fifteen years of experience with data analysis, engineering, hydrology, hydrogeology and contaminant transport in Ohio.

Water and Contaminant Movement in Soils

Water and contaminants that move with water move downward through the soil profile in two ways. Water and dissolved contaminants move through primary porosity matrix flow and through secondary porosity macropores. Primary porosity is the space between the particles of the soil matrix while secondary porosity (for example fractures) is formed post-deposition. When thinking about primary and secondary porosity, it can be helpful to think about a brick. The particles of a brick can be thought of as grains of soil. If a brick is submerged in water, the inside of the brick only gets wet after an extended period of submersion (primary porosity). If you pile bricks up and pour water over them, water is primarily transported around the bricks through the gaps (secondary porosity). A PowerPoint presentation addressing these pathways *"How water moves from the surface to underlying aquifers"* can be found on the Association of Ohio Pedologists (AOP) web site (Weatherington-Rice, 2022a).

Secondary macropores include physical/chemical-controlled fractures and biologically-controlled biopores that are formed by plant roots and earthworms. Soil scientists have been studying these processes for more than half a century and can determine if secondary porosity will control discharge, allowing for the rapid migration of liquid manures into tile drainage systems (where present) and into the receiving waters. This research has not been restricted to Ohio but has been documented and established worldwide. We have included references from Pennsylvania (Yu et al., 2014), Iowa (Burkart et al., 2004; Helmke et al., 2005) and Canada (Dadfar et al., 2010). As a result of this research, it is possible to predict whether a soil will fracture and, therefore, whether water movement by secondary porosity is a significant pathway for transport of water and contaminants. See Attachment B for additional technical information.

Maumee River Basin Soil Types

The Maumee River Basin is a significant drainage source for the Western Lake Erie Basin and incorporates portions of southeastern Michigan (drained by the St. Joseph River); northeastern Indiana where the Ohio/Indiana St. Marys River and the Michigan/Ohio/Indiana St. Joseph River converge at Fort Wayne to form the Maumee River; and northwestern Ohio. This area is the subject of a United States Geological Survey Water-Resources Investigation Report (Myers and Metzker, 2000). The soils in Ohio, Indiana and Michigan within the watershed are derived from glacial tills (occasionally tile-drained for agriculture), fine-grained stratified sediments (lacustrine deposits, almost always tile drained for agriculture) and coarse-grained stratified sediments (beach ridges and dunes from previous glacial lakes that usually are relatively permeable and do not require tile drainage) (Figures 1 and 2).

The majority of the Maumee River Basin is in Ohio and is incorporated into the Huron-Erie Lake Plains in the *Physiographic Regions of Ohio* map (Figure 3). The *Soils Regions of Ohio* map identifies the area as Region 1-the Lake Plains (Figure 4). The primary soils associations of the agriculturally tile-drained portions found in the region are Hoytville, Nappanee, Paulding and Toledo soils. Because of the nature of the lake-derived glacial deposits and the overlying lacustrine materials, for the most part, these soils are clay loams, silty clays, silty clay loams, loams, and sandy loams. Where beach ridges are present, the Toledo soils can be classified as loamy fine sands or sands. These soil classifications are critical because they can be used to determine if an agricultural field will drain primarily through secondary porosity macropore flow or by primary porosity.

When the soils of Region 1 of the Ohio map are matched against Kim's Textural Triangle (Figure 5), the Hoytville, Nappanee and Paulding soils fall within the area expected to be fractured (unshaded area in Figure 5). Those that are too coarse to be within the fractured zone have 76% or more sand content and, therefore, have such high primary porosity that water and dissolved contaminants drain rapidly through the soil profile in the absence of secondary fractures. Given these soils, water applied to agricultural fields in the Maumee Basin will drain rapidly through the soil profile either by primary porosity (sandy soils in the colored area of Figure 5) or by secondary macropore porosity (soils in the unshaded area of Figure 5).

Tile Drainage in the Maumee River Basin

Historically, the fine-grained lacustrine lowland of the Maumee River Basin was known as the Black Swamp. It was considered unusable before the advent of subsurface agricultural drainage systems. While the larger region settled in the early 1800s, the Black Swamp took longer to settle because extensive drainage systems had to be installed to make the land usable for agriculture. These efforts began about 1850 and continue to this day.

Subsurface drainage (also referred to as tile drainage) is accomplished today by burying perforated plastic pipes in the ground (previously clay or other materials were used). Excess water in the soil profile enters the pipes and is removed from the soil to artificially lower the water table (Ghane, 2018). According to Myers and Metzker (2000), in 1994 approximately 70% of the Maumee River Basin was agricultural. Given the soils in the watershed, in order to be used for agriculture, the water table in these areas must be lowered using subsurface drainage. AgTile-US (Valayamkunnath et al., 2020), provides estimates for land in the USA which uses subsurface tile drainage (Figure 6). Figure 6 shows that the Maumee River Basin has many areas that have subsurface drainage tiles.

Use of Liquid Animal Manure in Agriculture

During the 20th century, dry commercial fertilizer (P_2O_5) was applied at the same time that the seed was planted. The dry fertilizer was placed in a box on the planting bar next to the seed box and the fertilizer was spread into a trench next to the seed trench and then both trenches were closed (using two and four row corn planters). This application was known as banding. These fertilizers were commercially available in the Maumee River Basin. For instance, Federal

Fertilizer built their plant in 1950 in Butler, Indiana in the watershed, six miles from the Ohio State line, (City of Butler Indiana, 2022). Phosphorus applied in this form binds to the soil until plant roots absorb it for plant growth. Therefore, if the soil stays in place, so does the phosphorus (Weatherington-Rice, 2022b).

However, even in the flat Western Lake Erie Basin, soil erosion occurs. With the movement of soil off the farm fields, the dry phosphorus also left the farm fields, contributing to the loading of phosphorus in Lake Erie. By the 1980s, The US Department of Agriculture (USDA) Soil Conservation Service (SCS), later the Natural Resources Conservation Service (NRCS) and the local county soil and water conservation districts encouraged the implementation of no-till and reduced tillage farming practices to reduce soil erosion from farm fields. These efforts were successful and phosphorus levels in Lake Erie reduced as erosion from fields was also reduced.

After 2000, the DRP levels in Lake Erie started to increase. While the phosphorus loading rates associated with erosion diminished (which came from solid P attached to soil particles being washed off the fields into rivers that discharge to Lake Erie), the dissolved reactive phosphorus (DRP) levels began to increase. This situation has continued to affect the water quality of the Western Lake Erie Basin (Weatherington-Rice, 2022b). A primary driver of this rebound is that phosphorus was being applied to agricultural fields in the watershed in different forms. Farmers moved away from using a commercial dry form of phosphorus to using animal-based manure sources of phosphorus and broadcast phosphorus fertilizer. Currently, most phosphorus being applied in the watershed comes from two sources, liquid animal manures (which are mostly water and can be surface applied or injected below the surface of the soil) and commercial fertilizer which is often dry.

As farm fields got larger and farming equipment got larger and was able to plant many more rows of seed, the spacing on the tool bar replaced the fertilizer boxes with more seed boxes. This necessitated a different application method for the phosphorus fertilizer. The current common practice is to broadcast the phosphorus fertilizer over the surface of the fields in the fall after harvest. For efficiency, farmers typically apply enough phosphorus for two to four years of plant growth.

Starting in the 1970s, traditional, low concentration animal husbandry (resulting mostly in solid manure) began to be replaced with CAFOs and smaller concentrated animal husbandry systems that use less land and use liquid manure handling systems. This trend became more pronounced in the 1990s. To accommodate these larger facilities, SCS/NRCS and OSU Cooperative Extension encouraged the building of liquid waste handling systems. Often, cost-share funds were offered as incentives.

Why did the use of liquid animal manure as fertilizer increase? Initially, farmers switched because they had to pay for the commercial fertilizer and they could get the liquid manure for free, even often applied for free, because it was a waste product. As CAFOs increased in size and number, producers were often left with more liquid animal manure than they had farm fields for application, so the liquid manure was transported to other farm fields in the vicinity for use as fertilizer (Weatherington-Rice, 2022b). Under the current brokerage system, farmers pay a minimal charge for liquid manure used to fertilize the fields. Figure 7 shows the increase of animal units in the watershed after 2000. Ohio EPA estimates that there is 80% more liquid animal manure being generated in the watershed than there was in 2000. Only large facilities are regulated and more large facilities are waiting to be permitted.

The other factor is that with changes in farming equipment, application methods changed. Liquid manure has a high water content because of the equipment used to apply it to farm fields. If it were drier (a thicker slurry), the manure solids would clog the spray nozzles (used to surface apply the liquid manure) and the injectors (used to inject the liquid manure into the soil below the surface). Simply thickening the manure (which would reduce the mobility of the solids and associated nutrients through the subsurface) would require a new type of machinery to be built, manufactured and purchased.

It is important to note that CAFOs and animal facilities that generate liquid manure are not distributed evenly throughout the Maumee River Basin. The Environmental Working Group (EWG) compiled data for the watershed draining into the Western Basin of Lake Erie (EWG, 2022) showing that many animal feeding operations are not permitted (purple) and also that they are concentrated in different areas of the watershed (Figure 8). Figure 8 should be compared to Figure 9 that shows where the crop farms are located (Myers and Metzker, 2000). Given that liquid manure must be transported from each animal feeding operation and applied to fields, fields in close proximity to an animal feeding operation are the most economically viable for disposal of this wastewater.

Behavior of Liquid Waste Applied to Tiled Fields

When water is applied to cropland, it can take several routes (Figure 10). Some can be absorbed by the growing plants in the field and be transpired back into the atmosphere. Some can directly evaporate back to the atmosphere. Some can run off the field to the closest body of water as surface runoff. Some can be move through the soil profile and enter agricultural field tiles and discharge as tile drainage. Some can seep down to become baseflow for surface water or it can continue to move downward and recharge the regional groundwater flow. The relative amounts of water following each route depends on the time of year, soil type, and other environmental conditions. When water moves through the soil profile it can move through primary porosity or secondary porosity. In the Maumee River Basin, much of the time (with the exception of late winter and early spring when the soil is frozen or waterlogged), water will primarily move through the soil profile through the fractures/macropores (secondary porosity).[1]

[1] There is an uncommon exception to the pathways illustrated in Figure 10, depending on the prevalence and condition of biopores. In soils that are in long term no-till, that have not suffered any compaction from farming equipment and where each biopore and fracture are inhabited by living and healthy earthworms, the earthworms will block up the biopores and fractures to avoid being dosed with liquid manure. They will maintain the blockage until the liquid manure has migrated into the soil matrix and/or been washed off the site via surface flow. If the soil is compacted, little to no migration into the soil is physically possible unless macropores are available to transport the liquid and the liquid manure will remain pooled on the surface until it is either evaporated or is washed off the field with the next rain event. In September 2021, Frank Gibbs gave a zoom presentation updating the most recent findings about the success of healthy earthworms in biopores blocking rapid water movement through secondary porosity to tile drainage and underlying baseflow. The presentation was given at the OARDC Northwest Agricultural Research Station near Hoytville, Ohio. The presentation was part of the Association of Ohio

Liquid animal wastes are more than 90% water and they behave the same as water when applied to farm fields. Therefore, in tile drained fields, some liquid manure will be absorbed by growing plants, some will evaporate, some will be washed off as surface runoff and enter surface water, some will drain through the soil profile until it enters tile drainage and is discharged to surface water, some will seep down and become baseflow to surface water bodies and some will recharge the regional groundwater. Therefore, the application of liquid manure to agricultural fields in the Maumee River Basin results in transport of DRP (and other constituents, including nitrogen and bacteria) in the liquid manure to the rivers and into Lake Erie through surface runoff, migration to tile drainage, and/or transport in baseflow.

Frank Gibbs, reported in the August 20, 2006 article in the State Line Observer, made an eloquent plea for reducing the amount of water in the liquid manure (Attachment C). He explained his research that encountered liquid manures moving through the soil to the tiles in a matter of minutes, even when the conditions were ideal for application of liquid manure. Gibbs pointed out that even when the farmer did everything right, the liquid manure still moved rapidly into the tile.

Much of the initial Gibbs and Shipitalo research was done in northwest Ohio, because Gibbs was stationed in Findlay. The Ohio Fracture Flow Working Group has held field days all over Ohio that used Gibbs' tile smoker. These field days also used a technique developed by Ralph Haefner and the United States Geological Survey Water Section in Ohio to dye fractures with an environmentally safe dye. No matter the tillage practices and the soils, fractures and biopores transferred smoke indicating the presence of macropores. Photographs from a demonstration in Wooster, Ohio (outside the Maumee River Basin) are included in Attachment D. During this demonstration, a field tile was located that drained both a corn field and a hay field. The corn field had been reworked as much as possible-moldboard plowed, disked, raked, planted and cultivated several times for weed control prior to planting with corn. The expectation was that this amount of disruption would have eliminated transport via secondary porosity (macropores). Nonetheless, smoke traveled through the tile, into the corn field and was visible at the surface. Similar demonstrations have been done throughout Ohio, and all demonstrate the prevalence of macropores and, therefore, the transport of water and associated contaminants via secondary porosity.

The phosphorus in liquid animal wastes exists primarily as DRP. Phosphorus, in this form binds poorly to the soil, instead, it moves through the soil with water. Trying to get DRP to bind to compacted soil clods is like trying to get water to soak into a brick. It's possible to put a brick in a pail of water and wet the outside of the brick, but the brick would have to soak in that bucket for a very long time before much water would soak into the interior of the brick. Before the DRP can be sorbed to the soil, the water and the DRP applied to the field, is transported through the soil profile through secondary porosity (Weatherington-Rice, 2022b).

Pedologists (soil scientists) Fall Field Days continuing education program. The zoom presentation was captured on video, has been edited, and will soon be available on the Association of Ohio Pedologists web page, https://www.ohiopedologist.org/education.

Liquid manure (and the DRP and dissolved nitrogen) moves through the soil to the underlying tile drainage systems (where present), which degrades water quality and impairs the receiving bodies of water-streams, rivers and lakes. These relationships were studied at length by the Ohio Lake Erie Phosphorus Task Forces I and II and were documented in their final reports (April 2010 Final Report and the November 2013 Task Force II Final Report). This Task Force determined that 90% of the DRP delivered to the Lake Erie Western Basin came from agricultural practices, much of which came from the field application of liquid animal manures. These liquid manures rapidly move offsite and into the receiving waters of the tributaries to Western Lake Erie. Julie Weatherington-Rice served as the Ohio Academy of Science Fracture Flow Working Group representative on both Task Forces.

Effect of Best Management Practices (BMPs) on DRP Loss through Tiles

There are many factors that contribute to the movement of DRP into the Western Lake Erie Basin. Some are beyond our control and beyond the scope of a TMDL. For example, changes in rainfall patterns relating to climate change, and increase in the pH of precipitation. It is, therefore, imperative that we address practices within the Maumee River Basin that are within our control to reduce DRP transport to surface water. Addressing agricultural pollution is difficult due to the diffuse nature of this pollution. However, there are steps that can be taken to reduce the transport of DRP to the Western Lake Erie Basin from agricultural land uses. As with most environmental problems, there are options for addressing DRP transport from agricultural land. Current options include treating subsurface drainage and runoff to remove DRP; changing application methods to reduce the transport of DRP to surface water; and changing the way in which pollution sources (including manure from CAFOs) are handled prior to application.

Management of nutrient loading from farm fields has traditionally been achieved using the 4Rs (applying fertilizer from the right source, at the right rate, at the right time and in the right place) and using BMPs. Traditional BMPs, associated with reducing phosphorus loading to rivers, streams and lakes, target soil erosion. Before the advent of no-till cropping and the use of liquid animal manures for fertilizers, the spring application of granular fertilizers was common. The majority of phosphorus loss from fields was, therefore, a result of erosion of the soil and concomitant transport of sorbed phosphorus to surface water bodies. BMPs that address soil erosion (including no-till, low till, grassed waterways, cover crops and buffer strips) address phosphorus loading by reducing the transport of phosphorus sorbed to soil particles (Winsor, 2023). However, these BMPs do not significantly reduce the transport of DRP from liquid animal manure to surface water via subsurface drainage.

Liquid animal manure can be spread on the surface of fields or injected into the soil. When surface applied, the DRP in liquid manure can be washed from the fields if rainfall occurs shortly after application. When liquid manure is surface applied or injected, some portion of it can be transported through the subsurface (through macropores) to drain tiles and transported to surface water; or it can migrate through the subsurface to the groundwater where it can be discharged as baseflow to the surface water. When liquid manure is injected into the soil (below the surface), it was thought to minimize movement to the tiles. However, as Gibbs discussed (Attachment D), even with good conditions and correct equipment, the water and transported contaminants appears rapidly in the tile drains. One effect of this is that DRP and other contaminants are rapidly transported to surface water and subsequently to the Western Lake Erie Basin. The other impact, is that the liquid manure that is applied to fields to provide nutrients for plants, is removed too rapidly for crops to take up the nutrients.

Liquid animal manures (applied to farm fields) have been transported through subsurface drainage and into receiving streams, resulting in fish kills. Hoorman and Shipitalo (2006) investigated 98 incidents in Ohio between the years of 2000 and 2003 where animal wastes contaminated subsurface drainage effluent across Ohio. As can be seen in Figure 11 many of the contaminated sites were found in northwest Ohio, either in the Maumee River Basin or in nearby river basins.

According to Hoorman and Shipitalo (2006), "*Regardless of whether mismanagement occurred, preferential flow of the liquid wastes to subsurface drains via soil macropores was a major contributing factor to off-site movement of contaminants associated with liquid waste applications.*" These authors discuss that tillage has been proposed as a method to disrupt macropores and minimize the transport of liquid wastes to drainage systems. The authors examined 14 incidents where tilling was noted as occurring prior to offsite movement of contaminants from liquid animal manure. The authors concluded that, "*Tillage will probably reduce movement of liquid wastes to subsurface drains, but it is not likely to eliminate it in all situations...Similarly, avoiding application in a relatively narrow zone above the sub-drains will probably not be entirely effective as recent studies have suggested that solutes and particulate matter can move laterally up to several yards (meters) in the near surface soil horizons before moving downwards in preferential flow paths in tilled soils.*"

It has been suggested that controlling flow from tile drains can mitigate the impact of DRP on receiving waters by maintaining the DRP in the tile lines. Flow from tile drains can be controlled by plugging the tiles or by engineered structures that control the depth of water in the tile. In order to use this methodology, every drain tile outlet must be plugged or equipped with a flow control structure. Given the number of tile drains in a typical field in northwest Ohio, this would be very expensive. Even if the tiles are plugged, or the depth of water is controlled, in order to plant tile drained fields, the water table must be lowered to allow equipment to operate in the fields. This results in tile drainage being discharged in the spring months. It is important to note that even if the water in the subsurface of a tile drained field cannot discharge through the drain tile, the water (and the associated DRP) can move down through the subsurface. This water (and DRP) will then become part of the the underlying groundwater that discharges as baseflow to the streams and rivers in the watershed. Simple tile plugs have been used for decades but Frank Gibbs warns against them stating that they blow out with a good rain, allowing the recently applied liquid manures to be rapidly discharged from the mains draining to open ditches. Hoorman and Shipitalo (2006) state that "*Drain line stops should only be used as an emergency measure and in instances where the systems have been modified for their use.*"

The TMDL discounts DRP loss through subsurface drainage because "*current nutrient management standards*" and state law and regulations include "*requirements aimed to reduce the risk of these discharge events.*" We have reviewed the regulations the TMDL is referring to, Ohio Administrative Code 901:10-2-14(C) and (E), as well as the appendices and tables (including Appendices A, B, C and E). These rules are complex and, therefore, challenging to apply in reality.

Appendix B assumes that the drier the soil is, the more liquid the matrix will absorb and the higher the loading rate can be. This ignores the presence of macropores and the fact that the drier the soil, the more dominant the macropore flow will be. This table sets up the perfect storm to short circuit the liquid manure into the tiles. Additionally, applying liquid manure when soils are wet (at or near field capacity), increases the chance of liquid manure running off the fields as surface runoff.

The rules otherwise focus on surface BMPs taking care of the movement of the liquid manure off the fields and directly into surface water. The rules encourage the use of tile plugs if tile discharges are observed, but as noted earlier, plugs can fail and blow out. Between the higher loading rates for drier soils, the reliance on surface BMPs and counting on tile plugs as a back-up, these rules have set up conditions for failure. This set of rules will not significantly reduce DRP going to the lake from liquid manure.

It may also be possible to employ treatment systems, including wetlands to mitigate the impact on receiving waters. However, significant areas of land and/or technology implementation will be needed to create treatment systems for both baseflow and tile drainage in this watershed to remove DRP from surface water before it enters the rivers and Lake Erie. It is known that wetlands can provide a sink for phosphorus in the vegetation, but vegetation is only a temporary sink for phosphorus, as the vegetation decomposes in the fall and winter, much of the phosphorus is released back into the water and soil. Therefore, if wetlands are to be used as a phosphorus sink, it will be necessary to remove vegetation from the wetlands on a regular (annual) basis.

Other BMPs relating to subsurface drainage have been investigated and are still being developed. USDA-ARS has been developing underground P-removal structures (filters) that trap phosphorus in the matrix and reduce the transport of DRP to surface water bodies. These filters could be installed at drain tile outlets but would be expensive and the filter medium would need to be replaced when phosphorus binding locations are exhausted (Winsor, 2023). Dr. Zwierschke has been involved the design of a constructed wetland that collects tile drainage and surface runoff from a farm field in northwest Ohio. The wetland effluent is treated in a filter to remove DRP prior to discharge to surface water. It is, however, not practical to build wetlands (and a P-filter) to treat drainage effluent and surface runoff from every field in the Maumee River Basin.

Ghane (2018) summarizes the pros and cons of subsurface drainage in Table 1 (reproduced below). There clearly are benefits to the farmer and without drainage much of the Maumee River Basin would still be the Black Swamp. However, when addressing the issues of nutrient transport, it is clear that tile drainage increases the transport of DRP, nitrates and other water contaminants. When these systems are coupled with liquid manure application, the discharge to Lake Erie is increased.

Table 1. Pros and Cons of Subsurface Drainage in Humid Regions.

Pros	Cons
Increases crop yield	Excess phosphorus transport
Less variability in yearly crop yield	Excess nitrate transport
Increases soil aeration	Less groundwater recharge
Improves soil structure	Accelerates loss of soil organic matter
Decreases surface runoff	
Provides timely field operations and trafficability	

Two-stage ditches were considered as a solution around the turn of the 21st century but they have not proved to be as successful as hoped. Two-stage ditches are designed to replicate natural stream processes by incorporating extended side benches. Two-stage ditches have been used to reduce sediment discharge (and consequently, can reduce phosphorus associated with erosion). There have been mixed results using two-stage ditches to reduce DRP from surface water in ditches and might be part of the solution if used in conjunction with other BMPs (Kindervater, 2017).

The previously discussed BMPs and measures to reduce DRP in surface water, require implementation over the entire watershed, in every farm field. However, changing the way manure is handled at the source (CAFOs and animal operations) requires changes at a finite number of facilities (at the source). For a small family farm, liquid manures can be treated in a septic tank and leach field. Manure from a few beef cattle, chickens, ducks and/or goats can be managed as a dry manure, composted and applied to the farm fields and/or the family garden depending on the nutritional needs of the soil and projected crop(s). Nutrient soil testing is recommended for application rates. However, treatment of wastes from larger facilities (including CAFOs), remains a major concern.

A possibility for CAFOs are large-scale composting facilities that stabilize the phosphorus into a more stable form. The City of Columbus composts biosolids resulting from wastewater treatment at a site south of Columbus. The product (Com-Til) is used as an organic fertilizer and soil conditioner and is sold to wholesalers in Central Ohio. In addition, Dr. Fred Michel presented results of an ongoing study at OARDC (Ohio Agricultural Research and Development Center) relating to the composting of manure from horses, cows, hogs and poultry. The composted manure can be transported further (due to the weight differential) and, due to the form of the phosphorus in the composted manure, is less prone to leach DRP that can be washed from the fields by surface runoff or be transported through the soil to subsurface drains and to surface water.

Another current fertilizer application method is broadcasting dry fertilizer after the growing season. In some cases, the application is incorporated with tillage which both disturbs the crop residue and breaks the surface of the soil allowing for erosion from the fields with each rainfall event and snowmelt event after application. In these situations, not only the soil but the fertilizer can be washed away. If the broadcast fertilizer is not incorporated, then it is exposed to fall rain events and snow melts. Once the fertilizer is mixed with water, it dissolves and becomes part of the DRP load that is contributed to the watershed. Shipitalo et al. (2013) noted that research has concluded that the weather and timing of rainfall relative to tillage and nutrient application are the dominant factors contributing to nutrient loss from fields when using broadcast fertilizer. In 2018, Korucu et al. concluded that broadcasting fertilizer in the fall when a cover crop is actively growing, improves soil structure and reduces sediment and nutrient losses in surface runoff due to rainfall shortly after fertilizer application.

In the Maumee River Basin TMDL process, Ohio EPA acknowledges the significant reduction that will be required from non-point sources, including nutrient management (identified in their slides as including commercial and manure) (Figure 12). It is the opinion of the authors that the reduction sought by Ohio EPA in the TMDL process will not be met unless the amount of DRP entering surface waters in the Maumee River Basin from fertilizer/liquid manure application to farm fields is quantified and technology is applied to reduce loading from this source. This reduction in loading can be achieved by treating manure (for example in packaged wastewater treatment systems or composting) rather than applying liquid manure to farm fields. Winsor (2023), quoted Chad Penn (USDA-ARS), "*Since municipal wastewater treatment P sources have been mostly addressed, agricultural sources in the Maumee River have become the main concern.*"

A review of a recent *Western Lake Erie harmful algal bloom season projection* (NOAA and NCWQR, August 3, 2022) shows that the projected total annual harmful algal bloom (HAB) severity in 2022 is expected to approximate HAB severity in 2021. The cumulative total bioavilable phosphorus (TBP) loads for the Maumee River at Waterville in 2022, Ohio are projected to be almost as high as 2021 (Attachment E). As learned by the Ohio Lake Erie Phosphorus Task Force, approximately 90% of the phosphorus measured at Waterville comes from agricultural sources. Therefore, since the DRP loading for 2022 is expected to be almost as high as 2021 and considerably higher than 2020, it appears that manure management programs in the watershed will be required to measurably reduce the impact of phosphorus in the watershed.

Summary and Conclusions

Ohio EPA's slides (Figure 12) demonstrate that a significant reduction of DRP is going to be required as part of the TMDL process and that a large reduction in phosphorus loading will be required from improving agricultural source management including manure application in the Maumee River Basin. Liquid animal manures applied to the surface of a field, pool on the field, then drain through macropores to the subsurface or are washed offsite in the next storm. DRP moves with water. Liquid animal manures injected into the soil are short circuited into the macropores due to fracturing, moving quickly to the tile drains and baseflow of the streams. Fields that are first plowed to break up the macropore connections are subject to erosion and the DRP deposited on the soil is carried away with the rainfall when erosion occurs. The soils in the Maumee River Basin are prone to fracturing resulting in rapid transport of the DRP to tile drains and drainage ditches. Once DRP enters the tile drains or baseflow for the streams and ditches, the DRP is discharged into the rivers and into Lake Erie. In 2013, it was determined that 90% of DRP delivered to the Western Basin of Lake Erie came from agricultural practices, including field application of liquid manures. The 4Rs of nutrient stewardship and current BMPs (which primarily target the transport of phosphorus associated with erosion) do not significantly reduce the transport of DRP from liquid animal manure to surface water via subsurface drainage. BMPs that are currently being investigated, including p-filters, require the installation of equipment at the outlet of drain tiles across the watershed. It is, therefore, be necessary to look at managing animal manure differently at the source (CAFOs) or reducing the volume of liquid manure that is applied to farm fields to accomplish significant DRP reductions from drainage effluent in the Maumee River Basin.

The soils and agricultural practices that result in rapid DRP transport from farm fields to the Western Lake Erie Basin in the Maumee River Basin have similarities across the area. This means that neighboring watersheds (including the Sandusky River in Ohio and the southern portion of the watershed of the Raisin River in Michigan) are likely subject to similar processes.

As with most environmental concerns, there are no easy and cheap answers. If CAFOs continue to operate in the Western Lake Erie basin, manure management must be addressed (costing the industry money). If liquid manure is to be applied to farm fields, measuring and mitigating DRP movement to surface water must be addressed (costing farmers money). Not doing either of these things will negatively impact Lake Erie and harmful algal blooms will continue to be a problem in the Western Lake Erie Basin.

Respectfully submitted,
BENNETT & WILLIAMS ENVIRONMENTAL CONSULTANTS, INC.

Julie Weatherington-Rice, PhD

Julie Weatherington-Rice, PhD, CPG, CPSS
Senior Scientist

KHughes Zwierschke

Kerry Hughes Zwierschke, P.E., PhD.
Principal Engineer

EXHIBIT 22

PERMIT NO. MIG010000

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENTAL QUALITY

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM
WASTEWATER DISCHARGE GENERAL PERMIT

CONCENTRATED ANIMAL FEEDING OPERATIONS

In compliance with the provisions of the Federal Water Pollution Control Act (33 U.S.C. 1251 *et seq*., as amended; the “Federal Act”); Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA); Part 41, Sewerage Systems, of the NREPA; and Michigan Executive Order 2011-1, Concentrated Animal Feeding Operations (CAFOs) are authorized to operate facilities specified in individual “Certificates of Coverage” (COCs) in accordance with effluent limitations, monitoring requirements and other conditions set forth in this general National Pollutant Discharge Elimination System (NPDES) permit (the “permit”).

The applicability of this permit shall be limited to CAFOs that have not been determined by the Michigan Department of Environmental Quality (Department) to need an individual NPDES permit. New swine, poultry, and veal facilities with contaminated areas of the production area exposed to precipitation, including waste storage structures, are not eligible for this permit. New means populated after January 20, 2009. Discharges which may cause or contribute to a violation of a water quality standard are not authorized by this permit.

In order to constitute a valid authorization to discharge, this permit must be complemented by a COC issued by the Department and copies of both must be kept at the permitted CAFO. The following will be identified in the COC (as appropriate):

- The rainfall event magnitude at the production area [Part I.B.1.a.2)]
- The date by which existing CAFOs shall attain six months waste storage [Part I.B.1.a.4)]
- The date by which existing waste storage structures shall meet Natural Resources Conservation Services (NRCS) Practice Standard No. 313 [Part I.B.1.b.2)b)B)] along with a statement that specifies if the requirements specified in this permit or the requirements specified in the previous version of this permit, issued March 30, 2010, apply to existing waste storage structures
- The date by which the permittee shall cease using waste storage structures that do not meet standards and will not be upgraded [Part I.B.1.b.2)c)]
- Data for the application rate table for crops not listed in the permit [Part I.B.3.c.2)]
- Alternate land application rates and methodologies [Part I.B.3.c.2)]
- Total Maximum Daily Loads (TMDL) if the permittee’s production or land application areas are located within a watershed(s) covered by an approved *E. coli*, biota, or dissolved oxygen TMDL (Part I.C.10.)
- Percent of outside materials allowed in the anaerobic digester associated with the CAFO permitted under this COC, if that percentage is greater than five (Part I.C.11.)

Compliance dates in reissued COCs shall be carried over from the expiring COC, unless modified by the Department.

Unless specified otherwise, all contact with the Department required by this permit shall be to the position indicated in the COC.

This permit takes immediate effect on the date of issuance. The provisions of this permit are severable. After notice and opportunity for a hearing, this permit may be modified, suspended, or revoked in whole or in part during its term in accordance with applicable laws and rules.

This permit shall expire at midnight, **April 1, 2020**.

Issued: April 30, 2015.

Original Permit Signed by Philip Argiroff
Philip Argiroff, Chief
Permits Section
Water Resources Division

PERMIT FEE REQUIREMENTS

In accordance with Section 324.3120 of the NREPA, the permittee shall make payment of an annual permit fee to the Department for each October 1 the permit is in effect regardless of occurrence of discharge. The permittee shall submit the fee in response to the Department's annual notice. The fee shall be postmarked by January 15 for notices mailed by December 1. The fee is due no later than 45 days after receiving the notice for notices mailed after December 1.

CONTESTED CASE INFORMATION

The terms and conditions of this permit shall apply to an individual facility on the effective date of a COC for the facility. The Department of Licensing and Regulatory Affairs may grant a contested case hearing on this permit in accordance with the NREPA. Any person who is aggrieved by this permit may file a sworn petition with the Michigan Administrative Hearing System within the Michigan Department of Licensing and Regulatory Affairs, c/o the Michigan Department of Environmental Quality, setting forth the conditions of the permit which are being challenged and specifying the grounds for the challenge. The Department of Licensing and Regulatory Affairs may reject any petition filed more than 60 days after issuance as being untimely.

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PART I

Section A. Effluent Limitations And Monitoring Requirements

1. Authorized Discharges and Overflows

During the period beginning on the effective date of this permit and lasting until the expiration of this permit, the permittee is authorized to discharge the following, provided that the discharge does not cause or contribute to an exceedance of Michigan's Water Quality Standards:

a. CAFO waste in the overflow from the storage structures for cattle, horses and sheep, and existing swine, poultry, and veal facilities identified in Part I.B.1. below, when all of the following conditions are met:
   1) These structures are properly designed, constructed, operated, and maintained.
   2) Precipitation events cause an overflow of the storage structures to occur.
   3) The production area is operated in accordance with the requirements of this permit.

b. Precipitation caused runoff from land application areas and areas listed in Part I.B.3.h. that are managed in accordance with the NMP (see Part I.B. below).

This permit does not authorize any discharge to the groundwaters. Such discharge may be authorized by a groundwater discharge permit issued pursuant to the Michigan Act.

2. Monitoring Discharges and Overflows from Storage Structures

The discharge authorized in Part I.A.1.a., above, shall be monitored four times daily (every six hours) by the permittee as specified below on any day when there is a discharge:

Parameter	Units	Sample Type
Overflow Volume (at storage structure)	MGD	Report Total Daily Volume
Discharge to Surface Waters Volume	MGD	Report Total Daily Volume
Overflow Observation (at storage structure)	---	Report Visual Condition of the Overflow
Discharge to Surface Waters Observation	---	Report Physical Characteristics (see below)

Any physical characteristics of the discharge at the point of discharge to surface waters (i.e., unnatural turbidity, color, oil film, odor, floating solids, foams, settleable solids, suspended solids, or deposits) shall be reported concurrently with the discharge reporting required in Part II.C.6. and included in the discharge report required by Part I.C.1.

3. Prohibited Discharges

During the period beginning on the effective date of this permit and lasting until the expiration of this permit, the permittee is prohibited from having any dry weather discharge or discharging any CAFO waste and/or runoff that fails to meet the requirements of Part I.A.1. Discharges due to overflows from storage structures at new swine, poultry, or veal facilities are prohibited. Discharges from land application activities that do not meet the requirements of Part I.A.1. or that cause an exceedance of Michigan's Water Quality Standards are prohibited.

PART I

Section B. Nutrient Management Plan

The permittee shall implement the following requirements.

1. CAFO Waste Storage Structures

a. Volume Design Requirements

The permittee shall have CAFO waste storage structures in place and operational at all times that are adequately designed, constructed, maintained, and operated to contain the total combined volume of all of the following:

1) All CAFO waste generated from the operation of the CAFO in a six-month or greater time period (including normal precipitation and runoff in the production area during the same time period). This is the operational volume of the storage structure.

2) For cattle, horses, and sheep, and existing (populated prior to January 20, 2009) swine, poultry, and veal facilities, all production area waste generated from the 25-year 24-hour rainfall event. The magnitude of the rainfall event will be specified in the COC. This is an emergency volume to be kept available to contain large rainfall events. New (populated on or after January 20, 2009) swine, poultry, and veal facilities shall be designed to have all contaminated areas of the production area, including waste storage structures, totally enclosed and not subject to precipitation and, therefore, not needing room for the emergency volume in their storage structures.

3) An additional design capacity of a minimum of 12 inches of freeboard for storage structures that are subject to precipitation caused runoff. For storage structures that are not subject to precipitation-caused runoff, the freeboard shall be a minimum of 6 inches. This is the freeboard volume.

4) Records documenting the current design volume of any CAFO waste storage structures, including volume for solids accumulation, design treatment volume, total design volume, volumes of the operational, emergency, and freeboard volumes, and approximate number of days of storage capacity shall be included in the permittee's CNMP. For CAFOs not previously permitted, the COC may specify the date by which the permittee shall attain six months storage volume capacity, but that date shall be no more than three years after the COC issuance date.

b. Physical Design & Construction Requirements

1) Depth Gauge

CAFO waste storage structures shall include an easily visible, clearly marked depth gauge. Clear, major divisions shall be marked to delineate the operational, emergency, and freeboard volumes as specified above in Part I.B.1.a. (two volumes for new swine, poultry, and veal facilities). The top mark of the gauge shall be placed level with the lowest point on the top of the storage structure wall or dike. The elevation for the gauge shall be re-established as necessary but not less than every five years to adjust for any movement or settling. Materials used must be durable and able to withstand freezing and thawing (examples: large chain, heavy-duty PVC, steel rod). Any depth gauges that are destroyed or missing must be replaced immediately. Under-barn storages may be measured with a dip-stick or similar device. For solid stackable CAFO waste storage, depth gauge levels may be permanently marked on sidewalls.

2) Structural Design

Records documenting or demonstrating the current structural design as required below, including as-built drawings and specifications, of any CAFO waste storage structures, whether or not currently in use, shall be kept with the permittee's CNMP until such structure is permanently closed in accordance with Part I.C.3. Included in the CNMP submitted to the Department shall be a short description of the structural design of each structure (type of structure; dimensions including depth; liner material, thickness, and condition; depth from the design bottom elevation to the seasonal high water table), a statement whether the engineer's evaluation has been completed or not, and a brief description of the results of the evaluation (meets NRCS 313 2014 or provides environmental performance equivalent to NRCS 313 2005 or 2014).

a) New Storage Structures (constructed after the effective date of the COC)

Except as otherwise required by this permit, CAFO waste storage structures shall, at a minimum, be constructed in accordance with NRCS 313 2014.

b) Existing Storage Structures at Newly-Permitted CAFOs (facilities without prior NPDES permit coverage) and Previously-Permitted CAFOs (storage structures constructed prior to the issuance of the CAFO's first COC)

PART I

Section B. Nutrient Management Plan

A) In a permit application for coverage under this permit, the applicant shall either:
i) For each existing storage structure document through an evaluation by a professional engineer that each structure is constructed in accordance with NRCS 313 2005 or 2014. Submit to the Department documentation signed by an engineer verifying that each structure is constructed in accordance with NRCS 313 2005 or 2014. Complete as-built plans, specifications, drawings, etc. shall be kept at the farm with the CNMP and do not need to be submitted, or
ii) For each existing storage structure, on a form provided by the Department and submitted to the Department, demonstrate environmental performance equivalent to NRCS 313 2014. The demonstration shall be accomplished through an evaluation by a professional engineer.

B) If the applicant for a Newly-Permitted CAFO cannot provide the documentation or demonstration required by (i) or (ii) above, the applicant may request that the COC specify a date by which the permittee shall provide storage structures that attain (i) above, but that date shall be no more than three years after the COC issuance date.

C) Previously evaluated storage structures at permitted CAFOs shall have documentation demonstrating that the structure was constructed to, or provides equivalent environmental protection to, NRCS 313 2003 or 2005.

c) Existing Storage Structures not Meeting Standards
Usage, for the storage of large CAFO waste, of existing storage structures that do not meet the requirements above in Part B) and will not be upgraded to meet NRCS 313 Standards by the date in the COC, shall be discontinued by that same date in the COC. Such structures shall be maintained or permanently closed in accordance with Part I.C.3. Records of usage, maintenance, or closure shall be included in the CNMP.

c. Inspection Requirements
The permittee shall develop a Storage Structure Inspection Plan and inspect the CAFO waste storage structures a minimum of one time weekly year-round. The inspection plan shall be included in the CNMP and results of the inspections shall be kept with the CNMP on a form provided by the Department. Individual results shall be kept for a period of five years. The plan shall include all of the following inspections:
1) The CAFO waste storage structures for cracking, inadequate vegetative cover, woody vegetative growth, evidence of overflow, leaks, seeps, erosion, slumping, animal burrowing or breakthrough, and condition of the storage structure liner
2) The depth of the CAFO waste in the storage structure and the available operating capacity as indicated by the depth gauge
3) The collection system, lift stations, mechanical and electrical systems, transfer stations, control structures, and pump stations to assure that valves, gates, and alarms are set correctly and all are properly functioning.

d. Operation & Maintenance Requirements
The permittee shall implement a Storage Structure Operation and Maintenance Program that incorporates all of the following management practices. The permittee shall initiate steps to correct any condition that is not in accordance with the Storage Structure Operation and Maintenance Program. A copy of the program shall be included in the CNMP. Specific records below shall be kept with the CNMP unless specified otherwise below.
1) In the event that the level of CAFO waste in the storage structure rises above the maximum operational volume level and enters the emergency volume level, the Department shall be notified. The level in the storage structure shall be reduced within one week, unless a longer time period is authorized by the Department (the removed CAFO waste shall be land applied in accordance with this permit or the Department shall be notified if another method of disposal is to be used) and the emergency volume shall be restored. Descriptions of such events shall be recorded in the CNMP.
2) At some point in time during the period of November 1 to December 31 of each year, there shall be an available operational volume in the CAFO waste storage structures equal to the volume of CAFO waste generated from the operation of the CAFO in a six-month or greater time period (including normal precipitation and runoff in the production area during the same time period). The date of this occurring

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shall be recorded in the CNMP and reported to the Department in accordance with Part II.C.5, Compliance Dates Notification.

3) Vegetation shall be maintained at a height that stabilizes earthen CAFO waste storage structures, provides for adequate visual inspection of the storage structures, and protects the integrity of the storage structure liners. The vegetation shall have sufficient density to prevent erosion. Woody vegetation shall be removed promptly from waste storage berms and other areas where roots may penetrate or disturb waste storage facility liners or waste treatment facilities.

4) Dike damage caused by erosion, slumping, or animal burrowing shall be corrected immediately and steps taken to prevent occurrences in the future.

5) The integrity of the CAFO waste storage structure liner shall be protected. Liner damages shall be corrected immediately and steps taken to prevent future occurrences.

6) Problems with the collection system, lift stations, mechanical and electrical systems, transfer stations, control structures, and pump stations shall be corrected as soon as possible. Records of these inspections and records documenting any actions taken to correct deficiencies shall be kept with the CNMP for a minimum of five years. Deficiencies not corrected within 30 days must be accompanied by an explanation of the factors causing the delayed correction.

7) CAFO waste shall be stored only in storage structures as described above, except for solid stackable manure collected in-barn prior to transfer to storage.

2. Best Management Practices Requirements

The following are designed to achieve the objective of preventing unauthorized discharges to waters of the state from production areas and land application activities.

a. Conservation Practices
The permittee shall maintain specific conservation practices near or at production areas, land application areas, and heavy use areas within pastures associated with the CAFO that are sufficient to control the runoff of pollutants to surface waters of the state in quantities that may cause or contribute to a violation of water quality standards. These practices shall be consistent with NRCS Conservation Practices and in compliance with the requirements of this permit. The permittee shall include within the CNMP a list of conservation practices used near or at production areas and land application areas. This list does not need to include temporary practices or other practices already required by this permit.

b. Divert Clean Water
The permittee shall design and implement structures and management practices to divert clean storm water to prevent contact with contaminated portions of the production areas. Clean storm water may include roof runoff, runoff from adjacent land, and runoff from feed or silage storage areas where such runoff has not contacted feed, silage, or silage leachate. Describe in the CNMP structures and management practices used to divert clean water from the production area and/or beneficial uses of diverted water if it will be collected for reuse.

c. Prevent Direct Contact of Animals with Waters of the State
There shall be no access of animals to surface waters of the state at the production area of the CAFO. The permittee shall develop and implement appropriate controls to protect water quality by preventing access of animals to waters of the state and shall describe such controls in the CNMP.

d. Animal Mortality
The permittee shall handle and dispose of dead animals in a manner that prevents contamination of waters of the state. Mortalities must not be disposed of in any liquid CAFO waste or storm water storage structure that is not specifically designed to treat animal mortalities. A description of mortality management practices shall be included in the CNMP. Records of mortality handling and disposal shall be kept with the permittee's CNMP for a minimum of five years.

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e. Chemical Disposal
The permittee shall prevent introduction of hazardous or toxic chemicals (for purposes of disposal) into CAFO waste storage structures. Examples of hazardous and toxic chemicals are pesticides and petroleum products/by-products. Identify in the CNMP appropriate practices that ensure chemicals and other contaminants handled at the CAFO are not disposed of in any CAFO waste or storm water storage or treatment system.

f. Inspection, Proper Operation, and Maintenance
The permittee shall develop and implement an Inspection, Operation, and Maintenance Program that includes periodic visual inspections, proper operation, and maintenance of all CAFO waste-handling equipment including piping and transfer lines, and all runoff management devices (e.g., cleaning separators, barnyards, catch basins, screens) to prevent unauthorized discharges to surface water and groundwater. A copy of the program shall be included in the CNMP. Specific inspection requirements include, but are not limited to, all of the following:
1) Weekly visual inspections of all clean storm water diversion devices and outlets.
2) Daily visual inspections of water lines, including drinking water and cooling water lines, and above-ground piping and transfer lines, or an equivalent method of checking for water line leaks that incorporates the use of water meters, pressure gauges, or some other monitoring method.
3) All CAFO waste-handling equipment including piping and transfer lines, and all runoff management devices shall be accessible such that required visual inspections may occur. This may necessitate frequent removal of vegetation, snow, or other obstructions.
4) Any deficiencies shall be corrected as soon as possible.
5) Records of these inspections and records documenting any actions taken to correct deficiencies shall be shall be recorded on a form provided by the Department and shall be kept in the CNMP for a minimum of five years. Deficiencies not corrected within 30 days must be accompanied by an explanation of the factors causing the delayed correction.

3. Land Application of CAFO Waste

a. Field-by-Field Assessment
The permittee shall conduct a field-by-field assessment of all land application areas. Each field shall be assessed prior to use for land application of CAFO waste. The assessment shall include field maps with location information and identify field-specific conditions, including, but not limited to, slopes, soil type, locations of tile outlets, tile risers and tile depth, conservation practices, and offsite conditions, such as buffers and distance or conveyance to surface waters. The assessment shall also identify areas which, due to topography, activities, or other factors, have a potential for erosion. The assessment shall also identify fields, or portions of fields, that will be used for surface application of CAFO waste without incorporation to frozen or snow-covered ground in accordance with the Department 2005 Technical Standard for the Surface Application of CAFO Waste on Frozen or Snow-Covered Ground Without Incorporation or Injection (last page of this permit). The results of this assessment, along with consideration of the form and source of the CAFO waste and all nutrient inputs in addition to those from large CAFO waste, shall be used to ensure that the amount, timing, and method of application of CAFO waste:
1) does not exceed the capacity of the soil to assimilate the CAFO waste
2) is in accordance with field-specific nutrient management practices that ensures appropriate agricultural utilization of the nutrients in the CAFO waste
3) does not exceed the maximum annual land application rates specified in Part I.B.3.c., below
4) will not result in unauthorized discharges
All assessments shall be kept in the CNMP. An assessment for a particular field can be deleted from the CNMP once that field is no longer used for land application.
Any new fields shall be assessed prior to their use for land application activities. The Department shall be notified of the new fields prior to their use through submittal of a permit modification request that includes the field-by-field assessment, a map showing the entire field, its size in acres, location information, planned crops, and realistic crop yield goals. The request will be public noticed. The permittee may use the field eighteen calendar days after submittal of the request unless notified otherwise by the Department.

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b. Field Inspections
Prior to conducting land application of CAFO waste to fields determined to be suitable under Part I.B.3.a. above, the permittee shall perform the following inspections at the indicated frequency to ensure that unauthorized discharges do not occur as a result of the land application of CAFO waste. Records of inspections, monitoring, and sampling required by this section shall be recorded in the Land Application Log required by Part I.B.3.d.

1) CAFO waste shall be sampled a minimum of once per year to determine nutrient content and analyzed for total Kjeldahl nitrogen (TKN), ammonium nitrogen, and total phosphorus. CAFO waste shall be sampled in a manner that produces a representative sample for analysis. Guidance for CAFO waste sampling protocols can be found in Bulletin NCR 567 available from Michigan State University Extension. Analytical methods shall be as required by Part II.B.2. The CAFO waste test results shall be used to determine land application rates as described in c) below. Record the nutrient levels and analysis methods in the Land Application Log and include in the CNMP.

2) Soils at land application sites shall be sampled a minimum of once every three years, analyzed to determine phosphorus levels, and the soil test results shall be used to determine land application rates as described in c) below. Sample soil using an 8-inch vertical core, and take 20 or more cores in a random pattern spread evenly over each uniform field area. A uniform field area shall be no greater than 20 acres or it can be up to 40 acres if that field has one soil map unit and has been managed as a single field for the last ten years. The 20 cores shall be composited into one sample and analyzed using the Bray P1 method. Alternate methods may be used upon approval of the Department. Record the phosphorus levels in the Land Application Log and in the CNMP. Additional information on soil sampling can be found in Michigan State University Extension Bulletins E2904 and E498.

3) The permittee shall inspect each field no earlier than 48 hours prior to each land application of CAFO waste to that field to evaluate the current suitability of the field for application. This inspection shall include, at a minimum, the state of all tile outlets, evidence of soil cracking, the moisture-holding capacity of the soil, crop maturity, and the condition of designated conservation practices (i.e., grassed waterways, buffers, diversions). Results and findings of all inspections shall be recorded in the Land Application Log.

4) The permittee shall visually inspect all tile outlets draining a given field immediately prior to the land application of CAFO wastes to that field. Tile outlets shall be inspected again upon completion of the land application to the field, or at the end of the working day should application continue on that field for more than one day (include in the Land Application Log written descriptions of tile outlet inspection results, and observe and compare color and odor of tile outlet effluents before and after land application).

5) All tiled fields to which CAFO wastes have been applied in the prior 30 days shall be visually inspected within 24 hours after the first rain event of one-half inch or greater, for signs of a discharge of CAFO waste. Written descriptions of tile inspection results shall be retained in the Land Application Log. If an inspection reveals a discharge with color, odor, or other characteristics indicative of an unauthorized discharge of CAFO waste, the permittee shall immediately notify the Department of the suspected unauthorized discharge in accordance with the reporting procedures contained in Part II.C.6 and record such findings in the Land Application Log.

6) The permittee shall inspect all land application equipment daily during use for leaks, structural integrity, and proper operation and maintenance. Land application equipment shall be calibrated annually to ensure proper application rates. Written records of inspections and calibrations shall be retained in the Land Application Log.

c. Maximum Annual Land Application Rates
The permittee may choose to use the Bray P1 numerical limits or the Michigan Phosphorus Risk Assessment (MPRA) tool (Version 2.0, Nov. 2012) to determine application rates. The permittee must use one system for its entire land application area for the life of the permit. For purposes of this permit, the MPRA is for rate calculations only and “Distance to surface water and/or surface inlets” is interpreted as described in g. below. The permittee shall comply with all of the following maximum annual land application rates:

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1) Land Application Rate Prohibitions
All of the following land application rate prohibitions apply.
a) If the Bray P1 soil test result is 150 parts per million (ppm) or more, CAFO waste applications shall be discontinued until nutrient use by crops reduces the Bray P1 soil test result to less than 150 ppm phosphorus (P) including when MPRA is used.
b) Fields where the MPRA risk is HIGH, CAFO waste shall not be applied.
c) The application rate shall not exceed the nitrogen (N) fertilizer recommendation (removal value for legumes) for the first crop year grown after the CAFO waste is applied as specified in b) below.
d) The application rate shall not exceed four years of P for each of the four crops planned for the next four years as calculated using the formula in b) below.
e) The total amount of N and P, regardless of source (manure, organic waste, commercial fertilizer, etc.), shall not exceed the first crop year nutrient requirements unless applying multiple crop years of P as allowed in 2) below. However, only one year of N can be applied as stated in c) above, unless samples or other relevant data shows additional N is needed for or will be beneficial to the crop. Documentation justifying additional N must be kept with the farm's CNMP.

2) Phosphorus Levels
a) If the Bray P1 soil test result is 75 ppm P or more, but less than 150 ppm P or a MPRA risk of MEDIUM, application rates shall be based on the maximum rates of P in annual pounds per acre as calculated using the following formula:

The realistic yield goal per acre, using the units specified in the table below, for the planned crop multiplied by the number in the P column for that crop. The maximum annual application rates as calculated above shall be achieved by using the CAFO waste test results for P to determine the amount of CAFO waste that may be land applied per acre per year.

The result is the maximum annual pounds per acre of P that may be applied for the first crop planned after application of CAFO waste. If the one year rate is impractical due to spreading equipment or crop production management, the permittee may apply up to two years of P at one time, but no P may be applied to that field for the second year. The two year P application rate shall be the results calculated using the formula above for each of the two crops planned for the next two years and those two annual results shall be added together to determine the maximum P application rate. In no case may the application rate exceed the N application rate as specified below.

b) If the Bray P1 soil test result is less than 75 ppm P or a MPRA risk of LOW, the annual rate of CAFO waste application shall not exceed the N fertilizer recommendation (removal value for legumes) for the first crop year grown after the CAFO waste is applied. (Information to determine N fertilizer recommendations or removal values can be found in Michigan State University Extension Bulletin E2904.) In no case may the application rate exceed four years of P calculated using the formula in a) above for each of the four crops planned for the next four years and those four annual results shall be added together to determine the maximum application rate. The maximum annual application rates as calculated above shall be achieved by using the CAFO waste test results for N to determine the amount of CAFO waste that may be land applied per acre per year.

P_2O_5 values are included for reference purposes.

Crop	Harvest Form	Unit of Realistic Yield Goal per Acre	P	P_2O_5
			- - lb/unit of yield - -	
Alfalfa	Hay	ton	5.72	13.1
Alfalfa	Haylage	ton	1.41	3.2
Apple	Fruit	ton	0.19	0.44
Asparagus	Shoots	ton	1.1	2.51
Barley	Grain	bushel	0.17	0.38
Barley	Straw	ton	1.41	3.2
Beans (dry edible)	Grain	cwt	0.53	1.2

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Beans (green, fresh)	Pods	ton	1.22	2.8
Blueberry	Fruit	ton	0.20	0.46
Bromegrass	Hay	ton	5.72	13
Buckwheat	Grain	bushel	0.11	0.25
Canola	Grain	bushel	0.40	0.91
Carrots	Root	ton	0.79	1.81
Cherries (sour)	Fruit	ton	0.3	0.69
Cherries (sweet)	Fruit	ton	0.37	0.85
Clover	Hay	ton	4.4	10
Clover-grass	Hay	ton	5.72	13
Corn	Grain	bushel	0.16	0.37
Corn	Stover	ton	3.61	8.2
Corn	Silage	ton	1.45	3.3
Corn	Sweet	ton	1.23	2.8
Cucumbers	Fruit	ton	0.47	1.1
Grapes	Fruit	ton	0.26	0.6
Millet	Grain	bushel	0.11	0.25
Mint	Hay	Ton	3.81	8.72
Oats	Grain	bushel	0.11	0.25
Oats	Straw	ton	1.23	2.8
Orchardgrass	Hay	ton	7.48	17
Peaches	Fruit	ton	0.24	0.55
Pears	Fruit	ton	0.23	0.53
Peppers, Green	Fruit	Ton	0.6	1.37
Plums	Fruit	ton	0.2	0.46
Potato	Tubers	cwt	0.06	0.13
Rye	Grain	bushel	0.18	0.41
Rye	Straw	ton	1.63	3.7
Rye	Silage	ton	0.66	1.5
Sorghum	Grain	bushel	0.17	0.39
Sorghum-Sudangrass	Hay	ton	6.6	15
Sorghum-Sudangrass	Haylage	ton	2.02	4.6
Soybean	Grain	bushel	0.35	0.8
Spelts	Grain	bushel	0.17	0.38
Squash	Fruit	ton	0.76	1.74
Sugar beets	Roots	ton	0.57	1.3
Sunflower	Grain	bushel	0.53	1.2
Timothy	Hay	ton	7.48	17
Tomatoes	Fruit	ton	0.57	1.3
Trefoil	Hay	ton	5.28	12
Wheat	Grain	bushel	0.28	0.63
Wheat	Straw	ton	1.45	3.3

Numbers for the tables above for crops not listed above shall be proposed in the permit application in a format similar to the above. The Department will review the proposal and approved numbers will be listed in the COC. The permittee may propose alternate land application rates and methodologies in the permit application. The Department will review the proposal and acceptable rates and methods will be included in the COC issued under this permit.

Methodology and calculations consistent with this Part, and their results, shall be recorded in the Land Application Log.

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d. Land Application Log
The results of land application inspections, monitoring, testing, and recordkeeping shall be recorded in a "Land Application Log" which shall be kept up-to-date and kept with the CNMP. Log records shall be kept for a minimum of five years. The permittee shall document in the log in writing, at a minimum, records required by Part I.B.3. and all of the following information and inspection results in the specified document:

1) Daily Land Application Record
   a) The time, date, quantity, method, location, and application rate for each location at which CAFO wastes are land applied
   b) A written description of weather conditions at the time of application and for 24 hours prior to and following application based on visual observation
   c) A statement whether the land was frozen or snow-covered at the time of application
2) Annual Report Form
   a) The crop, the realistic yield goal, and actual yield for each location at which CAFO wastes are land applied
   b) Methodology and calculations showing the total nitrogen and phosphorus to be applied to each field receiving CAFO waste, identifying all sources of nutrients, including sources other than CAFO waste
   c) The total amount of nitrogen and phosphorus actually applied to each field receiving CAFO waste, irrespective of source, including documentation of calculations for the total amount applied
3) Printouts of weather forecasts from the time of land application. Weather forecasts may also be saved as electronic files, in which case the files do not need to be physically located in the Land Application Log, but the log shall reference the location where the files are stored.

e. Prohibitions
Appropriate prohibitions, in compliance with the following, shall be included in the CNMP.

1) CAFO waste shall not be applied on land that is flooded or saturated with water at the time of land application.
2) CAFO waste shall not be applied during rainfall events.
3) CAFO waste shall not be surface applied without incorporation to frozen or snow-covered ground, except in accordance with the Department 2005 Technical Standard for the Surface Application of CAFO Waste on Frozen or Snow-Covered Ground Without Incorporation or Injection (last page of this permit) and to fields where the MARI score is Low or Very Low potential for manure movement from the field.
4) CAFO waste shall not be transferred to another person (a recipient as described in Part I.C.9.) where such waste will be surface applied without incorporation to frozen or snow-covered ground during the months of January, February or March unless the recipient agrees to follow the Department 2005 Technical Standard for the Surface Application of CAFO Waste on Frozen or Snow-Covered Ground Without Incorporation or Injection (last page of this permit).
5) CAFO waste application shall be delayed if rainfall exceeding one-half inch, or less if a lesser rainfall event is capable of producing an unauthorized discharge, is forecasted by the National Weather Service (NWS) during the planned time of application and within 24 hours after the time of the planned application. Forecast models to be used can be found on the internet at http://www.weather.gov/mdl/synop/products.php. Model data to be used for one-half inch shall be:

   GFS MOS (MEX) Text Message by Station Forecast: If the Q24 is 4 and the P24 is 70 or more for the same time period, or the Q24 is 5 or greater (with any P24 number), then CAFO waste land application shall be delayed until the Q24 is less than 4 or both the Q24 is less than 5 and the P24 is less than 70 for the same time period. The station to be used shall be that which is closest to the land application area. If no station is close, then use the closest 2 or 3 stations.

Different model data shall be used if it is determined that rainfall less than one-half inch on a particular field is capable of causing an unauthorized discharge. For example,: using a Q24 rating of 3 or greater may be appropriate on higher risk fields. If the NWS Web site is revised and the required forecast models are not available, the permittee shall contact the Department for information on which forecast models to use. Instructions for using this Web site are available from the Department. Other forecast services may be used upon approval of the Department.

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f. Methods
CAFO waste shall be subsurface injected or incorporated into the soil within 24 hours of application. CAFO waste subsurface injected into frozen or snow-covered ground shall have substantial soil coverage of the applied CAFO waste. The following exceptions apply:
1) Injection or incorporation may not be feasible where CAFO wastes are applied to pastures, perennial crops such as alfalfa, wheat stubble, or where no-till practices are used. CAFO waste may be applied to pastures or perennial crops such as alfalfa, wheat stubble, or where no-till practices are used, only if the CAFO waste will not enter waters of the state. CAFO waste shall not be applied if the waste may enter waters of the state.
2) On ground that is frozen or snow-covered, CAFO waste may be surface applied and not incorporated within 24 hours only if there is a field-by-field demonstration, in accordance with the Department 2005 Technical Standard for the Surface Application of CAFO Waste on Frozen or Snow-Covered Ground Without Incorporation or Injection (last page of this permit), showing that such land application will not result in a situation where CAFO waste may enter waters of the state. Demonstrations shall be kept with the Land Application Log and submitted to the Department prior to use of the field. CAFO waste surface applied to ground that is frozen or snow-covered shall be limited to no more than 1 crop year of P per winter season, including pastures, perennial crops such as alfalfa, wheat stubble, or where no-till practices are used.

g. Setbacks
The permittee shall comply with any of the following setback requirements:
1) CAFO waste shall not be applied closer than 100 feet to any ditches that are conduits to surface waters, surface waters except for up-gradient surface waters, open tile line intake structures, sinkholes, or agricultural well heads.
2) The permittee may substitute the 100-foot setback required in 1) above, with a 35-foot wide vegetated buffer. CAFO waste shall not be applied within the 35-foot buffer.
3) CAFO waste shall not be applied within grassed waterways and swales that are conduits to surface waters.
Setbacks shall be measured from the ordinary high water mark, where applicable, or from the upper edge of the bank if the ordinary high water mark cannot be determined. Setbacks for each field shall be shown on the CNMP field maps.

h. Non-Production Area Storm Water Management
The permittee shall implement practices including preventative maintenance, good housekeeping, and periodic inspections of at least once per year, to minimize and control pollutants in storm water discharges associated with the following areas:
1) Immediate access roads and rail lines used or traveled by carriers of raw materials, waste material, or by-products used or created by the facility
2) Sites used for handling material other than CAFO waste including new sand to be used as bedding (not sand previously used as bedding)
3) Refuse sites
4) Sites used for the storage and maintenance of material handling equipment
5) Shipping and receiving areas
Records and descriptions of non-production area storm water management practices shall be kept in the CNMP.

4. Comprehensive Nutrient Management Plan (CNMP)

The CNMP shall apply to both production areas and land application areas and shall be a written document that describes the practices, methods, and actions the permittee takes to meet all of the requirements of the Nutrient Management Plan, Part I.B.

a. Approval
The CNMP shall be approved by a Certified CNMP Provider.

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b. Submittal
The CNMP shall be submitted to the Department with the application for coverage under this permit. The permittee is encouraged to submit all or parts of the CNMP in electronic form. Electronic form means a digital file in a standard, common format provided on a compact disc or other media readily readable by a Windows-based personal computer.

c. Contents
The CNMP submitted to the Department shall include all of the information and requirements specified in the NMP Section, Part I.B. and a map of the production area that includes all of the items specified in the permit application and that shows all clean water and production area waste flow paths, pipes, control structures, valves, etc.

d. Annual Review and Report
The permittee shall annually review the CNMP and update the CNMP as necessary to meet the requirements of Part I.B.

The permittee shall submit an annual report for the preceding January 1 through December 31 (reporting period) to the Department by April 1 of each year. The annual report shall be submitted on a form provided by the Department. The annual report shall include, but is not limited to, all of the following:

1) The average number of animals, maximum number of animals at any one time, and the type of animals, whether in open confinement or housed under roof (beef cattle, broilers, layers, swine weighing 55 pounds or more, swine weighing less than 55 pounds, mature dairy cows, dairy heifers, veal calves, sheep and lambs, horses, ducks, turkeys, other)
2) Estimated amount of total CAFO waste generated by the CAFO during the reporting period (tons or gallons)
3) Estimated amount of total CAFO waste transferred to other persons (manifested waste) by the CAFO during the reporting period (tons or gallons)
4) Total number of acres for land application covered by the CNMP developed in accordance with this permit
5) Total number of acres under control of the CAFO that were used for land application of CAFO waste during the reporting period
6) A field-specific spreading plan which identifies where and how much CAFO waste will be applied to fields for the upcoming 12 months, what crops will be grown on those fields, and the realistic crop yield goals of those crops. The plan must account for all CAFO waste expected to be generated in the upcoming 12 months including waste to be transferred under manifest.
7) The following land application records for the reporting period for each field harvested during the reported period which utilized nutrients from previously-applied CAFO waste: actual crops planted, crop yield goals, actual crop yields, actual N and P content of land-applied CAFO waste, calculations conducted and data used in accordance with Part I.B.3.c., quantity of CAFO waste land applied (application rate), soil testing results, the amount of any supplemental fertilizer applied, N credits from previous crops, total amount of N and P applied (all sources), and the basis for the application rate.
8) A statement indicating whether the current version of the CAFO's CNMP was developed or approved by a certified CNMP provider
9) A summary of all CAFO waste discharges from the production area that have occurred during the reporting period, including date, time, and approximate volume
10) The retained self-monitoring certification as required by Part II.C.3

e. CNMP Revisions
Prior to a significant change in the operation of the CAFO, whenever there is an unauthorized discharge (see Parts I.A.1. and I.A.3.) where future discharges could be prevented by revisions to the CNMP, or if the Department determines that the CNMP is inadequate in preventing pollution, the CNMP shall be revised and the revisions approved by a Certified CNMP Provider. Within ninety (90) days of a significant change, an unauthorized discharge, or a Department-requested revision; the revised portions of the CNMP shall be submitted to the Department with a copy of the Certified CNMP Provider certification that the revised CNMP has been approved. Revisions to the CNMP, especially due to a significant change, may result in a permit modification, after opportunity for public comment.

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Significant change includes, but is not limited to, any of the following:

1) An increase in the number of animals that results in a greater than or equal to 10 percent increase in the volume of either the manure alone or the total CAFO waste generated per year as compared to the volumes identified in the application, as a cumulative total over the life of the COC
2) An increase in the number of animals that results in a decrease in the waste storage capacity time, as identified in the application, by 10 percent or greater, as a cumulative total over the life of the COC
3) An increase in the number of animals, where the CAFO waste generated by the livestock requires more land for its application than is available at the time of the increase
4) A decrease in the number of acres available for land application, where the CAFO waste generated requires more land for application than will be available after the decrease
5) The construction of a new animal housing facility or waste storage facility

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Section C. Other Requirements

1. Reporting of Overflows and Discharges from CAFO Waste Storage Structures and Land Application

If, for any reason, there is an overflow from CAFO waste storage structures and/or a discharge of pollutants to a surface water of the state from CAFO waste storage structures, production areas, or land application areas, the permittee shall report the overflow and/or discharge to the Department in accordance with the reporting procedures contained in Part II.C.6. Discharges to surface waters shall also be reported to the Clerk of the local unit of government and the County Health Department. In addition, the permittee shall keep a copy of the report together with the approved CNMP. The report shall include all of the following information:

a. A description of the overflow and/or discharge and its cause, including a description of the flow path to the surface water of the state
b. The period of overflow and/or discharge, including exact dates and times, the anticipated time it is expected to continue, and steps taken or planned to reduce, eliminate, and prevent recurrence of the overflow and/or discharge
c. Monitoring results as required by Part I.A.2
d. In the event of a discharge through tile lines, the permittee shall identify and document, for field(s) from which the discharge occurred, the location of tile and depth of tile. The permittee shall also document field conditions at the time of the discharge, determine why the discharge occurred, and how to prevent future discharges.
e. If the permittee believes that the discharge is an authorized discharge, then the permittee shall include a demonstration that the discharge meets the requirements of Part I.A.1.a. and/or Part I.A.1.b., as appropriate.

2. Construction of New Waste Storage Structures or Facilities

Before the construction or alteration of a waste storage structure, facility, or portions thereof, written notification shall be submitted to the Department. New waste storage and transfer structures shall be built to NRCS 313 2014 standard. Complete as-built plans, specifications, drawings, etc. shall be kept at the farm with the CNMP. As-built plans must be signed and stamped by a licensed professional engineer and state that the structure was built to the NRCS 313 2014 standard. Signed and stamped design drawings do not constitute as-built plans. Required supporting documentation may include soils reports documenting suitability of liner material, groundwater investigations reports, pictures, survey notes, concrete batch tickets, etc.

3. Closure of Structures and Facilities

The following conditions shall apply to the closure of lagoons, CAFO waste storage structures, earthen or synthetic lined basins, other manure and wastewater facilities, and silage facilities (collectively referred to as "structure(s)" for the remainder of this Part):

No structure shall be permanently abandoned. Structures shall be maintained at all times until closed in compliance with this section. All structures must be properly closed if the permittee ceases operation. In addition, any structure that is not in use for a period of twelve (12) consecutive months must be properly closed, unless the permittee intends to resume use of the structure at a later date and either: (a) maintains the structure as though it were actively in use, to prevent compromise of structural integrity and assure compliance with final effluent limitations, or (b) removes CAFO waste to a depth of one foot or less and refills the structure with clean water to preserve the integrity of the synthetic or earthen liner. In either case, the permittee shall conduct routine inspections, maintenance, and recordkeeping in compliance with this permit as though the structure were in use. The permittee shall notify the Department in writing prior to closing structures, or upon making a determination that the structures will be maintained as specified in (a) or (b) above. Prior to restoration of the use of the structure, the permittee shall notify the Department in writing and provide the opportunity for inspection.

The permittee shall accomplish closure by removing all waste materials to the maximum extent practicable. This shall include agitation and the addition of clean water as necessary to remove the waste materials. The permittee shall utilize as guidance the closure techniques contained in NRCS Conservation Practice Standard No. 360, Waste Facility Closure. All removed materials shall be utilized or disposed of in accordance with the permittee's approved CNMP, unless otherwise authorized by the Department.

PART I

Section C. Other Requirements

Unless the structure is being maintained for possible future use in accordance with the requirements above, completion of closure for structures shall occur as promptly as practicable after the permittee ceases to operate or, if the permittee has not ceased operations, 12 months from the date on which the use of the structure ceased, unless otherwise authorized by the Department.

4. Standards, Specifications and Practices

The published standards, specifications, and practices referenced in this permit are those which are in effect upon the effective date of this permit, unless otherwise provided by law. NRCS Conservation Practice Standards referred to in this permit are currently contained in Section IV, Conservation Practices and Michigan Construction Specifications, of the Michigan NRCS Field Office Technical Guide.

5. Facility Contact

The "Facility Contact" was specified in the application. The permittee may replace the facility contact at any time, and shall notify the Department in writing within 10 days after replacement (including the name, address, and telephone number of the new facility contact). The Department shall be notified in writing within 10 days after a change in any of the contact information (such as address or telephone number) from what was specified in the application.

a. The facility contact shall be any of the following (or a duly authorized representative of this person):
- For a corporation or a company, a principal executive officer of at least the level of vice president, or a designated representative, if the representative is responsible for the overall operation of the facility from which the discharge described in the permit application or other NPDES form originates
- For a partnership, a general partner
- For a sole proprietorship, the proprietor
- For a municipal, state, or other public facility, either a principal executive officer, the mayor, village president, city or village manager or other duly authorized employee

b. A person is a duly authorized representative only if both of the following requirements are met:
- The authorization is made in writing to the Department by a person described in paragraph a. of this section.
- The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity such as the position of plant manager, operator of a well or a well field, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters for the facility (a duly authorized representative may thus be either a named individual or any individual occupying a named position).

Nothing in this section obviates the permittee from properly submitting reports and forms as required by law.

6. Expiration and Reissuance

On or before <u>October 1, 2019</u>, a permittee seeking continued authorization under this permit beyond the permit's expiration date shall submit to the Department a written application containing such information, forms, and fees as required by the Department. Without an adequate application, a permittee's authorization will expire on <u>April 1, 2020</u>. With an adequate application, a permittee shall continue to be subject to the terms and conditions of the expired permit until the Department takes action on the application, unless this permit is terminated or revoked. However, the permittee need not seek continued permit coverage or reapply for a permit if both of the following apply:

a. The facility has ceased operation or is no longer a CAFO.

b. The permittee has demonstrated to the satisfaction of the Department that there is no remaining potential for a discharge of CAFO waste that was generated while the operation was a CAFO.

If this permit is terminated or revoked, all authorizations to discharge under the permit shall expire on the date of termination or revocation.

If this permit is modified, the Department will notify the permittee of any required action. Without an adequate response, a permittee's authorization to discharge will terminate on the effective date of the modified permit.

Section C. Other Requirements

With an adequate response, a permittee shall be subject to the terms and conditions of the modified permit on the effective date of the modified permit unless the Department notifies the permittee otherwise.

If the facility has ceased operation or is no longer a CAFO, the permittee shall request termination of authorization under this permit.

7. Compliance Dates for Existing Permittees

Compliance dates and associated requirements for permittees covered under the version of this permit issued March 30, 2010, shall be carried over, shall remain in effect, and shall be specified in COCs issued under this permit, unless the Department modifies the compliance date in the reissued COC.

8. Requirement to Obtain Individual Permit

The Department may require any person who is authorized to discharge by a COC and this permit to apply for and obtain an individual NPDES permit if any of the following circumstances apply:

a. the discharge is a significant contributor to pollution as determined by the Department on a case-by-case basis
b. the discharger is not complying, or has not complied, with the conditions of the permit
c. a change has occurred in the availability of demonstrated technology or practices for the control or abatement of waste applicable to the point source discharge
d. effluent standards and limitations are promulgated for point source discharges subject to this permit, or
e. the Department determines that the criteria under which the permit was issued no longer apply.

Any person may request the Department to take action pursuant to the provisions of Rule 2191 (Rule 323.2191 of the Michigan Administrative Code).

9. Requirements for Land Application Not Under the Control of the CAFO Permittee

In cases where CAFO waste is sold, given away, or otherwise transferred to another person (recipient) such that the land application of that CAFO waste is no longer under the operational control of the CAFO owner or operator that generates the CAFO waste (generator), a manifest shall be completed and used to track the transfer and use of the CAFO waste.

a. Prior to transfer of the CAFO waste, the CAFO owner or operator shall do all of the following:
    1) Prepare a manifest for tracking the CAFO waste before transferring the CAFO waste
    2) Designate on the manifest the recipient of the CAFO waste
b. The generator shall use a manifest form which is approved by the Department and which provides for the recording of all of the following information:
    1) A manifest document number
    2) The generator's name, mailing address, and telephone number
    3) The name and address of the recipient of the CAFO waste
    4) The nutrient content of the CAFO waste to be transferred, in sufficient detail to determine the appropriate land application rates
    5) The total quantity, by units of weight or volume, and the number and size of the loads or containers used to transfer that quantity of CAFO waste
    6) A statement that informs the recipient of his/her responsibility to properly manage the land application of the CAFO waste as necessary to assure there is no illegal discharge of pollutants to waters of the state
    7) The following certification by the generator: "I hereby declare that the CAFO waste is accurately described above and is suitable for land application"
    8) Other certification statements as may be required by the Department
    9) The address or other location description of the site or sites used by the recipient for land application or other disposal or use of the CAFO waste
    10) Signatures of the generator and recipient with dates of signature
c. The generator shall do all of the following with respect to the manifest:
    1) Sign and date the manifest certification prior to transfer of the CAFO waste.
    2) Obtain a dated signature of the recipient on the manifest and the date of acceptance of the CAFO waste.

PART I

Section C. Other Requirements

3) Retain a copy of the signed manifest.
4) Provide a signed copy to the recipient.
5) Advise the recipient of his or her responsibilities to complete the manifest and, if not completed at time of delivery, return a copy to the generator within 30 days after completion of the land application or other disposal or use of the CAFO waste.

d. One manifest may be used for multiple loads or containers of the same CAFO waste transferred to the same recipient. The manifest shall list separately each address or location used by the recipient for land application or other disposal or use of the CAFO waste. Each different address or location listing shall include the quantities of CAFO waste transferred to that location and dates of transfer.

e. The generator shall not sell, give away, or otherwise transfer CAFO waste to a recipient if any of the following are true:
1) The recipient fails or refuses to provide accurate information on the manifest in a timely manner.
2) The use or disposal information on the manifest indicates improper land application, use, or disposal.
3) The generator learns that there has been improper land application, use, or disposal of the manifested CAFO waste.
4) The generator has been advised by the Department that the Department or a court of appropriate jurisdiction has determined that the recipient has improperly land applied, used, or disposed of a manifested CAFO waste.

f. If the generator has been prohibited from selling, giving, or otherwise transferring CAFO waste to a particular recipient under Part I.C.9.e, above, and the generator wishes to resume selling, giving, or otherwise transferring CAFO waste to that particular recipient, then one of the following shall be accomplished:
1) For improper paperwork only, such as incomplete or inaccurate information on the manifest, the recipient must provide the correct, complete information.
2) For improper land application, use, or disposal of the CAFO waste by the recipient, the generator must demonstrate, in writing, to the Department that the improper land application, use, or disposal has been corrected, and the Department has provided approval of the demonstration.

g. All manifests shall be kept on-site with the CAFO owner or operator's CNMP for a minimum of five years and made available to the Department upon request.

h. The requirements of Part I.C.9. do not apply to quantities of CAFO waste less than one pickup truck load, one cubic yard, or one ton per recipient per day.

10. Water Quality Impaired Waters

a. Nitrogen or Phosphorus Impairment
The Department expects that full compliance with the conditions of this permit will allow the permittee to meet the pollutant loading capacity(ies) set forth for nitrogen or phosphorus in an approved Total Maximum Daily Load (TMDL).

b. *Escherichia coli*, Biota, Dissolved Oxygen Impairment
The permittee's COC will indicate if the permittee's production area or land application areas are located within a watershed(s) covered by an approved *E. coli*, biota, or dissolved oxygen TMDL. The Department will develop and publish guidance regarding how to evaluate operations and determine additional pollutant control measures. After the guidance is published, the permittee shall complete the following actions within 15 months of receiving notification from the Department:
1) Conduct a comprehensive evaluation of its operations.
2) Determine whether additional pollutant control measures need to be identified and implemented to meet the permittee's pollutant loading (or "concentration" in the case of E. coli) capacity(ies) set forth in the approved TMDL.
3) Submit a written report to the Department based on one of the following:
   a) If the permittee determines that the pollutant loading or concentration capacity(ies) established in the approved TMDL is not being exceeded, then the written report submitted to the Department shall justify that determination, or

PART I

Section C. Other Requirements

b) If the permittee determines that the pollutant loading or concentration capacity(ies) established in the approved TMDL is being exceeded, then the written report submitted to the Department shall identify additional pollutant control measures that need to be implemented by the permittee to achieve compliance with the pollutant loading capacity(ies) established in the approved TMDL. The permittee's written report shall also include an implementation schedule for each identified additional pollutant control measure.

Upon approval of the Department, and if the written report identifies needed additional pollutant control measures, the permittee shall implement the additional pollutant control measures according to the schedule. The approved written report detailing the additional pollutant control measures and the associated implementation schedule shall be included in the CNMP and shall be an enforceable part of this permit.

11. Treatment System

The CAFO may include an anaerobic digester-based treatment system. The application for coverage under this permit shall include a description of the construction and operation of the anaerobic digester-based treatment system, including a schematic or flow diagram of the process, a listing of all outside materials (non-CAFO waste) to be added to the digester, the percentage input to the digester comprised of outside materials, and a contingency plan in the event of system failures including computer malfunctions. The contingency plan shall address the actions to be taken by the permittee if the digester-based treatment system must be by-passed for any reason, including handling and storage of partially-digested contents.

Up to 20 percent of outside materials may be added to the digester to enhance operation. Quantities above 5 percent will be listed in the COC issued under this permit. The Department may prohibit the use of certain outside materials. The permittee shall keep with the CNMP the quantities and identity of outside materials added to the digester. Outside materials not listed in the application shall not be added to the digester without prior approval from the Department. The outputs from the treatment system shall be stored and managed in accordance with the permit. The digester shall be operated consistently with the information provided in the application for coverage under this permit.

12. Document Availability

Copies of all documents required by this permit, including the CNMP, Land Application Log, inspection records, etc,. shall be kept at the permitted farm and made available to the Department upon request.

PART II

Part II may include terms and /or conditions not applicable to discharges covered under this permit.

Section A. Definitions

Animal Feeding Operation (AFO) means a lot or facility that meets both of the following conditions:
1. Animals, other than aquatic animals, have been, are, or will be stabled or confined and fed or maintained for a total of 45 calendar days or more in any 12-month period
2. Crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over the portion of the lot or facility where animals are confined

Two or more AFOs under common ownership are considered to be a single AFO if they adjoin each other or if they use a common area or system for the disposal of wastes. Common area includes land application areas.

Concentrated Animal Feeding Operation (CAFO) means any AFO that requests coverage under the permit for which the Department determines that this permit is appropriate for the applicant's operation. A CAFO includes both production areas and land application areas.

CAFO Process Wastewater means water directly or indirectly used in the operation of a CAFO for any of the following:
1. Spillage or overflow from animal or poultry watering systems
2. Washing, cleaning, or flushing pens, barns, manure pits, or other AFO facilities
3. Direct contact swimming, washing, or spray cooling of animals
4. Dust control
5. Any water which comes into contact with, or is a constituent of, any raw materials, products, or byproducts, including manure, litter, feed, milk, eggs, or bedding

CAFO Waste means CAFO process wastewater, manure, production area waste, effluents from the properly and successfully operated treatment system, or any combination thereof.

Certificate of Coverage (COC) is a document, issued by the Department, which authorizes a discharge under a general permit.

Certified CNMP Provider is a person that attains and maintains certification requirements through a program approved by the United States Department of Agriculture Natural Resources Conservation Service (NRCS).

CNMP means Comprehensive Nutrient Management Plan and is the plan developed by the permittee to implement the requirements of the NMP.

Department means the Michigan Department of Environmental Quality.

Discharge as used in this permit means the addition of any waste, waste effluent, wastewater, pollutant, or any combination thereof to any surface water of the state.

Grassed Waterway means a natural or constructed channel for storm water drainage that originates and is located within a field used for growing crops, and that is used to carry surface water at a non-erosive velocity to a stable outlet and is established with suitable and adequate permanent vegetation.

Incorporation means a mechanical operation that physically mixes the surface-applied CAFO waste into the soil so that a significant amount of the surface-applied CAFO waste is not present on the land surface within one hour after mixing. Incorporation also means the soaking into the soil of "liquids being used for irrigation water" such that liquids and significant solid residues do not remain on the land surface. "Liquids being used for irrigation water" are contaminated runoff, milk house waste, or liquids from CAFO waste treated to separate liquids and solids. "Liquids being used for irrigation water" does not include untreated liquid manures.

Land Application means spraying or spreading of biosolids, CAFO waste, wastewater and/or derivatives onto the land surface, injecting below the land surface, or incorporating into the soil so that the biosolids, CAFO waste, wastewater and/or derivatives can either condition the soil or fertilize crops or vegetation grown in the soil.

Land Application Area means land under the control of an AFO owner or operator, whether it is owned, rented, leased, or subject to an access agreement to which CAFO waste is or may be applied. Land application area includes land not owned by the AFO owner or operator but where the AFO owner or operator has control of the land application of CAFO waste.

PART II

Section A. Definitions

Large CAFO is an AFO that stables or confines as many as or more than the numbers of animals specified in any of the following categories:
1. 700 mature dairy cattle (whether milked or dry cows)
2. 1,000 veal calves
3. 1,000 cattle other than mature dairy cows or veal calves. Cattle include heifers, steers, bulls, calves, and cow/calf pairs
4. 2,500 swine each weighing 55 pounds or more
5. 10,000 swine each weighing less than 55 pounds
6. 500 horses
7. 10,000 sheep or lambs
8. 55,000 turkeys
9. 30,000 laying hens or broilers, if the AFO uses a liquid manure handling system
10. 125,000 chickens (other than laying hens), if the AFO uses other than a liquid manure handling system
11. 82,000 laying hens, if the AFO uses other than a liquid manure handling system

Large CAFOs are required to obtain NPDES permits under Michigan Rule No. 323.2196.

Manure means animal excrement and is defined to include bedding, compost, and raw materials, or other materials commingled with animal excrement or set aside for disposal.

Maximum Annual Phosphorus Land Application Rate means the maximum quantity, per calendar year, of phosphorus (usually expressed in pounds per acre) that is allowed to be applied to crop fields where CAFO waste is spread, including the phosphorus contained in the CAFO waste.

MGD means million gallons per day.

New CAFO means a CAFO that is newly built and was not in production (i.e., animals were not on site) prior to January 30, 2004. New CAFO also means existing facilities where, due to expansion in production, the process or production equipment is totally replaced or new processes are added that are substantially independent of an existing source at the same site, after February 27, 2004. This does not include replacement due to acts of God or upgrades in technology that serve the existing production. This definition does not apply to “New” as used for swine, poultry, and veal facilities in Part I.B.1.a.2) on page 6.

NMP means Nutrient Management Plan and is the section in the permit that sets forth requirements and conditions to assure that water quality standards are met.

No Till Practices means where the field will not receive tillage from time of land application until after harvest of the next crop. .

NRCS means the Natural Resources Conservation Service of the United States Department of Agriculture.

NRCS 313 (date) means the NRCS Michigan Statewide Technical Guide, Section IV, Conservation Practice No. 313, Waste Storage Facility, dated either June 2003, November 2005 or August 2014.

Overflow means a release of CAFO waste resulting from the filling of CAFO waste storage structures beyond the point at which no more CAFO waste or storm water can be contained by the structure.

Pasture Land is land that is primarily used for the production of forage upon which livestock graze. Pasture land is characterized by a predominance of vegetation consisting of desirable forage species. Sites such as loafing areas, confinement areas, or feedlots which have livestock densities that preclude a predominance of desirable forage species are not considered pasture land. Heavy-use areas within pastures adjacent to, or associated with, the CAFO are part of the pasture and are not part of the production area. Examples of heavy-use areas include livestock travel lanes and small areas immediately adjacent to feed and watering stations.

Perennial means a plant that has a life cycle of more than two years.

PART II

Section A. Definitions

Production Area is the portion of the CAFO that includes all areas used for animal product production activities. This includes, but is not limited to: the animal confinement area, the manure storage area, the raw materials storage area, and the waste containment areas. The animal confinement area includes open lots, housed lots, feedlots, confinement houses, stall barns, free stall barns, milk rooms, milking centers, cow yards, barnyards, medication pens, walkers, animal walkways (not within pasture areas), and stables. The manure storage area includes lagoons, runoff ponds, storage sheds, stockpiles, under-house or pit storages, liquid impoundments, static piles, and composting piles. The raw materials storage area includes feed silos, silage bunkers, and bedding materials [new sand to be used as bedding (not sand previously used as bedding) is excluded from this definition]. The waste containment area includes settling basins and areas within berms and diversions which separate uncontaminated storm water. Also included in the definition of “production area” is any egg washing or egg processing facility and any area used in the storage, handling, treatment, or disposal of mortalities. Production areas do not include pasture lands or land application areas.

Production Area Waste means manure and any waste from the production area and any precipitation (e.g., rain or snow) which comes into contact with, or is contaminated by, manure or any of the components listed in the definition for “production area.” Production area waste also includes contaminated runoff from digester and treatment system areas. Production area waste does not include clean water that is diverted nor does it include water from land application areas.

Realistic Crop Yield Goals means expected crop yields based on soil productivity potential, the crop management practices utilized, and crop yield records for multiple years for the field. Yield goals shall be adjusted to counteract unusually low or high yields. When a field’s history is not available, another referenced source shall be used to estimate yield goal. A realistic crop yield goal is one which is achievable in three out of five crop years. If the goal is not achieved in at least three out of five years, then the goal shall be re-evaluated and revised.

Regional Administrator is the Region 5 Administrator, United States Environmental Protection Agency (USEPA), located at R-19J, 77 West Jackson Boulevard, Chicago, Illinois 60604.

Silage Leachate means a liquid, containing organic constituents, that results from the storage of harvested plant materials, which usually has a high water content.

Solid Stackable Manure means manure and manure mixed with bedding that can be piled up or stacked and will maintain a piled condition. It will also have the characteristic that it can be shoveled with a pitchfork.

Swale means a shallow, channel-like, linear depression within a field used for growing crops that is at a low spot on a hillslope and is used to transport storm water. It may or may not be vegetated.

Waste Storage Structure means both pond-type storage structures and fabricated storage structures.

Tile means a conduit, such as corrugated plastic tubing, tile, or pipe, installed beneath the ground surface to collect and/or convey drainage water.

Vegetated Buffer means a narrow, permanent strip of dense perennial vegetation, established parallel to the contours of and perpendicular to the dominant slope of the field, for the purposes of slowing water runoff, enhancing water infiltration, and minimizing the risk of any potential nutrients or pollutants from leaving the field and reaching surface waters.

Water Quality Standards means the Part 4 Water Quality Standards developed under Part 31 of Act No. 451 of the Public Acts of 1994, as amended, being Rules 323.1041 through 323.1117 of the Michigan Administrative Code.

25-year, 24-hour rainfall event or **100-year, 24-hour rainfall event** means the maximum 24-hour precipitation event with a probable recurrence interval of once in 25 years or 100 years, respectively, as defined by the “Rainfall Frequency Atlas of the Midwest,” Huff and Angel, Illinois State Water Survey, Champaign, Bulletin 71, 1992, and subsequent amendments, or equivalent regional or state rainfall probability information developed there from.

PART II

Section B. Monitoring Procedures

1. Representative Samples

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. Test Procedures

Test procedures for the analysis of pollutants shall conform to regulations promulgated pursuant to Section 304(h) of the Federal Act (40 CFR Part 136 – Guidelines Establishing Test Procedures for the Analysis of Pollutants), unless specified otherwise in this permit. **Test procedures used shall be sufficiently sensitive to determine compliance with applicable effluent limitations**. Requests to use test procedures not promulgated under 40 CFR Part 136 for pollutant monitoring required by this permit shall be made in accordance with the Alternate Test Procedures regulations specified in 40 CFR 136.4. These requests shall be submitted to the Chief of the Permits Section, Water Resources Division, Michigan Department of Environmental Quality, P.O. Box 30458, Lansing, Michigan, 48909-7958. The permittee may use such procedures upon approval.

The permittee shall periodically calibrate and perform maintenance procedures on all analytical instrumentation at intervals to ensure accuracy of measurements. The calibration and maintenance shall be performed as part of the permittee's laboratory Quality Control/Quality Assurance program.

3. Instrumentation

The permittee shall periodically calibrate and perform maintenance procedures on all monitoring instrumentation at intervals to ensure accuracy of measurements.

4. Recording Results

For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information: 1) the exact place, date, and time of measurement or sampling; 2) the person(s) who performed the measurement or sample collection; 3) the dates the analyses were performed; 4) the person(s) who performed the analyses; 5) the analytical techniques or methods used; 6) the date of and person responsible for equipment calibration; and 7) the results of all required analyses.

5. Records Retention

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained for a minimum of three (3) years, or longer if requested by the Regional Administrator or the Department.

PART II

Section C. Reporting Requirements

1. Start-up Notification

If the permittee will not discharge during the first 60 days following the effective date of this permit, the permittee shall notify the Department within 14 days following the effective date of this permit, and then 60 days prior to the commencement of the discharge.

2. Submittal Requirements for Self-Monitoring Data

Part 31 of the NREPA, specifically Section 324.3110(3) and R 323.2155(2) of Part 21, allows the Department to specify the forms to be utilized for reporting the required self-monitoring data. Unless instructed on the effluent limitations page to conduct "Retained Self-Monitoring" the permittee shall submit self-monitoring data via the Department's Electronic Environmental Discharge Monitoring Reporting (e2-DMR) system.

The permittee shall utilize the information provided on the e2-Reporting website at https://secure1.state.mi.us/e2rs/ to access and submit the electronic forms. Both monthly summary and daily data shall be submitted to the Department no later than the 20th day of the month following each month of the authorized discharge period(s). The permittee may be allowed to submit the electronic forms after this date if the Department has granted an extension to the submittal date.

3. Retained Self-Monitoring Requirements

If instructed on the effluent limits page (or otherwise authorized by the Department in accordance with the provisions of this permit) to conduct retained self-monitoring, the permittee shall maintain a year-to-date log of retained self-monitoring results and, upon request, provide such log for inspection to the staff of the Department. Retained self-monitoring results are public information and shall be promptly provided to the public upon request.

The permittee shall certify, in writing, to the Department, on or before January 10th (April 1st for animal feeding operation facilities) of each year, that: 1) all retained self-monitoring requirements have been complied with and a year-to-date log has been maintained; and 2) the application on which this permit is based still accurately describes the discharge. With this annual certification, the permittee shall submit a summary of the previous year's monitoring data. The summary shall include maximum values for samples to be reported as daily maximums and/or monthly maximums and minimum values for any daily minimum samples.

Retained self-monitoring may be denied to a permittee by notification in writing from the Department. In such cases, the permittee shall submit self-monitoring data in accordance with Part II.C.2., above. Such a denial may be rescinded by the Department upon written notification to the permittee. Reissuance or modification of this permit or reissuance or modification of an individual permittee's authorization to discharge shall not affect previous approval or denial for retained self-monitoring unless the Department provides notification in writing to the permittee.

4. Additional Monitoring by Permittee

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report. Such increased frequency shall also be indicated.

Monitoring required pursuant to Part 41 of the NREPA or Rule 35 of the Mobile Home Park Commission Act (Act 96 of the Public Acts of 1987) for assurance of proper facility operation shall be submitted as required by the Department.

PART II

Section C. Reporting Requirements

5. Compliance Dates Notification

Within 14 days of every compliance date specified in this permit, the permittee shall submit a *written* notification to the Department indicating whether or not the particular requirement was accomplished. If the requirement was not accomplished, the notification shall include an explanation of the failure to accomplish the requirement, actions taken or planned by the permittee to correct the situation, and an estimate of when the requirement will be accomplished. If a written report is required to be submitted by a specified date and the permittee accomplishes this, a separate written notification is not required.

6. Noncompliance Notification

Compliance with all applicable requirements set forth in the Federal Act, Parts 31 and 41 of the NREPA, and related regulations and rules is required. All instances of noncompliance shall be reported as follows:

a. 24-Hour Reporting
Any noncompliance which may endanger health or the environment (including maximum and/or minimum daily concentration discharge limitation exceedances) shall be reported, verbally, within 24 hours from the time the permittee becomes aware of the noncompliance. A written submission shall also be provided within five (5) days.

b. Other Reporting
The permittee shall report, in writing, all other instances of noncompliance not described in a. above at the time monitoring reports are submitted; or, in the case of retained self-monitoring, within five (5) days from the time the permittee becomes aware of the noncompliance.

Written reporting shall include: 1) a description of the discharge and cause of noncompliance; and 2) the period of noncompliance, including exact dates and times, or, if not yet corrected, the anticipated time the noncompliance is expected to continue, and the steps taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

7. Spill Notification

The permittee shall immediately report any release of any polluting material which occurs to the surface waters or groundwaters of the state, unless the permittee has determined that the release is not in excess of the threshold reporting quantities specified in the Part 5 Rules (R 324.2001 through R 324.2009 of the Michigan Administrative Code), by calling the Department at the number indicated on the second page of this permit (or, if this is a general permit, on the COC); or, if the notice is provided after regular working hours, call the Department's 24-hour Pollution Emergency Alerting System telephone number, 1-800-292-4706 (calls from **out-of-state** dial 1-517-373-7660).

Within ten (10) days of the release, the permittee shall submit to the Department a full written explanation as to the cause of the release, the discovery of the release, response (clean-up and/or recovery) measures taken, and preventative measures taken or a schedule for completion of measures to be taken to prevent reoccurrence of similar releases.

PART II

Section C. Reporting Requirements

8. Upset Noncompliance Notification

If a process "upset" (defined as an exceptional incident in which there is unintentional and temporary noncompliance with technology based permit effluent limitations because of factors beyond the reasonable control of the permittee) has occurred, the permittee who wishes to establish the affirmative defense of upset, shall notify the Department by telephone within 24 hours of becoming aware of such conditions; and within five (5) days, provide in writing, the following information:

a. that an upset occurred and that the permittee can identify the specific cause(s) of the upset;

b. that the permitted wastewater treatment facility was, at the time, being properly operated and maintained (note that an upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation); and

c. that the permittee has specified and taken action on all responsible steps to minimize or correct any adverse impact in the environment resulting from noncompliance with this permit.

No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review.

In any enforcement proceedings, the permittee, seeking to establish the occurrence of an upset, has the burden of proof.

9. Bypass Prohibition and Notification

a. Bypass Prohibition
Bypass is prohibited, and the Department may take an enforcement action, unless:

1) bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;

2) there were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate backup equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass; and

3) the permittee submitted notices as required under 9.b. or 9.c. below.

b. Notice of Anticipated Bypass
If the permittee knows in advance of the need for a bypass, it shall submit prior notice to the Department, if possible at least ten (10) days before the date of the bypass, and provide information about the anticipated bypass as required by the Department. The Department may approve an anticipated bypass, after considering its adverse effects, if it will meet the three (3) conditions listed in 9.a. above.

c. Notice of Unanticipated Bypass
The permittee shall submit notice to the Department of an unanticipated bypass by calling the Department at the number indicated on the second page of this permit (if the notice is provided after regular working hours, use the following number: 1-800-292-4706) as soon as possible, but no later than 24 hours from the time the permittee becomes aware of the circumstances.

PART II

Section C. Reporting Requirements

d. Written Report of Bypass
A written submission shall be provided within five (5) working days of commencing any bypass to the Department, and at additional times as directed by the Department. The written submission shall contain a description of the bypass and its cause; the period of bypass, including exact dates and times, and if the bypass has not been corrected, the anticipated time it is expected to continue; steps taken or planned to reduce, eliminate, and prevent reoccurrence of the bypass; and other information as required by the Department.

e. Bypass Not Exceeding Limitations
The permittee may allow any bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to ensure efficient operation. These bypasses are not subject to the provisions of 9.a., 9.b., 9.c., and 9.d., above. This provision does not relieve the permittee of any notification responsibilities under Part II.C.11. of this permit.

f. Definitions

1) Bypass means the intentional diversion of waste streams from any portion of a treatment facility.

2) Severe property damage means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

10. Bioaccumulative Chemicals of Concern (BCC)

Consistent with the requirements of R 323.1098 and R 323.1215 of the Michigan Administrative Code, the permittee is prohibited from undertaking any action that would result in a lowering of water quality from an increased loading of a BCC unless an increased use request and antidegradation demonstration have been submitted and approved by the Department.

11. Notification of Changes in Discharge

The permittee shall notify the Department, in writing, as soon as possible but no later than 10 days of knowing, or having reason to believe, that any activity or change has occurred or will occur which would result in the discharge of: 1) detectable levels of chemicals on the current Michigan Critical Materials Register, priority pollutants or hazardous substances set forth in 40 CFR 122.21, Appendix D, or the Pollutants of Initial Focus in the Great Lakes Water Quality Initiative specified in 40 CFR 132.6, Table 6, which were not acknowledged in the application or listed in the application at less than detectable levels; 2) detectable levels of any other chemical not listed in the application or listed at less than detection, for which the application specifically requested information; or 3) any chemical at levels greater than five times the average level reported in the complete application (see the first page of this permit, for the date(s) the complete application was submitted). Any other monitoring results obtained as a requirement of this permit shall be reported in accordance with the compliance schedules.

PART II

Section C. Reporting Requirements

12. Changes in Facility Operations

Any anticipated action or activity, including but not limited to facility expansion, production increases, or process modification, which will result in new or increased loadings of pollutants to the receiving waters must be reported to the Department by a) submission of an increased use request (application) and all information required under R 323.1098 (Antidegradation) of the Water Quality Standards or b) by notice if the following conditions are met: 1) the action or activity will not result in a change in the types of wastewater discharged or result in a greater quantity of wastewater than currently authorized by this permit; 2) the action or activity will not result in violations of the effluent limitations specified in this permit; 3) the action or activity is not prohibited by the requirements of Part II.C.10.; and 4) the action or activity will not require notification pursuant to Part II.C.11. Following such notice, the permit or, if applicable, the facility's COC may be modified according to applicable laws and rules to specify and limit any pollutant not previously limited.

13. Transfer of Ownership or Control

In the event of any change in control or ownership of facilities from which the authorized discharge emanates, the permittee shall submit to the Department 30 days prior to the actual transfer of ownership or control a written agreement between the current permittee and the new permittee containing: 1) the legal name and address of the new owner; 2) a specific date for the effective transfer of permit responsibility, coverage and liability; and 3) a certification of the continuity of or any changes in operations, wastewater discharge, or wastewater treatment.

If the new permittee is proposing changes in operations, wastewater discharge, or wastewater treatment, the Department may propose modification of this permit in accordance with applicable laws and rules.

14. Operations and Maintenance Manual

For wastewater treatment facilities that serve the public (and are thus subject to Part 41 of the NREPA), Section 4104 of Part 41 and associated Rule 2957 of the Michigan Administrative Code allow the Department to require an Operations and Maintenance (O&M) Manual from the facility. An up-to-date copy of the O&M Manual shall be kept at the facility and shall be provided to the Department upon request. The Department may review the O&M Manual in whole or in part at its discretion and require modifications to it if portions are determined to be inadequate.

At a minimum, the O&M Manual shall include the following information: permit standards; descriptions and operation information for all equipment; staffing information; laboratory requirements; record keeping requirements; a maintenance plan for equipment; an emergency operating plan; safety program information; and copies of all pertinent forms, as-built plans, and manufacturer's manuals.

Certification of the existence and accuracy of the O&M Manual shall be submitted to the Department at least sixty days prior to start-up of a new wastewater treatment facility. Recertification shall be submitted sixty days prior to start-up of any substantial improvements or modifications made to an existing wastewater treatment facility.

PART II

Section C. Reporting Requirements

15. Signatory Requirements

All applications, reports, or information submitted to the Department in accordance with the conditions of this permit and that require a signature shall be signed and certified as described in the Federal Act and the NREPA.

The Federal Act provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance, shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than 6 months per violation, or by both.

The NREPA (Section 3115(2)) provides that a person who at the time of the violation knew or should have known that he or she discharged a substance contrary to this part, or contrary to a permit, COC, or order issued or rule promulgated under this part, or who intentionally makes a false statement, representation, or certification in an application for or form pertaining to a permit or COC or in a notice or report required by the terms and conditions of an issued permit or COC, or who intentionally renders inaccurate a monitoring device or record required to be maintained by the Department, is guilty of a felony and shall be fined not less than $2,500.00 or more than $25,000.00 for each violation. The court may impose an additional fine of not more than $25,000.00 for each day during which the unlawful discharge occurred. If the conviction is for a violation committed after a first conviction of the person under this subsection, the court shall impose a fine of not less than $25,000.00 per day and not more than $50,000.00 per day of violation. Upon conviction, in addition to a fine, the court in its discretion may sentence the defendant to imprisonment for not more than 2 years or impose probation upon a person for a violation of this part. With the exception of the issuance of criminal complaints, issuance of warrants, and the holding of an arraignment, the circuit court for the county in which the violation occurred has exclusive jurisdiction. However, the person shall not be subject to the penalties of this subsection if the discharge of the effluent is in conformance with and obedient to a rule, order, permit, or COC of the Department. In addition to a fine, the attorney general may file a civil suit in a court of competent jurisdiction to recover the full value of the injuries done to the natural resources of the state and the costs of surveillance and enforcement by the state resulting from the violation.

16. Electronic Reporting

Upon notice by the Department that electronic reporting tools are available for specific reports or notifications, the permittee shall submit electronically all such reports or notifications as required by this permit.

PART II

Section D. Management Responsibilities

1. Duty to Comply

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit, more frequently than, or at a level in excess of, that authorized, shall constitute a violation of the permit.

It is the duty of the permittee to comply with all the terms and conditions of this permit. Any noncompliance with the Effluent Limitations, Special Conditions, or terms of this permit constitutes a violation of the NREPA and/or the Federal Act and constitutes grounds for enforcement action; for permit or Certificate of Coverage (COC) termination, revocation and reissuance, or modification; or denial of an application for permit or COC renewal.

It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

2. Facilities Operation

The permittee shall, at all times, properly operate and maintain all treatment or control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit. Proper operation and maintenance includes adequate laboratory controls and appropriate quality assurance procedures.

3. Power Failures

In order to maintain compliance with the effluent limitations of this permit and prevent unauthorized discharges, the permittee shall either:

a. provide an alternative power source sufficient to operate facilities utilized by the permittee to maintain compliance with the effluent limitations and conditions of this permit; or

b. upon the reduction, loss, or failure of one or more of the primary sources of power to facilities utilized by the permittee to maintain compliance with the effluent limitations and conditions of this permit, the permittee shall halt, reduce or otherwise control production and/or all discharge in order to maintain compliance with the effluent limitations and conditions of this permit.

4. Adverse Impact

The permittee shall take all reasonable steps to minimize or prevent any adverse impact to the surface waters or groundwaters of the state resulting from noncompliance with any effluent limitation specified in this permit including, but not limited to, such accelerated or additional monitoring as necessary to determine the nature and impact of the discharge in noncompliance.

PART II

Section D. Management Responsibilities

5. Containment Facilities

The permittee shall provide facilities for containment of any accidental losses of polluting materials in accordance with the requirements of the Part 5 Rules (R 324.2001 through R 324.2009 of the Michigan Administrative Code). For a Publicly Owned Treatment Work (POTW), these facilities shall be approved under Part 41 of the NREPA.

6. Waste Treatment Residues

Residuals (i.e. solids, sludges, biosolids, filter backwash, scrubber water, ash, grit, or other pollutants or wastes) removed from or resulting from treatment or control of wastewaters, including those that are generated during treatment or left over after treatment or control has ceased, shall be disposed of in an environmentally compatible manner and according to applicable laws and rules. These laws may include, but are not limited to, the NREPA, Part 31 for protection of water resources, Part 55 for air pollution control, Part 111 for hazardous waste management, Part 115 for solid waste management, Part 121 for liquid industrial wastes, Part 301 for protection of inland lakes and streams, and Part 303 for wetlands protection. Such disposal shall not result in any unlawful pollution of the air, surface waters or groundwaters of the state.

7. Right of Entry

The permittee shall allow the Department, any agent appointed by the Department, or the Regional Administrator, upon the presentation of credentials and, for animal feeding operation facilities, following appropriate biosecurity protocols:

a. to enter upon the permittee's premises where an effluent source is located or any place in which records are required to be kept under the terms and conditions of this permit; and

b. at reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect process facilities, treatment works, monitoring methods and equipment regulated or required under this permit; and to sample any discharge of pollutants.

8. Availability of Reports

Except for data determined to be confidential under Section 308 of the Federal Act and Rule 2128 (R 323.2128 of the Michigan Administrative Code), all reports prepared in accordance with the terms of this permit, shall be available for public inspection at the offices of the Department and the Regional Administrator. As required by the Federal Act, effluent data shall not be considered confidential. Knowingly making any false statement on any such report may result in the imposition of criminal penalties as provided for in Section 309 of the Federal Act and Sections 3112, 3115, 4106 and 4110 of the NREPA.

9. Duty to Provide Information

The permittee shall furnish to the Department, within a reasonable time, any information which the Department may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or the facility's COC, or to determine compliance with this permit. The permittee shall also furnish to the Department, upon request, copies of records required to be kept by this permit.

Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application or in any report to the Department, it shall promptly submit such facts or information.

PART II

Section E. Activities Not Authorized by This Permit

1. Discharge to the Groundwaters

This permit does not authorize any discharge to the groundwaters. Such discharge may be authorized by a groundwater discharge permit issued pursuant to the NREPA.

2. POTW Construction

This permit does not authorize or approve the construction or modification of any physical structures or facilities at a POTW. Approval for the construction or modification of any physical structures or facilities at a POTW shall be by permit issued under Part 41 of the NREPA.

3. Civil and Criminal Liability

Except as provided in permit conditions on "Bypass" (Part II.C.9. pursuant to 40 CFR 122.41(m)), nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance, whether or not such noncompliance is due to factors beyond the permittee’s control, such as accidents, equipment breakdowns, or labor disputes.

4. Oil and Hazardous Substance Liability

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee may be subject under Section 311 of the Federal Act except as are exempted by federal regulations.

5. State Laws

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable state law or regulation under authority preserved by Section 510 of the Federal Act.

6. Property Rights

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize violation of any federal, state or local laws or regulations, nor does it obviate the necessity of obtaining such permits, including any other Department of Environmental Quality permits, or approvals from other units of government as may be required by law.

PART III

Technical Standard for the Surface Application of Concentrated Animal Feeding Operations Waste on Frozen or Snow-Covered Ground Without Incorporation or Injection

When Concentrated Animal Feeding Operation (CAFO) waste is surface-applied to frozen or snow-covered ground, without incorporation or injection, and that application is followed by rainfall or temperatures rising above freezing, the CAFO waste can run off into lakes, streams, or drains. Documented evidence shows that this runoff can cause resource damage to the surface waters of the state. Therefore, in accordance with Title 40 of the Code of Federal Regulations, Section 123.36, Establishment of Technical Standards for Concentrated Animal Feeding Operations, and State Rule 323.2196(5), CAFO Permits, the Michigan Department of Environmental Quality, Water Bureau, establishes the following Technical Standard. This Technical Standard shall be used for field-by-field assessments, as required by National Pollutant Discharge Elimination System permits issued to CAFOs, to assure that the land application of CAFO waste to frozen or snow-covered ground, without incorporation or injection, will not result in CAFO waste entering the waters of the state.

Based on the frozen and/or snow-covered conditions, the minimal settling and breaking down of the waste during these conditions, and the inability to predict or control snowmelt and rainfall, there are no practices that can ensure the runoff from fields with surface-applied waste on frozen or snow-covered ground will not be polluted. This standard assumes that surface runoff from snowmelt and/or rainfall will occur, and that the runoff will be polluted if CAFO waste is surface-applied on frozen or snow-covered ground. Therefore, the way to prevent these discharges is to apply CAFO waste only to fields, or portions of fields, where the runoff will not reach surface waters.

A field-by-field assessment must be completed, and all of the following requirements must be met and documented:

1. The Natural Resources Conservation Service's Manure Application Risk Index (MARI)* has been completed to identify fields, or portions of fields, that scored 37 or lower on the MARI.

2. An on-site field inspection of the entire field, or portion of field, that scored 37 or lower under the MARI has been completed. The inspection will take into consideration the slope and location of surface waters, tile line risers, and other conduits to surface water.

3. Based on the on-site field inspection, the Comprehensive Nutrient Management Plan (CNMP) will include documentation on topographic maps, the fields or portions of fields where the runoff will not flow to surface waters, and designate those areas as the only areas authorized for surface application without incorporation to frozen or snow-covered ground.

4. The findings of the inspection and documentation in the CNMP will be approved by a certified CNMP provider.

This assessment must be incorporated into the CNMP, and submitted as part of the CNMP Executive Summary each year.

* Grigar, J., and Lemunyon, J. A Procedure for Determining the Land Available for Winter Spreading of Manure in Michigan. NRCS publication. (Available on the MDEQ NPDES website)

ORIGINAL SIGNED — April 19, 2005

Richard A. Powers, Chief — Date
Water Bureau

EXHIBIT 23

STATE LINE Observer

Frank Gibbs: Liquid manure is too wet

Written by David Green. Aug. 20, 2006

By DAVID GREEN

Don't blame tile lines for discharges of liquid manure into drains, says soil scientist and farmer Frank Gibbs, and don't blame the rich soil with its worm holes leading to the tile.

Put the blame on the watered down manure. That's where the problem lies.

Gibbs, from the National Resources Conservation Service office in Findlay, Ohio, spoke to farmers last Wednesday at the annual Center for Excellence Field Day at Bakerlads Farm north of Clayton.

Gibbs told how he came to this conclusion several years ago, after he got a call from a producer in Ohio who had a problem. He was applying manure from his swine operation at only about half the recommended rate, but it was still finding its way into tile and drains.

A DNR officer told the farmer that he wouldn't cite him for discharges this time, but it had to be stopped.

"I went down there thinking I'd see big cracks in the ground," Gibbs said, "but the soil moisture was ideal. Impeccable shape. I saw lots and lots of night crawler holes and I thought, 'My God, could this be what's going on here?'"

Gibbs got ahold of some dye—similar to the kind used to check for leaks in a toilet tank—dumped it into the manure lagoon and agitated the mixture. After he dug down to a six-inch tile, manure was injected into the soil with a drag line. The tile was dry when the experiment began.

“We wondered how long it might take to percolate down to the tile lines. Twenty minutes? Should we go to lunch?”

There was no time for lunch, Gibbs said. The dye was there within seconds, and every time a pass was made over a lateral tile line, another pulse of colored liquid came through.

Gibbs wondered if the pressure from the applicator pump was the cause, so they next tried a gravity-feed system. Same problem. One more idea came to mind. This time they avoided the watery manure from the lagoon and loaded some of the thicker slurry from the pit under the hog barn.

“It didn’t go anywhere,” Gibbs said. “It behaved like manure. We dug up some areas with a back hoe and it was laying right where it was shot.”

He knew then not to fault the tile nor the healthy soil.

“The problem is simple. We’re watering manure down to where it behaves like water. Let me repeat that. We’re watering manure down to where it behaves like water. You don’t need to be a rocket scientist to understand that.”

Gibbs has heard the suggestion that no-till soil is at fault. Get rid of the worm holes and there’s no conduit for the manure.

Not true.

“Preferential flow will occur in conventional tillage through cracks and around the soil structure,” he said. “We need to stop confusing the issue with tillage. The issue is that we’re adding too much water.”

This is a situation that needs to be addressed, Gibbs said.

“We need to keep on top of this. We really do. I think some basic research could solve the problem.”

Maybe the percentage of solids needs to be up to four or five percent, he said. Or, from what he learned in Europe, even higher.

The Dutch method

With so many Dutch farmers investing in this area, Gibbs decided to take a trip to the Netherlands to see how they farmed in that country. He was in for a surprise.

He didn't see any of the watered down manure that the large dairies are using here. The solid content was at about eight percent.

He noticed a plastic membrane spread over a storage lagoon with rain water waiting to be pumped from an overnight storm. Gibbs figured it was to keep the water out of the lagoon, but he was wrong. It was to control odor.

Gibbs watched as a farmer loaded his applicator with manure and inserted a paper form into equipment that recorded his position by GPS. Once in the field, additional data was stamped onto the form. A sample bag of manure was collected to send for analysis by a government agency.

If manure exceeds the allowable nitrate rates, Gibbs was told, the farmer receives a bill from the government.

The Dutch farmer joked about having one government official for every farmer, but it isn't the heavy regulation that's hurting agriculture in Holland, he said, it's simply a lack of space.

Gibbs returned home knowing that the practice of watering down manure didn't come from Europe.

"That's our technology," he said. "We're going to all the work of writing up Comprehensive Nutrient Management Plans and then where does it go? Into the tile. We just need a little bit of research to figure this thing out so we don't have to scrap the whole thing."

Gibbs said he's made attempts to urge agricultural agencies to study the issue, but it's never gone far.

"Everybody's going off in other directions," he said. "We need to work together. We don't have to destroy our soils. We don't need to rip our tile out.

"What we should do is look at solids. Eight percent isn't that much. I don't know why we can't tweak that."

- Aug. 30, 2006

Stop it in the root zone

A visit to Wisconsin gave soil scientist Frank Gibbs additional hope for the future.

“They have some really good things going on there,” he said.

For example, the custom manure applicators have formed an association. They have standards and training, for those who choose to join the group. They work closely with the EPA. They practice cleanup of spills for when something goes wrong.

Gibbs was impressed with the beautiful crops growing on rolling hills. The key was the soil.

“They’ve got hay and they’ve got alfalfa and they put manure on it,” he said.

In this area, it’s almost always corn and soybeans, year after year. It’s the root system of a plant such as alfalfa that breaks up the soil to prevent compaction.

Custom applicators have to work with what they’re given, Gibbs said, and sometimes control structures are in order. Gibbs has built shut-off valves at the property line to stop the flow of liquid manure. A catch basin is added to collect the flow—a septic tank will do the job—and the manure can be pumped out and applied in a safe area between tile lines.

It’s just a Band-Aid approach, Gibbs said, not a solution, but it’s better than using rubber tile plugs in which case a farmer has no idea if the manure has left the tile. Besides, he asks, do we know where all the tile is? And if we miss one, who’s fault is it?

That’s when the arguing and finger-pointing begins. When manure flows into a drain, who is at fault—the farmer who owns the animals, the owner of the land where it’s being applied, or the person in charge of the application?

“If we do it the wrong way,” Gibbs said, “it’s going to be a mess.”

Any time manure enters a tile line, it’s wasted. At that point, Gibbs said, the nutrient is too deep to be absorbed by plants.

“We have to stop it in the root zone,” Gibbs said.

Smoke test highlights no-till

As a long-time proponent of no-till farming, Frank Gibbs often tries to convince other farmers to give it a try.

One of his early attempts was to dig out a cubic foot of his no-till soil and place it next to a sample from his neighbor’s sugar beet field that suffered from a lot of compaction due to trucks. Then he would pour a bottle of water onto each and watch it soak into his soil and run off his neighbor’s.

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“It was kind of hokey,” Gibbs said. “Farmers would say, ‘You’re from the government. You probably poked holes in it.’ I needed a different way to show the value of no-till.”

He remembered a blower contraption a friend created for planting beans—it never worked right—and as a fan of Red Green, Gibbs got out the duct tape to rig up a device for blowing smoke into a tile line.

“I could make smoke come out of millions of worm holes,” he thought.

The smoke test shows good soil conditions and at the same time, it shows the avenue that liquid manure takes to reach tile lines. It takes the easiest route, Gibbs said, the path of least resistance. Through worm holes and cracks in the glacial till, manure can quickly makes its way to tile.

To set up the Center of Excellence Field Day at Bakerlads Farm, Gibbs dug a hole to reach a tile line. He found two hand-laid tile lines, then a plastic line, then another older line. Tile is everywhere.

He set up his blower, dropped in a smoke bomb and watched for smoke to start rising out of a soybean field. Smoke started to run toward the bean field, but the line made a turn and headed back into the cornfield. That’s the trouble with tile lines, he said, you never know how many there are or where they end up.

Watching smoke rise out of the soil is a great demonstration, Gibbs said, and a real attention-getter.

“It’s hard for folks to deny this stuff happens when there’s smoke coming up under their feet.”

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EXHIBIT 24

Testimony Excerpt of

EGLE Environmental Quality Specialist;

Bruce Washburn

STATE OF MICHIGAN

MICHIGAN ADMINISTRATION HEARING SYSTEM

In the matter of:	Docket No.:	20-009773
Petition of Michigan Farm Bureau; Michigan Milk Producers Association; Michigan Allied Poultry Industries; Foremost Farms USA; Michigan Pork Producers Association; Dairy Farmers of America; Select Milk Producers, Inc.; and 126 Identified Livestock Farms /	Permit No.:	MIG010000
	Part:	Part 31, Water Resources Protection
	Agency:	Department of Environment, Great Lakes and Energy
	Case Type:	Water Resources Division

HEARING - VOLUME NO. II

BEFORE DANIEL PULTER, ADMINISTRATIVE LAW JUDGE

Via Microsoft Teams Meeting

Tuesday, December 7, 2021, 9:00 a.m.

APPEARANCES:

For the Petitioners: MR. ZACHARY CHAD LARSEN (P72189)
MR. MICHAEL JOHN PATTWELL (P72419)
Clark Hill, PLC
212 East Cesar E. Chavez Avenue
Lansing, Michigan 48906
(517) 318-3053

For the Respondent: MS. ELIZABETH ANNE MORRISSEAU (P81899)
MS. JENNIFER A. ROSA (P58226)
Assistant Attorneys General
Department of Attorney General
525 West Ottawa Street
G. Mennen Building, 6th Floor
Lansing, Michigan 48933
(517) 373-7540

Q Did you maintain that memo in the ordinary course of business?
A Yes.
Q With reference to Exhibit R-65, please explain why the 2015 CAFO General Permit is insufficient to protect water quality.
A The Livestock Committee provided suggestions based on staff experience that would better protect water quality, including additional sampling requirements, a ban on winter spreading, and additional reporting requirements. This was documented in the memo to WRD Management and a compiled list of suggestions by compliance staff.
Q Based on your experience in compliance since certificates of coverage began to be issued under the 2015 CAFO General Permit, do you have an opinion as to whether those requirements have been sufficient, in practice, to protect water quality?
A Yes.
Q What is that opinion?
A No, they have not.
Q Please explain.
A The changes were ineffective because there have been continued issues with winter spreading and runoff, land application in general, and lack of proper waste tracking. We have also seen additional water bodies listed as

impaired, in part due to our ineffective control of CAFOs. Farms have continued to exploit the weaknesses of the permit by winter spreading when it is not necessary, and have created additional entities to avoid retaining responsibility for their waste.

Q What do you mean by winter spreading when it is not necessary?

A When more manure is applied than is actually necessary for crop production and also when it is applied even if there is enough storage capacity.

Q And what do you mean about creating additional entities to preclude retaining responsibility of waste?

A We have seen farms create legal entities to receive manifested waste, which allows the legal entity that operates the CAFO to avoid the responsibility of controlling the waste by manifesting it to a different corporate entity, even if it is run by the same people who run the CAFO. Although of course CAFO owners, like other businesses, can create related corporate entities for a variety of legitimate purposes, it is frustrating to the Department when the people who run a CAFO do not have to follow permit requirements if they manifest waste from one company they own to another company that they also own.

Q Did you work on the 2020 CAFO General Permit?

A Yes.

conditions during this time frame could be sufficient for land application of waste. We recognized these differences and put additional protections in place to account for the fact that this time of year has some of the highest runoff risks and there are no growing crops to utilize the nutrients. A complete ban would have been clearer for all involved and been the best for water quality, but we were willing to see if the protections put in place could be followed by farms and also still protect water quality.

Q From the compliance perspective, is it easier to ban wintertime spreading of waste?

A Yes. It is a presence/absence determination. Are they doing it? If so, then it is a violation. No other consideration is needed. The way the final permit landed, it will not be a straightforward determination and staff will have to assess if all conditions were met to allow the application.

Q Please explain your understanding of the maximum land application rates.

A The maximum land application rate is the maximum amount of waste that can be applied based on nutrients in the waste and the soil and crop interaction which is either based on the removal rate of phosphorus or nitrogen recommendation/removal rate depending on the crop. The rates are tied to the Bray P1 soil analysis, which is a test

Q How do the requirements of the 2020 CAFO General Permit change based on a CAFO's location in a TMDL area?

A For CAFOs located in nutrient TMDL areas, lower risk-management techniques and thresholds are required at land application areas. For E. coli, Biota, and Dissolved Oxygen TMDLs, CAFOs are given nine additional months to implement the published guidance. In the 2015 General Permit, CAFOs had 15 months to implement, and in the 2020 General Permit they were given 24 months.

Q Is this requirement also in the 2015 CAFO General Permit?

A Yes, for the E. coli, Biota, and Dissolved Oxygen TMDLs.

Q Once the 2020 CAFO General Permit is in effect, what new data will the Department begin receiving from CAFOs?

A The Department will be able to track when, where, and how much CAFO waste is being applied in a given location and how much of that is being manifested to non-regulated entities. The Department will also be able to start documenting the amount of nutrients and other pollutants that are being discharged by CAFOs.

Q How will having that data help the Department more precisely regulate CAFOs in the future?

A The data will be used to make correlations between land application of CAFO waste and water quality changes within the watersheds where CAFO waste is being applied. This will help the Department make the necessary changes to ensure the

Q Do you agree with the testimony that the 2015 CAFO General Permit is sufficient to control water pollution from CAFOs and that the 2020 CAFO General Permit is unnecessary?
A No.
Q First, can you put this into perspective and explain how different the 2015 CAFO General permit is from previous CAFO General Permits?
A The 2015 CAFO General Permit was not significantly different from the 2005 and 2010 CAFO General Permits. Saying that there is nothing wrong with the 2015 CAFO General Permit is like saying that the Department got it right the first time it drafted the 2005 CAFO General Permit. And that is not the case, considering how much that first version relied on standard industry practices, instead of establishing new requirements from the water quality perspective.
Q Would it be fair to call the 2005 CAFO General Permit a farming permit and the 2020 CAFO General Permit a water quality permit?
A Yes.
Q Why is that?
A The 2005 General Permit followed already established industry standards for many practices. In my opinion, these standards have heavy input from agricultural groups and limited input from groups looking to protect the environment and public health. The standards themselves reflect this

the Department did not know where CAFOs land-applied waste that they manifested. Can you put that into perspective? How much waste per year was the Department unable to track?

A **For example, in 2018, approximately 39 percent of liquid waste and 53 percent of solid waste was manifested, and in 2019, approximately 45 percent of liquid waste and 53 percent of solid waste was manifested. Annually, this equates to nearly 1.36 billion gallons and 614,000 tons, and 1.5 billion gallons and 667,000 tons, respectively for 2018 and 2019. This typically is higher strength waste because diluted wastewater has less value for third parties.**

Q Just with respect to petitioners, do you know how much of their waste they manifest?

A **Yes, 22 of them manifest 100 percent of their waste.**

Q Does anything else stand out regarding petitioners?

A **Yes. One of the largest group of farms contesting the permit, owned by the Sietsemas, manifests nearly 100 percent of its waste.**

Q Does the Department know where that manifested waste was land applied?

A **No.**

Q Was it applied in Total Maximum Daily Load (TMDL) watersheds?

A **I don't know.**

Q Generally speaking, does the Department know how much of any

manifested waste is applied in TMDL watersheds?
A **No.**
Q How does the Department know if manifested waste is land applied in TMDL watersheds?
A **The data we currently receive includes an address, at best, otherwise crossroads. It is very difficult to know to what extent manifested waste gets land applied in TMDL watersheds.**
Q Without regard for TMDL watersheds, how does the Department know if manifested waste ends up in surface waters?
A **We only know if it gets reported to us, either by the farm itself or a citizen, or if we happen to see it while in the area.**
Q If manifested waste (or any waste, for that matter) ends up in surface water, is it automatically a violation of water quality standards?
A **Not necessarily.**
Q How would you know if it is a violation of water quality standards?
A **We would have to obtain a sample and have it analyzed by a lab.**
Q Does the 2015 CAFO General Permit require water testing?
A **No, however, if a farm wants to claim it is an allowable discharge, they would have to prove it through testing.**
Q Have you ever had a farm submit sample results to show it

required to let us know if the fields are tiled. That's part of the field by field assessment. And we have not -- we've not parsed that out of the acreage.

Q Okay. That's all right. Yeah, that's sufficient. So how long have these systems existed on fields in Michigan?

A **From my understanding of just water resources in Michigan in general, it was -- Michigan's a swampy state. When they settled it they had to drain a lot of the swamp to make it habitable and for other reasons. So not to assume or make a statement that may be unfactual, but it's likely there's been drainage in Michigan since it's been settled. So to the extent it was tile, I mean, I can't speak to.**

Q Okay. But given that as you say that drainage has been used in this state since settlement, would it be a fair assumption that we don't know the precise location of tiles on all fields in Michigan?

A **Yes, that would be a factual statement.**

Q Okay. And so on page 59 of your testimony, lines 1 through 3, you testified that liquid manure should be mixed with solids before it's spread on a tiled field. Is that because liquid manure has a higher likelihood of flowing into tiles and discharging into the waters of the state without this mixing?

A **It has -- yes, it has a higher potential compared to a more solid manure.**

that I'm aware of that are MAEAP verified and under this CAFO program are not using MPRA, so the conclusion would lead me to that MPRA is not required by MAEAP.

Q Just to make one thing clear, do you know who, if any of the upcoming EGLE witnesses were responsible for developing the MPRA?

A Yeah, Thad Cleary was, he was on that team that developed the MPRA.

Q Okay. All right. I'm going to try to see if I can like one or two more questions in before I got to go. Okay. Let's talk about tiles. Are nutrients that discharge out of a tile line used by plants? Let me rephrase that question. Are nutrients that flow from a field through the tile line used by crops on that field?

A They could have been, but if they reached the tile line and they're in the drainage water, then they're likely not able to be used by the crop anymore.

Q Okay. So there was some discussion with Mr. Petoskey about tiles and avoiding getting waste into the tiles. Is one way to avoid waste getting into tiles knowing where all of them are?

A Sure. Because like I mentioned earlier in my testimony is some of them are shallow, six inches, up to several feet. So if in an area that the tile is very shallow and you inject too deep or not properly, then that could be a quick

EXHIBIT 25

A Watershed Moment.

Lake Huron rolls, Superior sings
In the rooms of her ice-water mansion.
Old Michigan steams like a young man's dreams
The islands and bays are for sportsmen.
And farther below Lake Ontario
Takes in what Lake Erie can send her.

In *The Wreck of the Edmund Fitzgerald*[1], Gordon Lightfoot sings the words to a geography lesson about the Great Lakes Basin, which is part of the St. Lawrence Watershed. This watershed includes parts of 11 American states and six Canadian provinces. The Great Lakes hold one-fifth of the world's, and 95% of the United States', fresh water supply. At its heart lies one state – Michigan, whose Great Lakes coastline of 3,288 miles[2], is more than any other state's except Alaska. What happens to Michigan's surface water impacts this entire system. Michigan is truly **The** Great Lakes State.

Figure 1. St. Lawrence Drainage Basin, including the Great Lakes Drainage Basin[3]

In 2015, The Less = More Coalition published [*Follow the Manure: Factory Farms and the Lake Erie Algal Crisis*], which targeted the role that Concentrated Animal Feeding Operations (CAFOs), or factory farms, and the manure they produce, play in contributing dissolved phosphorus to Lake Erie's toxic algae problems.

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[1] *The Wreck of the Edmund Fitzgerald.* Lightfoot, G. Summer Dreams. Eastern Sound Studios. December, 1975.
[2] *Great Lakes Facts and Figures,* Great Lakes Information Network http://www.great-lakes.net/lakes/ref/lakefact.html, updated March 13, 2017.
[3] http://www.infrastructure.gc.ca/images/great-lakes-grands-lacs_basin-bassinx390_eng.jpg

Follow the Manure, with its interactive maps, continued the work begun by Less = More's 2013 report, *Restoring the Balance to Michigan's Farming Landscape*, and showed the extent to which Federal subsidies fund these facilities in the Western Lake Erie Watershed. In many cases, these taxpayer dollars continue to fund the bad actors and ineffective agricultural practices, with disastrous effects in Lake Erie and throughout the Great Lakes Basin.

In 2017, we find ourselves at a watershed moment. Millions of dollars are being spent on various efforts to keep phosphorus from entering the surface waters of the Great Lakes in the form of additional subsidies through partnerships between the U.S. Dept. of Agriculture (USDA) and the U.S. Environmental Protection Agency (EPA). In addition, the USDA through the Farm Bill continues to subsidize commodity crop production which feeds these livestock, crop insurance, and conservation and EQIP pollution remediation/prevention programs. But, using the River Raisin, one of Lake Erie's tributaries, as an example, much work remains. While the level of total phosphorus in the Raisin has declined greatly over the years, the amount of dissolved phosphorus (which is the subset of total phosphorus that actually "feeds" the toxic algae) has almost doubled since the 1990's.[4] So, unless efforts are better targeted, it is just a matter of time before another toxic mass floats into another municipal water intake somewhere in the Great Lakes. Where will it happen next?

In this 2017 Appendix to The Less = More Coalition's *Follow the Manure* project, called *A Watershed Moment*, we turned our attention to Michigan and its 272 National Pollutant Discharge Elimination System (NPDES)-permitted CAFOs. These farms meet the EPA standards for a large CAFO[5], which in addition to animal numbers housed, must confine their animals for 45 days or more in a 12-month period, and no crops, vegetation, forage growth, or post-harvest residue are sustained in the normal growing season in the lot or facility. If they meet these criteria, they must obtain an NPDES CAFO permit, administered by the State of Michigan's Department of Environmental Quality (MDEQ) on behalf of the U.S. Environmental Protection Agency (USEPA). For this project, we tracked the main sites of factory farms (but not their satellite locations and feeder farms) under Michigan's General CAFO permit, as well as the Individual CAFO and No-Potential-to Discharge CAFO permits. Subsidies and violations were tracked according to the site itself, which may have had several owners over the years; those owners and all the names that subsidies and violations were received under, combined, are shown with that site. We did not track the processing facilities with CAFO permits, nor did we track the medium and small facilities that are not required to obtain permits. We also did not track the farms where animals are pastured, not confined.

As of December 31, 2016, Michigan's 272 permitted factory farms confined 20,640,837 animals that produced 3,348,566,912 gallons of CAFO waste[6]. These farms housed 311,553

[4]*Ferner Calls Phosphorus Reductions Misleading.* Henry, T. The Blade, Toledo, OH. October 2, 2015.

[5]https://www.epa.gov/sites/production/files/2015-08/documents/sector_table.pdf

[6]Defined in Michigan's NPDES CAFO permit application, "CAFO waste" includes, but is not limited to, process wastewater, manure, production area waste, silage leachate and runoff, and contaminated runoff.

dairy cows and heifers; 43,327 beef cattle and veal calves; 637,934 hogs; 18,898,149 chickens, and 749,874 turkeys.

About 79.5% of this waste was produced by dairy cows and heifers, and 2.5% came from beef cattle and veal calves. About 1.5% came from chickens (egg-layers, pullets, broilers) and less than .5% came from turkeys. Approximately 8% came from swine, and the remaining 8% was produced by farms that housed a combination of categories. Unlike human waste, CAFO waste is not treated. The vast majority of this untreated animal sewage is stored in giant open cesspits called lagoons, or under slatted barn floors, to which millions of gallons of clean groundwater are added, until it can be applied as liquid fertilizer on farm fields. The Southeast Lake Michigan Watershed (St. Joseph, Black-Macatawa, Kalamazoo, Upper Grand, Maple, Lower Grand, and Thornapple Rivers) is home to the most factory farms (149), the most CAFO waste produced (1.8 billion gallons), the most subsidies received ($59 million), and the most environmental enforcement actions by the State (388).

Figure 4. CAFO manure lagoons, Bean Creek/Maumee watershed. Photo: ECCSCM/Sierra Club/Lighthawk

Of special concern is the Saginaw Bay – Lake Huron area, where there are a very high number of these farms in a relatively small area. The most manure was produced by CAFOs in Huron County at nearly 402 million gallons, about 12% of the total produced in the State. The factory farms in Allegan County received the most subsidies (around $14 million) and earned the most environmental enforcement actions by the State at 255.

Concentrated animal feeding operations in Michigan's 4th Congressional District received the most subsidies, $26,928,362. By district, these farms also produced the most manure and waste at 1,022,563,988 gallons in 2016. This district includes all of Clare, Clinton, Gladwin, Gratiot, Isabella, Mecosta, Midland, Missaukee, Ogemaw, Osceola, Roscommon, Shiawassee, and Wexford counties, and portions of Montcalm and Saginaw counties. The factory farms in Michigan's 6th Congressional District amassed the most environmental enforcement actions by the State of Michigan through 2016, at 263. This district includes Allegan, Berrien, Cass, Kalamazoo, St. Joseph, and Van Buren Counties.

In total, Michigan's factory farms received $103,861,110 in a combination of Federal subsidies (listed above) from 1995-2014, and were cited for 644 environmental enforcement actions by the State (through Dec. 31, 2016). The large interactive map, *A Watershed Moment*, includes layers that allow the user to explore the facility locations by watershed and by Congressional district, the species housed and the number of livestock, the CAFO waste produced, the subsidies granted, and the environmental citations given for violations of their

NPDES permits for things like discharges of CAFO waste to the waters of the State. The sortable data table from which these maps were made is linked.

Figure 2. NASA Satellite, Great Lakes, 2011[7]

Since the 1970's, tremendous efforts have been made to clean up the polluted Great Lakes and their tributaries. But these lakes are now again at risk. Over 400,000 people in northwest Ohio and southeastern Michigan lost access to their drinking water for several days in August, 2014, when the City of Toledo's water treatment plant intake was closed due to an outbreak of cyanobacteria-produced microcystin in Lake Erie. Scientists and other experts had been watching these toxic algae outbreaks in The Great Lakes Basin for several years. In fact, the record year for these outbreaks before that was 2011[8], where these bright green outbreaks could be seen not only in Lake Erie, but also in Lake St. Clair, Saginaw Bay in Lake Huron, and even in Lake Michigan on NASA satellite maps. If we could have looked more closely, we would also have seen them in some of Michigan's inland lakes, most notably Lake Macatawa in Holland.

In Lake Erie, experts attribute the phosphorus runoff that is the limiting nutrient in these algal blooms to many sources, including construction activities, stormwater runoff, combined sewer overflow discharges, lawn and garden fertilizers, tree leaves, pet waste, faulty septic systems, climate change, quagga and zebra mussels, and agricultural practices such as increased tile drainage of farmland, no-till (a conservation practice that can stratify phosphorus in the top few inches of soil), fertilizer application rates, and more.

Figure 3. Wolf Creek, City of Adrian drinking water source, Raisin Watershed, CAFO manure application on snow. Photo: ECCSCM

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[7]*Harmful Algae Blooms Plague Lake Erie Again.* Borre, L. Water Currents, National Geographic Voices. April 24, 2013.
[8]Ibid

Mainly, according to these same experts, it comes from agriculture, and manure from livestock operations plays a big part[9, 10]. Saginaw Bay, Lake St. Clair, and even Lake Macatawa suffer similar problems from cyanobacteria-produced microcystin. In recognition of CAFO manure and the problems caused by its application on snow and frozen ground, the MDEQ sent a letter to all MI NPDES CAFO permit holders in October, 2014, in the Western Lake Erie, Saginaw Bay, and Macatawa watersheds asking them to "avoid land application on snow and frozen ground, if at all possible."[11] Cladaphora, a true algae which is also "fed" by excess nutrients such as phosphorus, and bacteria, adds to the problem in Saginaw Bay and Lake St. Clair.

Progress was made in Michigan during 2016 with the addition of its open waters of Lake Erie to the EPA 303(d) Impaired Waters list for phosphorus. But Environmentally Concerned Citizens of South Central Michigan's orthophosphate test results in a lake downstream from two CAFOs (dairy and swine) and where CAFO manure is applied continue to show excessive orthophosphate levels, and DNA tests taken of bacteria in the lake have all showed the presence of cattle DNA, and some contained swine DNA.[12]

Despite all of this subsidy money which is generally used for programs designed to combat sediment and erosion, instead of dissolved phosphorus that flows wherever the water goes, ECCSCM's edge-of-field test results where manure is applied continue to show excessive levels of orthophosphate. Our recommendations from 2015's *Follow the Manure* project still stand, which are:

- ***Stop giving shrinking federal taxpayer dollars for conservation practices to polluting CAFOs***.
- ***Change the phosphorus soil test requirements.*** Phosphorus soil test requirements need to be set to allow no more than 40 ppm (Bray P1) from manure and chemical fertilizer.
- ***Ban application of CAFO waste on frozen or snow-covered ground.***

Figure 5. January manure application, Bean Creek/Maumee Watershed. Photo: ECCSCM/Sierra Club/Lighthawk

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[9] *What is causing the harmful algal blooms in Lake Erie?* King, K., Smith, D., and Williams, M. Journal of Soil and Water Conservation, March/April 2015. Vol. 70, No. 2.

[10] *A Balanced Diet for Lake Erie: Reducing Phosphorus Loadings and Harmful Algal Blooms.* International Joint Commission. February, 2014.

[11] Letter, MDEQ staff to NPDES CAFO permit holders, October, 2014.

[12] Environmentally Concerned Citizens of South Central Michigan http://nocafos.org

- ***Require soil and edge-of-field water testing before a facility receives Environmental Quality Incentives Program subsidies and after they are implemented to determine their effectiveness.***
- ***Develop practices that address the role of subsurface tile drainage systems in agricultural runoff, especially where liquid manure is applied.***
- ***Develop a comprehensive policy based on the best and most current data across state lines.*** The Great Lakes Basin and the entire St. Lawrence River Watershed know no political boundaries. It is one system.

As with the previous Less = More Coalition projects, we continue to hope that this effort inspires further inquiry, as well as serious deliberation about how taxpayer money is spent to address this environmental crisis. Toxic algae isn't just a Lake Erie problem. It's found in Michigan's Great Lakes, and it's getting worse. It's now even in Michigan's smallest inland lakes. And according to the IJC, 80% of Lake Erie's total annual inflow comes through the St. Clair River, from Lakes Michigan, Superior, and Huron.[13] It's an entire ecosystem.

Just like it says in the song.

[13] *A Balanced Diet for Lake Erie.*

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Credits:

This project was prepared by Environmentally Concerned Citizens of South Central Michigan, The Socially Responsible Agricultural Project, and University of Michigan-Dearborn student James Campbell on behalf of the members of Less=More, a diverse coalition of organizations seeking to create a fair playing field for sustainable farms in Michigan. Special thanks goes to Environmentally Concerned Citizens of South Central Michigan for its comprehensive data on CAFOs in Lenawee and Hillsdale Counties. Less=More Steering Committee members include: *Center for Food Safety, Crane Dance Farm, LLC, East Lansing Food Coop, Environmentally Concerned Citizens of South Central Michigan, Food & Water Watch, Greater Grand Rapids Food Systems Council, Groundswell Farm, Humane Society of the United States, Michigan Voices for Good Food Policy, Michigan Young Farmers Coalition, Sierra Club Michigan Chapter and The Socially Responsible Agricultural Project.*

Sources:

This project is only as robust as the data it is based on, and there is reason to believe that not all instances of CAFO pollution that come to the attention of agency regulators are officially recorded, nor were all CAFO permit records viewable to the public, in the MDEQ MIWaters database at the time the records were searched. The project authors and the members of the Less = More Coalition make no guarantee of accuracy and are not responsible for any errors.

Farm Data including violations: MDEQ MIWaters database. Profiles; 2015 CAFO Annual Reports, due Apr. 1, 2016; 2015/2016 manure production reports; 2015/2016 NPDES CAFO new applications and permit renewal applications; 2015/2016 Comprehensive Nutrient Management Plans (CNMPs) https://miwaters.deq.state.mi.us/miwaters/#/external/home

NPDES Permit Inventory as of November, 2016: http://www.michigan.gov/deq/0,4561,7-135-3313_72753-10780--,00.html

Subsidies: Environmental Working Group's Farm Subsidy Database https://farm.ewg.org/?_ga=1.70764243.250448904.1489451193

Freedom of Information Act Requests to MDEQ Water Resources Division staff dated 7.1.2016, 7.7.2016, 7.10.2016, 1.20.2017, 1.22.2017

Environmentally Concerned Citizens of South Central Michigan http://nocafos.org

EXHIBIT 26

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Farm Subsidies

- Farm Subsidy Primer
- USDA Fact Sheets

Crop Insurance

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- Is Federal Crop Insurance Policy Leading to Another Dust Bowl?
- Crop Insurance: an Annual Disaster
- Boondoggle
- Cutting Waste in the Crop Insurance Program
- Pumped Up

Other Resources

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EWG Farm Subsidy Database

1 to 30 of 4,966
Recipients in this zipcode received $1,277,361,728 from 1995-2019

Rank	Name	Location	Subsidy Total 1995-‡
1	Dykhuis Farms Incorporated	Holland, MI 49423	$ 36,548.29
2	Dykhuis Farms Inc	Holland, MI 49423	$ 804,644.54
3	Jay Dykhuis	Holland, MI 49423	$ 20,903.00
4	Jenna Dykhuis	Holland, MI 49423	Farm Owner
5	Robert Dykhuis	Holland, MI 49423	$ 470,989.00
6	Joseph Dykhuis	Holland, MI 49423	$ 83,696.63
7	Joseph Dykhuis	Holland, MI 49423	$ 1,354.50
8	Cara Dykhuis	Holland, MI 49423	Farm Owner
9	Rachel Lea Dykhuis	Holland, MI 49423	$ 6,750.00
10	Rachel Lea Dykhuis	Holland, MI 49423	Farm Owner
11	Dykhuis Crops Partnership	Holland, MI 49423	$ 176,254.00
12	Muriel Faye Dykhuis	Grand Haven, MI 49417	$ 47,493.73
13	Joseph R Dykhuis	Holland, MI 49423	Farm Owner
14	Erin J Dykhuis	Holland, MI 49423	$ 101,729.18
15	Lorrie L Dykhuis	Holland, MI 49423	Farm Owner
16	Dusseau Farmss	Deerfield, MI 49238	$ 117,614.95
17	Maple Leaf Farm	Gladstone, MI 49837	$ 229,939.18
18	Harner Farms LLC	Eau Claire, MI 49111	$ 525,520.96
19	Howell Farms Ltd	Lapeer, MI 48446	$ 111,016.77

21	Hamlin Farms	Webberville, MI 48892	$ 4,406,947.88
22	Storehalder Farms	Waldron, MI 49288	$ 3,168,553.20
23	Pridgeon Farms	Montgomery, MI 49255	$ 2,198,661.59
24	Johnson Farms	Otisville, MI 48463	$ 2,024,185.67
25	Petro Farms	Gobles, MI 49055	$ 1,469,259.78
26	Kendale Farms	Bronson, MI 49028	$ 1,400,919.45
27	Gustafson Farms	Williamston, MI 48895	$ 1,286,687.39
28	Stoneman Farms	Breckenridge, MI 48615	$ 1,237,834.93
29	Pf Farms	Stockbridge, MI 49285	$ 1,045,308.04
30	Gould Farms	Morenci, MI 49256	$ 1,027,844.24

Next >>

‡ Data for 2020 includes payments made by USDA through June 30, 2020 and does not include crop insurance premium subsidies.

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EXHIBIT 27

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Taylor & Francis

J Hunger Environ Nutr. 2009 Jul; 4(3-4): 375–392. PMCID: PMC3489134
Published online 2009 Dec 11. doi: 10.1080/19320240903321292 PMID: 23144676

Economies of Size in Production Agriculture

Michael Duffy

Iowa State University, Ames, Iowa, USA
Address correspondence to Michael Duffy, Graduate Program in Sustainable Agriculture, Iowa State University, 478 Heady Hall, Iowa State University, Ames, IA 50011. E-mail: mduffy@iastate.edu

Abstract

Economies of size refer to the ability of a farm to lower costs of production by increasing production. Agriculture production displays an L-shaped average cost curve where costs are lower initially but reach a point where no further gains are achieved. Spreading fixed costs, bulk purchases, and marketing power are cited as reasons for economies of size. Labor-reducing technologies may be the primary reason. Most studies do not include the external costs from prophylactic antibiotic use, impact on rural communities, and environmental damage associated with large-scale production. These can contribute to the economies of size.

Keywords: economies of size in production agriculture, labor use, farm definition

INTRODUCTION

This article discusses economies of size, especially as they relate to production agriculture. It focuses mainly on Midwestern agriculture, but to the extent possible other regions will be discussed.

The discussion on economies of size presented here is from an overall perspective. The theoretical underpinnings and economic discussions can be found in other sources.[1]

Before beginning any discussion on economies of size it is first necessary to define the term. The concept of economies of size means that the average cost per unit of production decreases as the size of the farm increases. The economies can occur because the farmer is able to spread more production over the same level of fixed expenses. Or, economies of size can occur when a farm is able to obtain volume discounts for inputs such as seed or fertilizer. An example would be the cost for pollution monitoring around a swine production facility. If the farm is required to monitor the groundwater around the facility for contamination, they must put in a well and monitoring equipment, which represent fixed costs and can serve a large number of pigs. As the number of pigs sold increases, the costs for this aspect of production would decrease. And, as a result, monitoring in this fashion would actually provide a cost advantage to a larger operation.

Two related concepts will be mentioned here only for the sake of avoiding confusion. One is economies of scale, which measure what happens if all inputs are increased by the same proportion. If costs per unit go up, then there are diseconomies of scale. If costs per unit go down, there are increasing economies of scale, and if the costs per unit remain the same, there are constant returns to scale.

The other concept is economies of scope, which refer to reducing costs for using resources by spreading the resources over more than one enterprise.

Hofstrand summarized the concepts of size and scope by noting that size spreads fixed resources over more units of output whereas scope spreads the cost of a given set of resources or skills over more than one product or enterprise.[2]

Discussion of economies of size in production agriculture and the desirability of small farms has ebbed and flowed over time. One of this country's earliest political debates centered on the conflicting views held by Thomas Jefferson and Alexander Hamilton regarding land ownership. Jefferson argued for family ownership of farms as a means of ensuring interest in the democratic process. Hamilton argued for selling the land to the highest bidder as a means of paying off the Revolutionary War debt. Jefferson won the debate and the United States followed the principal objective of promoting family farms.

In the early part of the 20th century problems emerged for this ideal, problems related to economies of size. In 1909 President Roosevelt formed the Country Life Commission to address the issues of poverty in rural America.

The Commission found that in spite of the advances and money spent up until that time "… agriculture is not commercially as profitable as it is entitled to be for the labor and energy that the farmer expends and the risks that he assumes …" and "The farmer is almost necessarily handicapped in the development of his business because his capital small and the volume of his transactions limited; and he usually stands particularly alone against organized interests" (Report of Commission on Country Life, 1909, in Wunderlich, p. 146[3]).

This Commission report renewed the efforts to improve the lives of the farmers by increasing their productivity. The increases in productivity were directed toward technologies that substituted capital for labor.

The period following the report was very good for US agriculture. In fact, "parity" prices were established in the period from 1915 to 1919. The United States followed policies geared toward maintaining those prices for decades.

The US economy moved through two World Wars and the Great Depression after the parity price period. Agricultural productivity continued to increase as new labor-saving technologies were developed.

Farm incomes fell after World War II and again there was unrest in the countryside. In 1954 President Eisenhower ordered the US Dept of Agriculture to prepare a report on the state of the agricultural economy. The report concluded that expanding agricultural productivity was the key and "One of the recommendations to increase agricultural productivity was to allow farms to expand in order to take advantage of new labor-reducing technologies. It was argued that the expansion of small farms could be facilitated using programs designed to retrain and move agricultural workers to non-farm industries."[4] Others have noted that "While some of the implemented government policies were successful, most of the reductions in farm labor and the corresponding increases in farm size were the result of changing technology."[5]

At the beginning of the 20th century there were concerns over the need to add more technology to production agriculture. These were followed in the middle of the century by a feeling that the new technology had already removed the need for much of the labor and what we needed to do was "move agricultural workers to non-farm industries."

Towards the end of the 20th century, new fears were raised that family farms were losing ground and the move to increase productivity by decreasing labor may have yielded undesirable consequences. A Small Farms Commission, created by the Secretary of Agriculture in 1998, urged the government to recognize small farms and their contributions to society and actively support them.[6] The Commission emphasized that research must be "… dedicated to optimizing the labor and ingenuity of small farm operators and the biological assets of their farms using less capital-intensive investments." (p. 31)[6]

Over time in the United States economies of size with respect to substituting capital for labor have been encouraged and discouraged. Research and technology have been the primary drivers in changing the situation with respect to economies of size. In spite of the Small Farms Commission report, we continue to move toward a dual agriculture with many small farms and relatively few large farms. Economies of size remain an often-debated topic.

CENSUS DATA

The Census of Agriculture is the best source for a consistently gathered set of agricultural data for the entire country. The census provides an opportunity to examine several aspects of the issues related to economies of size.

The first agricultural census was taken in 1840 and it was conducted every 10 years until 1920. Since then the Census of Agriculture generally has been conducted on a 5-year basis.[7]

The Bureau of the Census conducted the Census of Agriculture until 1996 when the responsibility was transferred to the USDA primarily because the Census Bureau was going to increase the size needed for an operation to be considered a farm.

One of the major difficulties with examining national farm-level data is how to determine what is considered a farm. For the purposes of the Census, a farm is defined as "… any place from which $1000 or more of agricultural products were produced and sold, or normally would have been sold, during the census year." (p. ix)[7] This definition has been used since 1974 and has created many problems and inconsistencies when people use or try to interpret the Census data. A major problem currently is the age of the definition. Inflation alone would suggest that the cutoff point should be raised to at least $5000.

Another problem is the change in census coverage initiated by the USDA in 2002 in an effort to survey more very small farms. They did not change the definition; they simply chose to count more people. The change in coverage has led to a change in the composition of the farms considered in the census.

Figure 1 shows the distribution of farms and sales in the United States based on sales categories. Notice in this figure the very smallest category, sales of less than $1000, makes up over 30% of the farms. It is important to remember that the definition of a farm is any place that "could have sold" $1000 worth of agricultural products. These farms with sales less than $1000 are referred to as *point farms*. The farms are assigned points based on the agricultural enterprises and if the points total 1000, they are included as farms in the count. One pig has a point value of 150, so raising 7 pigs would classify a place as being a farm. A horse has a point value of 200 whether or not it is sold, which means that 5 horses classify a place as a farm.

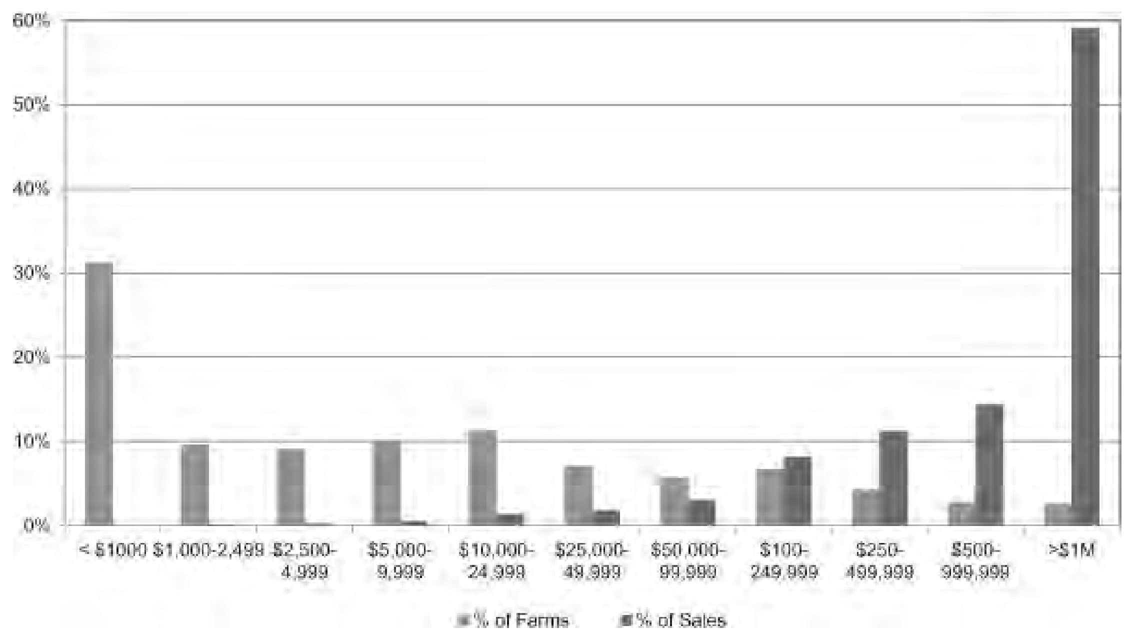

FIGURE 1

Distribution of farms and sales in the United States, 2007.

Figure 1 shows that the majority of farms are small and they account for very little of the agricultural sales in the United States. The largest two categories, those with sales over $500,000, represented 5% of US farms and had 74% of the sales in 2007. At the other end of the spectrum, farms with sales less than $5000 accounted for 50% of the farms and generated less than 1% of the sales.

It is interesting to note that government payments are greater than sales for the smallest group. For farms in the smallest size group over 90% of the combined sales and government payments come from the government.

It is important to keep the size issue in mind when working with the census data. In many contexts, discussions about average farms are almost meaningless without making some distinction regarding the size of farm.

With this caveat in mind there are two ways to use the Census data to examine economies of size in US agriculture. The first item of interest is presented in Figure 2, which shows the dollar value of sales for every dollar of expenses reported. This is a measure of efficiency. The more sales a farm can generate for each dollar of expense, the more profitable it will be. Such efficiency gains can be thought of as economies of size at the aggregate level.

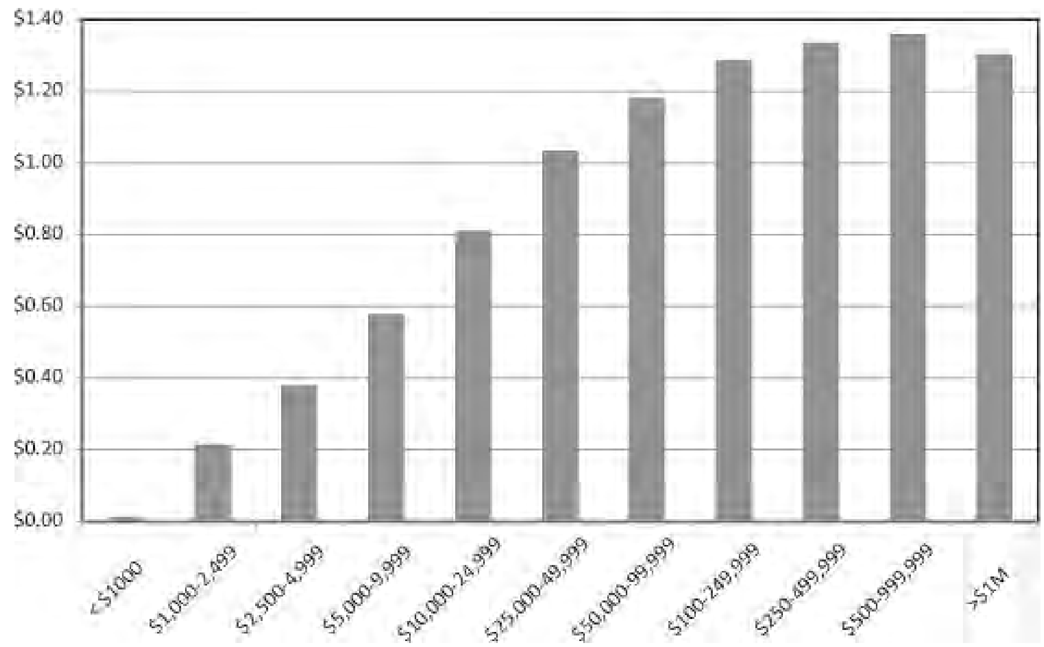

FIGURE 2

Dollars of farm sales per dollar of farm expenses, United States, 2007.

Notice in Figure 2 that the amount of sales per dollar of expenditure increases rapidly until reaching approximately $100,000 in sales. Once this level of sales is reached the ratio flattens out, indicating no further gains in efficiency with respect to expenses relative to sales. It is interesting to note in Figure 2 that the ratio tends to grow smaller with the largest size group. Figure 2 shows that there are very definite gains in efficiency as a farm increases in size but the rate of gain slows and actually decreases as size increases.

Figure 3 also illustrates the extent of economies of size present in the US farm sector. This figure shows the percentage of farms with a positive net cash farm income in 2007. It looks very similar to Figure 2 in that there are rapid increases in the percentage of farms showing positive net cash farm income, but this increase flattens out starting at around $100,000 in sales.

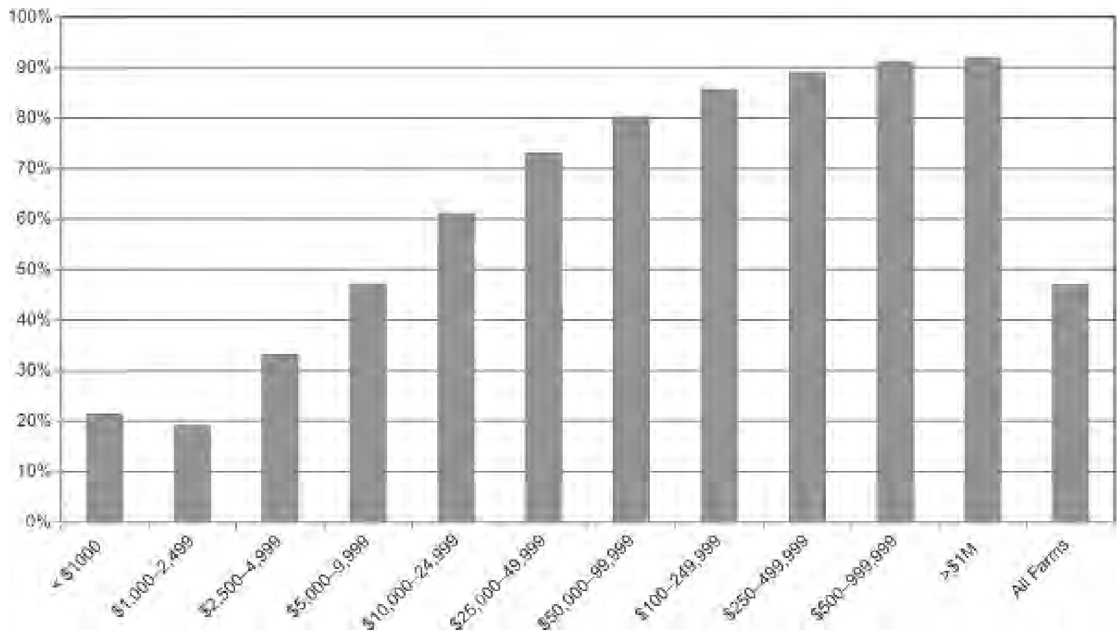

FIGURE 3

Percentage of US farms with positive net farm cash income, 2007.

ECONOMIES OF SIZE IN IOWA

Economies of size for agricultural production in Iowa can best be illustrated using data from the Iowa Farm Business Association (IFBA), a record-keeping service for Iowa farmers. These farm operations would be more representative of the larger farms as shown in the census data.

Figure 4 shows the total economic costs of production per bushel of corn for farms in the IFBA based on the number of row crop acres farmed. In Figure 4 the cost per bushel decreases over the smaller acre categories but flattens out by 800 row crop acres. There is even some indication that the costs may start increasing at that point.

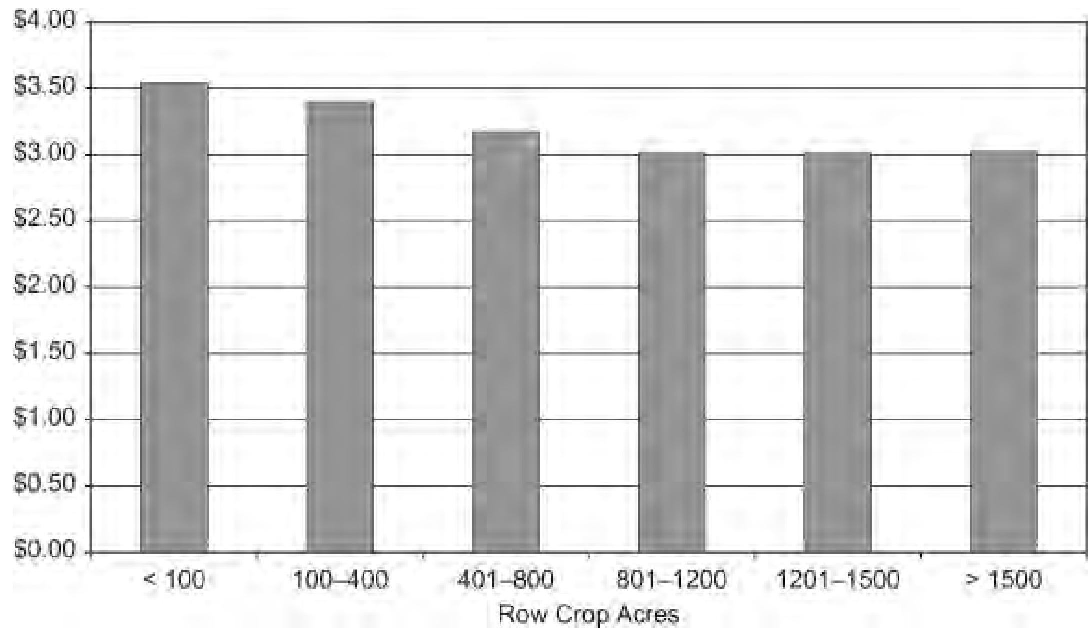

FIGURE 4

Total economic cost per bushel for corn based on number of row crop acres.[12]

Figure 5 shows the average cost per bushel for soybeans based on the number of row crop acres. Soybeans exhibit an average cost curve similar to corn. The low point for soybeans appears to be approximately 400 row crop acres.

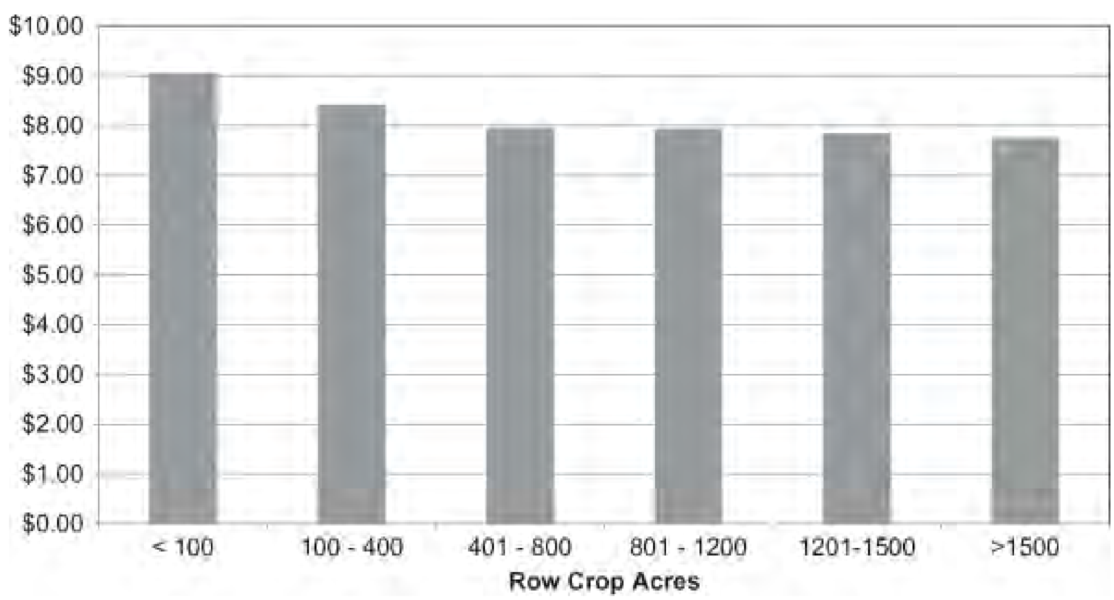

FIGURE 5

Total economic cost per bushel for soybeans based on number of row crop acres.[12]

Figures 4 and 5 display what is known as an L-shaped average cost curve. That means there are initial economies of size but these size advantages dissipate, and then costs remain relatively flat over a range of sizes. "Most normative studies of crop farms, both early and recent, while identifying economies of size, have given little evidence that the cost curve deviates significantly from a sagging "L" shape." (p. 206)[1]

Hallam further discussed the economies of size in agricultural production: "The general conclusion is that while some economies of size or scale may exist for livestock farms that significant economies, at least as conventionally defined, do not exist for most crop production activities. While differences in efficiency and growth paths differ among firms, few of these seem to be directly related to economies of size and scale."[1(p 224)]

One observation by Hallam[1] was the discrepancy between farmers with respect to costs of production. This is illustrated in Figure 6, which shows the costs per bushel for corn when the cost groups are divided into thirds. Figure 6 reports an almost $1.50 per bushel difference in costs of production between the high-cost producers and the low-cost producers.

FIGURE 6

Corn total economic cost per bushel by cost group.[12]

Figure 7 presents the number of corn acres for the farms in each cost group. Figure 7 shows that the high-cost producers had the fewest corn acres, whereas the middle-cost producers had the greatest number of corn acres. This means that the lowest-cost producers had fewer acres. Figures 6 and 7 reveal a couple of distinguishing characteristics that are important to remember when considering production agriculture. First, there is considerable variation among farms, even farms producing the same crop. The second observation is that the number of acres is not a guarantee of lower cost production. Many other factors determine whether a farmer is a low-cost producer per unit of output.

FIGURE 7

Number of corn acres based on cost group for corn.[12]

Hallam[1] noted that livestock production appears to be different with respect to economies of size. Livestock production efficiencies and the changing structure of animal agriculture have been discussed in many places, most recently by MacDonald and McBride.[8]

Figure 8 shows the costs of production per hundredweight for farms in the Iowa Farm Business Association based on the number of pigs marketed. Figure 9 presents the cost per hundredweight of pork produced based on the number of sows. Figures 8 and 9 both illustrate economies of size found in most animal production. They show a more extreme drop in costs of production as size increases when compared to the crop costs shown in Figures 4 and 5.

FIGURE 8

Cash flow costs per hundredweight for pork based on the number of pigs marketed.[12]

FIGURE 9

Cash flow cost per hundredweight of pork produced based on the number of sows.[12]

Technological changes and changes in production have led to the dramatic decreases in costs of production. Differences in costs of production for swine have been noted for a long time. One study reported that "… farrow-to-finish swine producers can achieve essentially the same profitability per unit of production across a wide range of volumes of production." (p. 1)[9] MacDonald and McBride note, "There are substantial economies of scale up to certain threshold sizes, and farms can operate efficiently at sizes that are much larger than the thresholds." (p. 36)[8]

There appears to be two major differences between animal and crop production with respect to economies of size. One of the major differences is the vertical integration of the industry, which has led to a major consolidation in the processing industry.

The declining number of packing plants illustrates the consolidation in the processing industries. In 1976 there were 858 cattle packing plants and 497 swine packing plants. In 1998 there were 221 and 182 cattle and swine processing plants, respectively, a decrease of 74% in the cattle plants and a 63% decrease in swine processing plants.

The decrease in the number of plants has been coupled with an increase in the number of animals slaughtered by size of plants. For example, in 1976, 9% of the cattle were slaughtered in plants slaughtering more than 500,000 head per year. By 1998, these same-sized plants were slaughtering 67% of the animals. In 1976, 2% of the swine were slaughtered in plants slaughtering more than 1 million head per year. By 1998 the plants slaughtering over 1 million head increased to 16% of the hogs slaughtered.

Large-scale processing plants possess economies of size. One of the biggest components of these economies of size is procurement of the animals. As the packing plants have gotten larger, they have demanded a larger volume from the individual producer. This favors the larger-scale producers and requires either an increase in the size of production or some form of joint marketing. Production contracts have become commonplace and today the majority of pork is raised under some form of contract. Smaller producers may have similar costs of production but access to the market has become a significant problem.

The second major factor that has led to the increased size of animal production operations is the ability to pass along costs to those not making the production decisions. These external costs are generally not calculated in the costs of production or measuring the efficiency of the large scale production. MacDonald and McBride discussed these external costs, which generally fall into two major categories.[8] The first category is the environmental costs. Confinement of large numbers of animals generates manure and odor and has the potential to cause water and air quality deterioration. These problems will increase as the number of animals per unit increase.

A second potential external cost concerns the threat to food safety from the use of prophylactic antibiotics. Large numbers of animals housed together have greater potential for disease. Routine antibiotic use can increase the chances for antibiotic resistance to develop and for contamination of the product. The severity of these problems depends on the individual operator, and the potential for problems increases as the concentration of the animals increase.

Animal agriculture demonstrates the changes inherent in an industrial approach to agriculture. The specialization of production often ignores the benefits and advantages of the synergy that exists in agriculture. Crops can feed the animals, animal manure can provide nutrients for the crops, and the farmers can add value to their production with a more holistic approach. Increased environmental costs, food safety concerns, undesirable odor, and concentration of the food supply are just a few of the concerns that have arisen with the change in philosophy of producing animals and animal products. One publication in the early 1990s stated that “animal agriculture is changing rapidly from Midwestern enterprises of diversified farming to those which manufacture muscle protein.” (p. 1)[13] This industrialized approach has led us to many of the problems and issues we face today.

DISCUSSION

If farms display an L-shaped average cost curve and expansion does not lower the costs of production, why are we seeing such expansion in farm size? The basic answer is that farms are getting larger because they do not incur diseconomies of size. As the farm increases in size the cost per unit of output remains relatively flat. As the number of units of output increases and there is no significant difference in the cost of production, income will increase. For example, using the average acreage shown in Figure 4, a farm with 800 acres of corn would have an average total cost of production of approximately $3.00 per bushel. If the yield was 200 bushels per acre and the price of corn was $3.50 per bushel, the farm would make $80,000 [($3.50-$3.00) ∗ 200 ∗ 800]. But, if the same farm had 1,500 acres of corn they would make $150,000 [($3.50-$3.00) ∗ 200 ∗ 1500]. So, the larger farm will earn almost double the amount of income.

Such expansion is possible because of the labor-saving technologies that have been developed for production agriculture. Figures 10 and 11 show the hours of labor required for corn and soybeans per acre and per 100 bushels, respectively.

FIGURE 10

Number of hours per acre for corn and soybean production.

FIGURE 11

Number of hours to produce 100 bushels of corn and soybeans.

Figure 10 illustrates the tremendous decline in labor requirements per acre, especially since the end of WWII. This decrease is primarily due to adoption of mechanical technologies, in particular the tractor. Figure 11 shows the major decrease in labor requirements per unit of production that occurred between 1939 and 1949. This decrease was due to the changes in technologies available, especially seed and fertilizers.

As the amount of labor required per acre has declined, the number of acres that a farmer can farm has increased. Although there will be considerable variation, a conservative estimation of the hours of fieldwork for corn and soybeans is approximately one hour per acre. Using this estimate, farming 800 acres would take approximately 800 h of labor and farming 1500 acres would take 1500 h of labor. A 40-hour-a-week job for 50 weeks a year would be 2000 h. Of course, the hours of labor for crop production are not evenly distributed over the year. Crop production labor has two heavy periods: in the spring at planting time and in the fall during harvest. This makes direct comparisons difficult, but such a comparison does provide some order of magnitude regarding the hours of labor available.

In addition to labor-saving technologies, other technologies have been developed that have lead to economies of size and thus an increase in the size of farms. Herbicide-resistant soybeans are one such technology. A statewide comparison of the returns to herbicide-resistant soybeans and conventional soybeans in Iowa found there was no significant difference in returns.[10] Given these findings, why was there such rapid adoption of herbicide-resistant soybeans? There were essentially no herbicide-resistant acres planted in 1996, and yet in just 4 or 5 years more than 90% of the soybean acres were using this technology. Farmers had a variety of reasons, including ease of harvest and ability to cover more acres. Perhaps most telling was the farmer who said that he planted them because "they offered weed management that any idiot could do."

Mechanical technology is another reason farms are getting bigger. New machines are capable of covering far more acres in less time and they are able to perform different jobs. Strip-tillage is an example of a popular recent practice made possible by changes in equipment. Strip-tillage saves soil, but its primary appeal for many is the decrease in labor needed.

Technology comes with a price. If costs increase and the resulting changes in revenue do not offset the increases, the profit margins narrow and farmers need to cover more acres to maintain their incomes. Willard Cochrane described this phenomenon as the "technology treadmill."[14] Technology enables one person to farm more acres, but as more acres are farmed, the costs increase. So, they must adopt technology that allows them to farm even more acres and the cycle escalates further.

One of the advantages for larger farms is the ability to purchase in bulk. Bulk purchases allow the larger farm to acquire the same input but at a reduced cost. The cost reduction reflects the lower transaction costs for the input supplier: less paperwork, less handling, lower shipping costs, and so forth. In addition, the risk of default or non-payment increases as the number of purchasers increases. It could be argued that even though the probability of the risk of a default increases with more purchasers, the loss associated with any single default would go down and so the expected value would be the same. However, it would be easier and cheaper for the supplier to monitor fewer purchasers and so the probability of any single farm defaulting would be reduced.

Another advantage for larger farms is the ability to more fully utilize labor and employ labor-saving technology. Some technologies such as machinery might be cheaper for a smaller farm if they used smaller equipment. But, other technologies such as yield monitors, soil sampling, and weather stations have relatively fixed costs, and the more bushels or units of production, the cheaper the cost of technology per unit.

Information technologies, including marketing, would be relatively fixed in price; the more units of production, the lower the cost per unit. Some smaller farms will find it uneconomical to employ these technologies relative to their larger counterparts.

There are disadvantages to increasing farm size as well. One of the major drawbacks is the changing nature of farming as the farm size grows. As a farm gets larger, the composition and complexity of the farming operation are altered. The farmer changes from being someone actively involved with the agronomic/animal husbandry aspects of farming to being one who is a personnel and office manager. Whether or not this is a good move depends on the goals of the individual farmer.

The United States is no longer seeing an increase in farmland and instead is actually seeing a decrease as available land is converted to urban and other uses. This means that if farmers are going to expand the amount of land being farmed, they have to travel greater distances. In Iowa traveling 50 to 100 miles to farm a parcel of land is becoming more common. This transformation in farming styles has at least 3 ramifications.

The farther a farmer has to travel to reach land being farmed, the greater the cost. Equipment has to be hauled adding transportation costs, and extra time is needed to move the equipment from farm to farm.

A drawback to traveling greater distances and increasing the amount of acres farmed in general is the loss of time to pay attention to details. Studies examining the characteristics of high-profit farms relative to low-profit farms show that management is a key factor. Much of this management is in the intangible attention to details. A farmer who is farming many acres will have to be quick about it and cannot take the time to ensure that equipment is functioning at the optimum level.

Another serious drawback to farming more acres or handling more livestock is the inability to fully understand the unique characteristics of each unit of the operation. Different fields have areas that respond differently to inputs. Technology in global positioning and guidance systems can help overcome, this but there are still nuances that can be captured only by personal observation over time. Too often with large acreages, farmers do not have the time to observe the land they are farming.

CONCLUSIONS

Economies of size exist in production agriculture. But, these economies are dissipated much sooner than is realized. Almost every study has found that the average cost curve of most agricultural production is L-shaped. That is, costs decrease over a certain size range, but then they become flat. Increases in size beyond where the curve becomes flat lead to increased income but not increased efficiency. Studies also have shown that the curve may start to increase after certain sizes are reached. These studies suggest a U-shaped average cost curve.

There are many reasons why farms continue to get larger. One is that agriculture has such tight margins and farmers must increase the volume of production if they are to produce an adequate income. In many cases the farmer has stepped onto the technology treadmill. They get bigger equipment so they can farm more acres. As they farm more acres they have to adopt techniques that increase their costs but also lower their profit margins. As the farmers' profit margins tighten they need to have more acres to generate an adequate income. With more acres they need bigger equipment so they can farm more acres. And so it goes.

Farming, like most other industries, has substituted capital for labor. The capital can buy technology that makes life and the job easier but the technology comes with a price. The substitution of capital for labor has led to many changes in agricultural production. Unfortunately, today we are seeing situations where the capital is substituting for management. The farmer's comment that herbicide-resistant soybeans offered him weed management that "any idiot could do" is a perfect example.

This does not imply that farmers do not use management. They must continually evaluate and manage, but what they manage now are chemicals and methods to overcome natural systems. They do not use management that helps them "… work with the biological assets of their farms using less capital-intensive assets." (p. 31)[6]

The technology being developed today is technology that favors larger farms. It either has a high fixed cost and/or technology that enables one person to cover more acres. Such technology is furthering the goals of the Eisenhower Commission discussed earlier.

The technology we have developed has led to the cheapest out-of-pocket food supply in the world. In the United States today we spend less of our disposable income on food (9.8% in 2007) than anywhere else in the world. The farmers' share of the food dollar has actually been declining, and in 2006 of the farmer received just 19 cents of every $1 spent on food in the United States.[11]

Technological advances have led to the lower portion of disposable income being spent on food and to the farmer receiving a lower share of the food dollar. But, it is important to recognize that increases in disposable income also have contributed to these trends. Food has a low-income elasticity; in other words, after basic food needs are met, increases in income will lead to lower amounts of income being spent on food. This concept is known as Engle's law, which states that with constant tastes and preferences as the level of income rises, the proportion of income spent on food decreases. This concept, named after the statistician Ernst Engle, does not imply that expenditure on food will not change but that the proportion of income spent on food will decrease.

In spite of the increases in income, technology and the move toward greater economies of size have led to many unintended consequences. These consequences have not been factored into the estimate of costs of our food.

Outcomes of larger farms capturing current economies of size include questions about the stability of the food supply and potential monopolization of food production. Based on the 2007 Census, farms with sales over $500,000 accounted for 5% of the farms and 74% of all agricultural sales. This means that just 116,286 farms accounted for almost three fourths of all the value of sales of agricultural products in the country. The changing structure of agriculture can lead to a breakdown in competition and maybe even monopolization of food production. Hallam noted that "An industry with numerous producers may be more likely to supply food in both good and bad economic times." (p. 41)[1] He went on to note that this could be due to profits elsewhere, bad management, labor unrest, attempts to manipulate the market, weather problems in concentrated areas, etc.

Food safety is another concern that arises from large-scale production and distribution. The recent cases of salmonella in tomatoes, sprouts, peppers, meat, and peanut butter are examples of what can occur. It can be argued that larger farms are better able to afford the technology necessary to prevent such food contamination. This harkens back to the ability to spread fixed costs over more output, thus lowering average costs of production. There are arguments that can be made about food contamination episodes, but one thing is clear: large-scale production can have large-scale impacts when problems do occur. Illnesses and the costs of massive recalls are not likely to be factored into most discussions of the advantages of larger farms and agricultural operations.

Environmental impacts are another factor not clearly accounted for in the discussion regarding economies of scale. It is interesting that some of the production technologies producing lower soil erosion also promote more chemical usage and produce labor savings which leads to economies of size. No-till and strip-till are examples of such conservation-friendly production technologies.

Most of the existing environmental regulations tend to favor large-scale operations. Monitoring requirements, fencing regulations, and other regulations generally have a large component of their costs as fixed costs. This means that the larger-scale operations will have more units of output over which to spread the costs, thus lowering the average costs of production.

Rural communities/life, intrinsic rural values, and socioeconomic welfare are all being affected by the changing structure of agriculture. Larger farm sizes spurred by economies of scale have had a significant impact on rural America as witnessed by the formation of the Small Farms Commission.

Economies of size exist in production agriculture for a variety of reasons and have far-reaching consequences for food production and rural America's future. Whether the economies of size would exist to the same extent if we accounted for all costs is debatable. Research that favors large-scale farming and reducing the amount of labor needed has led to many of the economies of size. Such research has produced cheap bulk commodities and cheap food for consumers. What would happen if we made better use of the biological nature of production agriculture, researched technologies that favored small-scale production, and accounted for all costs is unknown. One thing is certain: the current path with its emphasis on economies of size has produced many undesirable consequences.

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EXHIBIT 28

Testimony Excerpt of

EGLE Environmental Quality Analyst; Megan McMahon

STATE OF MICHIGAN

MICHIGAN ADMINISTRATION HEARING SYSTEM

In the matter of:	Docket No.:	20-009773
Petition of Michigan Farm Bureau; Michigan Milk Producers Association; Michigan Allied Poultry Industries; Foremost Farms USA; Michigan Pork Producers Association; Dairy Farmers of America; Select Milk Producers, Inc.; and 126 Identified Livestock Farms /	Permit No.:	MIG010000
	Part:	Part 31, Water Resources Protection
	Agency:	Department of Environment, Great Lakes and Energy
	Case Type:	Water Resources Division

HEARING - VOLUME NO. II

BEFORE DANIEL PULTER, ADMINISTRATIVE LAW JUDGE

Via Microsoft Teams Meeting

Tuesday, December 7, 2021, 9:00 a.m.

APPEARANCES:

For the Petitioners:
MR. ZACHARY CHAD LARSEN (P72189)
MR. MICHAEL JOHN PATTWELL (P72419)
Clark Hill, PLC
212 East Cesar E. Chavez Avenue
Lansing, Michigan 48906
(517) 318-3053

For the Respondent:
MS. ELIZABETH ANNE MORRISSEAU (P81899)
MS. JENNIFER A. ROSA (P58226)
Assistant Attorneys General
Department of Attorney General
525 West Ottawa Street
G. Mennen Building, 6th Floor
Lansing, Michigan 48933
(517) 373-7540

Q What did you do next?
A I met with WRD management to discuss which stakeholders to invite to the stakeholder meetings. I then obtained the contact information for stakeholders and provided it to the secretary so she could e-mail them a letter developed by Sylvia Heaton inviting them to the meeting.
Q Is Exhibit 15 the letter you are referring to that Sylvia Heaton drafted and the secretary sent to stakeholders?
A Yes.
Q How many stakeholder meetings were there?
A Three.
Q When and where did they take place?
A The meetings were held March 11, 2019; May 20, 2019; and June 17, 2019, at the Constitution Hall in Lansing for approximately four hours each.
Q What did you do in relation to these meetings?
A Before the meetings, I arranged for the meeting room reservations and set-up and provided a list of attendees to the building security. At the meetings, I kept track of participation via sign-in sheets and a spreadsheet. During the meetings I would participate in discussions, but only minimally for clarification in order to allow stakeholders to provide the most input.
Q Did each meeting cover the same topics?
A No. At the beginning of the first stakeholder meeting,

participants brought up their concerns. While there was likely some overlap in the discussions, each meeting focused on a few of these concerns at a time.

Q How did the Department capture what was said at these meetings?

A During the stakeholder meetings, two WRD staff members listed the discussion topics that were suggested by both stakeholders and WRD staff. WRD focused the topics on permit requirements but kept note of other issues like compliance and enforcement concerns.

Q How did the Department use the stakeholder comments in the 2020 CAFO General Permit process?

A The issues and the potential solutions were considered by the Department when developing the permit.

Q Do you have sign-in sheets from each of the three stakeholder meetings?

A Yes.

Q Did you maintain them in the ordinary course of your work at the Department?

A Yes, there is a hard copy on my desk at work and a pdf copy on my computer.

Q Is Exhibit 16 a true and correct copy of the attendance sheet collected during the March 11, 2019 stakeholder meeting?

A Yes.

Q Referring to Exhibit 20, do these documents accurately reflect the public notice given to the three newspapers?
A Yes.
Q When was the 2020 CAFO General Permit put out for public notice?
A From October 30, 2019, through December 18, 2019, for a period of 50 days.
Q How did you notify the public?
A Via MiWaters, the Department calendar, and in 3 newspapers.
Q What did the Department do during this public notice period?
A Received public comments.
Q How many meetings did the Department hold?
A The WRD held three public meetings and public hearings. They also had meetings with some permittees after the public comment period because the permittees had additional questions and wanted clarification.
Q When and where were the meetings held?
A Adrian College, December 3, 2019. The public meeting was at 6:00 p.m. and the public hearing followed from 7:00 p.m. to 9:00 p.m. The second one was at Grand Valley State University on December 5, 2019. The public meeting was at 6:00 p.m. and the public hearing followed from 7:00 p.m. to 9:00 p.m. The final one was at the Lansing Historical Center on December 9, 2019. The public meeting was at 1:00 p.m. and the public hearing followed from 2:00 p.m. to 4:00

EXHIBIT 29

PERMIT NO. MIG010000

STATE OF MICHIGAN
DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM WASTEWATER DISCHARGE GENERAL PERMIT

CONCENTRATED ANIMAL FEEDING OPERATIONS

In compliance with the provisions of the federal Clean Water Act (federal Water Pollution Control Act, 33 U.S.C. 1251 *et seq*., as amended); Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA); Part 41, Sewerage Systems, of the NREPA; and Michigan Executive Order 2019-06, Concentrated Animal Feeding Operations (CAFOs) are authorized to operate facilities specified in individual Certificates of Coverage (COCs) in accordance with effluent limitations, monitoring requirements and other conditions set forth in this general National Pollutant Discharge Elimination System (NPDES) permit (permit).

The applicability of this permit shall be limited to CAFOs that have not been determined by the Michigan Department of Environment, Great Lakes, and Energy (Department) to need an individual NPDES permit. New swine, poultry, and veal facilities with contaminated areas of the production area exposed to precipitation, including waste storage structures, are not eligible for this permit. “New” means populated after January 20, 2009. Egg processing, egg washing, and duck facilities are not eligible for this permit. Discharges which may cause or contribute to a violation of a water quality standard are not authorized by this permit.

In order to constitute a valid authorization to discharge, this permit must be complemented by a COC issued by the Department and copies of both must be kept at the permitted CAFO. The following will be identified in the COC (as appropriate):

- The rainfall event magnitude at the production area (Part I.B.1.a.2.)
- Data for the application rate table for crops not listed in the permit (Part I.B.3.c.2.)
- Notification of a Total Maximum Daily Load (TMDL) if the permittee’s production or land application areas are located within a watershed(s) covered by an approved *Escherichia coli (E. coli)*, and/or biota, and/or dissolved oxygen, and/or nutrient (nitrogen or phosphorus) TMDL (Part I.C.9.)
- ~~The date by which the use of the Michigan Phosphorus Risk Assessment (MPRA) will be required~~
- The date by which the permittee must provide documentation of Natural Resources Conservation Standard (NRCS) 313 environmental equivalency for waste storage structures not meeting NRCS 313 and procured after the effective date of the COC
- Percent of outside materials allowed in the anaerobic digester associated with the CAFO permitted under the COC, if that percentage is greater than five (Part I.C.10.)

Unless specified otherwise, all contact with the Department required by this permit shall be to the position indicated in the COC.

This permit takes effect on April 1, 2020. The provisions of this permit are severable. After notice and opportunity for a hearing, this permit may be modified, suspended, or revoked in whole or in part during its term in accordance with applicable laws and rules.

This permit shall expire at midnight, **April 1, 2025**.

Issued: DRAFT

DRAFT
Christine Alexander, Manager
Permits Section
Water Resources Division

PERMIT FEE REQUIREMENTS

In accordance with Section 324.3120 of the NREPA, the permittee shall make payment of an annual permit fee to the Department for each October 1 the permit is in effect regardless of occurrence of discharge. The permittee shall submit the fee in response to the Department's annual notice. Payment may be made electronically via the Department's MiWaters system. The MiWaters website is located at https://miwaters.deq.state.mi.us. Payment shall be submitted or postmarked by January 15 for notices mailed by December 1. Payment shall be submitted or postmarked no later than 45 days after receiving the notice for notices mailed after December 1.

CONTESTED CASE INFORMATION

~~The terms and conditions of this permit shall apply to an individual facility on the effective date of a COC for the facility. The Department of Licensing and Regulatory Affairs may grant a contested case hearing on this permit in accordance with the NREPA.~~ Any person who is aggrieved by this permit may file a sworn petition with the Michigan Administrative Hearing System within the Michigan Department of Licensing and Regulatory Affairs, c/o the Michigan Department of Environment, Great Lakes, and Energy, setting forth the conditions of the permit which are being challenged and specifying the grounds for the challenge. The Department of Licensing and Regulatory Affairs may reject any petition filed more than 60 days after issuance as being untimely.

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PART I

Section A. Effluent Limitations and Monitoring Requirements

1. Authorized Discharges and Overflows

During the period beginning on the effective date of this permit and lasting until the expiration of this permit, overflows and discharges are authorized per the following:

a. Overflows from CAFO Waste Storage Structures
Overflows from CAFO waste storage structures for cattle, horses, sheep, and existing swine, poultry, and veal facilities identified in Part I.B.1. are properly designed, constructed, and are operated and maintained in accordance with the requirements of this permit, the overflow is caused by precipitation events, and do not cause or contribute to an exceedance of Michigan's water quality standards.

b. Discharges from Land Application Areas
Discharges of CAFO waste to surface waters of the state that do not cause or contribute to an exceedance of Michigan's water quality standards are authorized from the land application areas managed in accordance with the Nutrient Management Plan (NMP) requirements set forth in Part I.B.3.

2. Monitoring Requirements

THE DISCHARGE AUTHORIZED IN PART I.A.1 ABOVE, SHALL BE MONITORED BY THE PERMITTEE AS SPECIFIED BELOW.

Parameter	Units	Daily Maximum	Sample Type	Monitoring Frequency
Storage Structure Overflow				
Volume	Gal	(report)	Report Total Daily Volume	See Part I.A.2.b.
Discharge to Surface Waters of the State				
Volume	Gal	(report)	Report Total Daily Volume	See Part I.A.2.b.
5-Day Carbonaceous BioCHEMICAL~~logical~~ Oxygen Demand (CBOD5)	mg/l	(report)	Grab	See Part I.A.2.b.
Escherichia coli (*E.coli*)	counts/100ml	(report)	Grab	See Part I.A.2.b.
Total Phosphorus (as P)	mg/l	(report)	Grab	See Part I.A.2.b.
Ammonia Nitrogen (as N)	mg/l	(report)	Grab	See Part I.A.2.b.
Total Suspended Solids (TSS)	mg/l	(report)	Grab	See Part I.A.2.b.

a. Narrative Standard
The receiving water shall contain no turbidity, color, oil films, floating solids, foams, settleable solids, or deposits as a result of a discharge which are or may become injurious to any designated use.

b. Monitoring Frequency
Discharges and overflows shall be monitored once daily by the permittee as specified above on any day on which a discharge occurs. The first sample shall occur within the first six hours of discharge, and then daily thereafter, until the end of the discharge event. All monitoring shall be in accordance with Part II.B.2. of this permit.

c. Monitoring Location and Reporting Requirements
Samples, measurements, and observations of all discharges and overflows shall be taken in compliance with the monitoring requirements in Part I.A.2., be representative of the discharge and are taken prior to the discharge entering surface waters. The permittee shall notify the Department in accordance with the

PART I

Section A. Effluent Limits and Monitoring Requirements

reporting requirements set forth in Part II.C.6. of this permit and shall submit the monitoring requirements set forth in Part I.C.1. of this permit.

3. Prohibited Discharges

a. This permit does not authorize any discharge to the groundwaters of the state. Such discharge may be authorized by a groundwater discharge permit issued pursuant to Part 22, Groundwater Quality, of the NREPA.

b. This permit does not authorize dry weather discharge or a discharge of CAFO waste and/or runoff that fails to meet the requirements of Part I.A.1. of this permit. Discharges due to overflows from storage structures at new swine, poultry, or veal facilities are prohibited. Discharges from land application activities that do not meet the requirements of Part I.A.1. of this permit or that cause an exceedance of Michigan's Water Quality Standards are prohibited. Any unauthorized discharges shall be monitored in accordance with Part I.A.2.

c. THIS PERMIT DOES NOT AUTHORIZE A DISCHARGE FROM NEW SAND BEDDING,

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Section B. Nutrient Management Plan

The permittee shall implement the following requirements.

1. CAFO Waste Storage Structures

a. Volume Design Requirements
The permittee shall have distinct CAFO waste storage structures DESIGNED for each waste type (liquid, AS DEFINED IN NRCS STANDARD 313 (2017), or solid, stackable manure) in place and operational at all times that are adequately designed, constructed, maintained, and operated as per Part I.B.1. to contain the total combined volume of all of the following:

1) All CAFO waste generated from the operation of the CAFO, in a six-month or greater time period, including residual solids in waste storage structures designed for liquids, normal precipitation and runoff, and drifted snow accumulation in the production area during the same time period. For under-barn storages, inaccessible concrete lined storages, soil lined storages (either earthen or natural clay base), or synthetic lined storages that receive manure, the residual solids shall be at least ~~one foot~~ SIX INCHES, unless the permittee demonstrates annually a lesser amount is achievable. This is the operational volume of the storage structure.

2) For cattle, horses, and sheep, and existing (populated prior to January 20, 2009) swine, poultry, and veal facilities, all production area waste and all RUNOFF AND direct ~~and indirect~~ precipitation generated from the 25-year 24-hour rainfall event. The magnitude of the rainfall event will be specified in the COC. This is an emergency volume to be kept available to contain large rainfall events.

3) New (populated on or after January 20, 2009) swine, poultry, and veal facilities shall be designed to have all contaminated areas of the production area, including waste storage structures, totally enclosed and not subject to precipitation and, therefore, not needing room for the emergency volume in their storage structures.

4) An additional design capacity of a minimum of 12 inches of freeboard for storage structures that are subject to precipitation-caused runoff. For storage structures that are not subject to precipitation-caused runoff, the freeboard shall be a minimum of 6 inches. This is the freeboard volume.

5) ~~CAFO waste storage structure design calculations shall not include calculations of evaporation.~~

6) Records documenting the current design volume of every CAFO waste storage structure, including volume for residual solids, design treatment volume, total design volume, volumes of the operational, emergency, and freeboard volumes, and approximate number of days of storage capacity shall be kept in the permittee's Comprehensive Nutrient Management Plan (CNMP) for a minimum of five years from the date of creation.

b. Physical Design and Construction Requirements

1) Depth Gauge
CAFO waste storage structures shall include an easily visible, clearly marked depth gauge. Clear, major divisions shall be marked to delineate the operational, emergency (if applicable), and freeboard volumes as specified above in Part I.B.1.a. The top mark of the gauge shall be placed level with the lowest point on the top of the storage structure wall or dike. The elevation for the gauge shall be re-established as necessary but not less than every five years to adjust for any movement or settling. Materials used must be durable and able to withstand freezing and thawing (e.g. large chain, heavy-duty PVC, steel rod). Any depth gauges that are destroyed or missing must be replaced immediately. Under-barn storages may be measured with a dipstick or similar device.

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For solid stackable CAFO waste storage, depth gauge levels may be permanently marked on sidewalls.

2) Structural Design
Records documenting or demonstrating the current structural design as required below, including as-built drawings and specifications, of any CAFO waste storage structures, whether or not currently in use, shall be kept with the permittee's CNMP for a minimum five years from the date of creation. Included in the CNMP submitted to the Department shall be a short description of the structural design of each structure (type of structure; dimensions including depth; liner material, thickness, and condition; depth from the design bottom elevation to the seasonal high water table), a statement whether a professional engineer's evaluation has been completed or not, and a brief description of the results of the evaluation (meets Natural Resources Conservation Service (NRCS) 313 2017 or provides environmental performance equivalent to NRCS 313 2005, 2014, or 2017).

a) New Storage Structures (constructed after the effective date of the COC)
Except as otherwise required by this permit, CAFO waste storage structures shall, at a minimum, be constructed in accordance with NRCS 313 2017.

b) Existing Storage Structures at Newly Permitted CAFOs (facilities without prior NPDES permit coverage)

In a permit application for coverage under this permit, the applicant shall either:

(a) For each existing storage structure document through an evaluation by a professional engineer that each structure is constructed in accordance with NRCS 313 2014 or 2017. Submit to the Department documentation signed by a professional engineer verifying that each structure is constructed in accordance with NRCS 313 2014 or 2017. Complete as-built plans, specifications, drawings, etc. shall be kept at the facility with the CNMP and do not need to be submitted unless requested by the Department, or

(b) For each existing storage structure, on a form provided by the Department and submitted to the Department, demonstrate environmental performance equivalent to NRCS 313 2014. The demonstration shall be accomplished through an evaluation by a professional engineer.

i. The applicant for a Newly Permitted CAFO must provide the documentation or demonstration required by (a) or (b) above prior to populating livestock to the numbers which would require an NPDES permit (per the definition of Part II.A. Large CAFO).

ii. Previously evaluated storage structures at permitted CAFOs shall have documentation demonstrating that the structure was constructed to, or provides equivalent environmental protection to, NRCS 313 2003, 2005, or 2014.

c) For Previously Permitted CAFOs acquiring previously constructed waste storage structures from an unpermitted facility, the COC shall specify the date by which the permittee shall meet the requirements of i) or ii) below, but that date shall be no more than two years from the acquisition of the structures.

i) For each existing storage structure, document through an evaluation by a professional engineer that each structure is constructed in accordance with NRCS 313 2014 or 2017. Submit to the Department documentation signed by a professional engineer verifying that each structure is constructed in accordance with NRCS 313 2014 or 2017. Complete as-built plans, specifications, drawings, etc. shall be kept at the facility with the CNMP and do not need to be submitted unless requested by the Department, or

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ii) For each existing storage structure, on a form provided by the Department and submitted to the Department, demonstrate environmental performance equivalent to NRCS 313 2014. The demonstration shall be accomplished through an evaluation by a professional engineer.

d) Waste Storage Structures for Solid Stackable Manure Not Subject to Precipitation
Waste storage structures that will hold solid stackable manure that is totally enclosed and not subject to precipitation, will also be designed and constructed so that storage shall, at a minimum, include the following:

i) All CAFO waste generated from the operation of the CAFO in a six-month or greater time period;

ii) CAFO waste shall be covered or stored inside a structure such that it is protected from wind and will not be contacted by precipitation;

iii) All ~~structural wooden components below the roofline of the building and all~~ wood in contact with litter should be pressure treated;

iv) the ~~height of the litter stack not to exceed 7 feet, with litter to structural wooden components contact limited to 5 feet.~~ THE PERMITTEE SHALL INCLUDE THE BASIS AND METHOD FOR DOCUMENTING SIX MONTHS STORAGE CAPACITY IN ACCORDANCE WITH PART I.B.1.D.2.

1) TO DETERMINE STORAGE CAPACITY, THE PERMITEE MAY USE ANY OF THE FOLLOWING METHODS, OR IN COMBINATION, TO VERIFY SIX MONTHS OF POULTRY LITTER STORAGE CAPACITY:

A) COMPLETED AS-BUILD DRAWINGS; OR

B) CERTIFIED CNMP PROVIDER CALCULATIONS WHICH INCLUDE INFORMATION FROM THE ANIMAL WASTE MANAGEMENT REPORT OR CAFO FACILITY CALCULATIONS. THE INFORMATION AT A MINIMUM SHALL INCLUDE STACK CHARACTERISTICS, SUCH AS MAXIMUM STACK HEIGTH, MAXIMUM STACK ANGLE, AND WALL HEIGHT.

2) TO DETERMINE LITER PRODUCTION, THE PERMITEE MAY USE ANY OF THE FOLLOWING METHODS, OR IN COMBINATION, TO VERIFY SIX MONTHS OF POULTRY LITTER STORAGE CAPACITY:

A) A THREE-YEAR AVERAGE OF REPORTED PRODUCTION (I.E., CAFO WASTE IN CUBIC FEET) IN THE CAFO FACILITY'S ANNUAL REPORT. THE THREE-YEAR AVERAGE SHALL CONSIST OF DATA FROM THE HIGHEST THREE YEARS DURING THE LAST FIVE YEARS; OR

B) IF REPORTED PRODUCTION IS NOT AVAILABLE, DATA FROM THE MIDWEST PLAN SERVICE (MWPS-18, SECTION 1 (2004)) SHALL BE USED IN COMBINATION WITH ANY PREVIOUS YEAR'S DATA.

v) ALL DOCUMENTATION AND CERTIFICATION OF SIX MONTHS OF STORAGE CAPACITY SHALL BE SUBMITTED TO THE DEPARTMENT AS PART OF THE CNMP, AND SUBMITTED TO THE DEPARTMENT VIA MIWATERS (HTTPS://MIWATERS.DEQ.STATE.MI.US), WITH THE EXCEPTION OF THE COMPLETED AS-BUILT DRAWINGS THAT SHALL BE KEPT ON SITE AT THE CAFO FACILITY.

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vi) storm water shall not run onto or under the stored CAFO waste; and

vii) a minimum of two feet separation distance to the seasonal high-water table or a minimum of one-foot separation if an impermeable barrier is used under the stored CAFO waste. Impermeable barriers must be constructed of at least 12 inches of compacted clay, at least four inches of concrete, or another material of similar structural integrity.

e) Existing Storage Structures Not Meeting Standards
Existing storage structures that do not meet the requirements above in Part I.B.1. and will not be upgraded to meet NRCS 313 Standards shall be maintained or permanently closed in accordance with Part I.C.3. Records of usage, maintenance, or closure shall be kept in the CNMP. A notification of discontinued use shall be made via MiWaters (https://miwaters.deq.state.mi.us). If a waste storage structure is to be closed, this shall be completed within six months from the notification.

c. Inspection Requirements
The permittee shall develop a Storage Structure Inspection Plan to be kept in the CNMP. CAFO waste storage structures shall be inspected weekly. The results of the inspection shall be recorded on the "CAFO Inspection Record" form provided by the Department and kept in the CNMP for a minimum of 5 years from the date of creation. The plan shall include all of the following weekly inspections:

1) The CAFO waste storage structures for cracking, inadequate vegetative cover, woody vegetative growth, evidence of overflow, leaks, seeps, erosion, slumping, animal burrowing or breakthrough, and condition of the storage structure liner or stacking pad.

2) The depth of the CAFO waste in the storage structure and the available operating capacity as indicated by the depth gauge.

3) The collection system, lift stations, mechanical and electrical systems, transfer stations, control structures, and pump stations to ensure that valves, gates, and alarms are correctly set and all are properly functioning.

4) Any deficiencies found as a result of these inspections shall be corrected as soon as possible. Deficiencies and corrective actions taken shall be documented on the CAFO Inspection Record and kept in the CNMP for a minimum of 5 years from the date of creation.

d. Operation and Maintenance Requirements
The permittee shall implement a Storage Structure Operation and Maintenance Program that incorporates all the following management practices. The permittee shall initiate steps to correct any condition that is not in accordance with the Storage Structure Operation and Maintenance Program. A copy of the program shall be included in the CNMP. Specific records below shall be kept with the CNMP for a minimum of 5 years from the date of creation, unless specified otherwise below.

1) In the event the level of CAFO waste in the storage structure rises above the maximum operational volume level and enters the emergency volume level, the Department shall be notified. The level in the storage structure shall be reduced and the emergency volume restored within one week, unless a longer time period is authorized by the Department. The removed CAFO waste shall be land applied in accordance with this permit or the Department shall be notified if another method of disposal is to be used. Descriptions of such events shall be recorded and kept in the CNMP for a minimum of 5 years from the date of creation.

2) During the period of November 1 to December 31 of each year, there shall be an available operational volume in the CAFO waste storage structures equal to the volume of CAFO waste generated from the operation of the CAFO in a six-month or greater time period (including normal precipitation and runoff in the production area during the same time period). The date of this determination shall be kept in the CNMP for a minimum of 5 years from the date of creation and

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shall be certified via MiWaters (https://miwaters.deq.state.mi.us) to the Department by January 14 of the next calendar year, in accordance with Part II.C.5.

3) Vegetation shall be maintained at a height that stabilizes earthen CAFO waste storage structures, provides for adequate visual inspection of the storage structures, and protects the integrity of the storage structure liners. The vegetation shall have sufficient density to prevent erosion. Woody vegetation shall be removed promptly from waste storage berms and other areas where roots may penetrate or disturb waste storage facility liners or waste treatment facilities.

4) Dike damage caused by erosion, slumping, or animal burrowing shall be corrected immediately and steps taken to prevent occurrences in the future.

5) The integrity of the CAFO waste storage structure liner shall be protected. Liner damages shall be corrected immediately, and steps taken to prevent future occurrences.

6) Problems with the collection system, lift stations, mechanical and electrical systems, transfer stations, control structures, and pump stations shall be corrected as soon as possible. Records of these inspections and records documenting any actions taken to correct deficiencies shall be kept with the CNMP for a minimum of five years from the date of creation. Deficiencies not corrected within 30 days must be accompanied by an explanation of the factors causing the delayed correction.

7) CAFO waste shall be stored only in storage structures as described ~~above~~ IN PART I.B.1.A, B, AND D.

8) CAFO waste storage structures shall not contain human sanitary waste.

2. Best Management Practices Requirements

The following are designed to achieve the objective of preventing unauthorized discharges to surface waters of the state from production areas and land application activities.

a. Conservation Practices
The permittee shall maintain specific conservation practices near or at production areas, land application areas, and heavy use areas within pastures associated with the CAFO that are sufficient to control the runoff of pollutants to surface waters of the state in quantities that may cause or contribute to a violation of water quality standards. These practices shall be consistent with NRCS Conservation Practices and in compliance with the requirements of this permit. The permittee shall include within the CNMP a list of conservation practices used near or at production areas and land application areas. This list does not need to include temporary practices or other practices already required by this permit. Records documenting the inspection of the conservation practices (with the exception of those utilized on land application areas) shall be kept in the CNMP for a minimum of 5 years from the date of creation. Conservation practices on land application areas receiving CAFO waste shall be inspected and reported on the “Daily Manure Application Record.”

b. Divert Clean Water
The permittee shall design and implement structures and management practices to divert clean storm water to prevent contact with contaminated portions of the production areas. Clean storm water may include roof runoff, runoff from adjacent land, and runoff from feed or silage storage areas where such runoff has not contacted feed, silage, or silage leachate. The permittee shall describe in the CNMP structures and management practices used to divert clean water from the production area and/or beneficial uses of diverted water if it will be collected for reuse.

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c. Prevent Direct Contact of Animals with Surface Waters of the State
There shall be no access of animals to surface waters of the state at the production area of the CAFO. The permittee shall develop and implement appropriate controls to protect water quality by preventing access of animals to surface waters of the state and shall describe such controls in the CNMP. Records documenting the proper implementation of controls preventing access of animals to surface waters of the state shall be ~~reported~~ RECORDED on the "CAFO Inspection Report" form and kept in the CNMP for a minimum of 5 years from the date of creation.

d. Animal Mortality
The permittee shall handle, store, or dispose of dead animals in a manner that prevents contamination of surface waters of the state. Mortalities, including but not limited to any animal refuse or parts other than excrement (INCLUDING BUT NOT LIMITED TO ENTRAILS AND VISCERA OR PARTS OTHER THAN EXCREMENT), must not be disposed of in any liquid CAFO waste storage structure or storm water storage structure that is not specifically designed to treat animal mortalities, with the exception of leachate from properly designed and operated composting structures. Records documenting the proper management of animal mortalities shall be reported on the "CAFO Inspection Report" form and kept in the CNMP for a minimum of 5 years from the date of creation.

e. Chemical Disposal
The permittee shall prevent introduction of hazardous or toxic chemicals (for purposes of disposal) into CAFO waste storage structures. Examples of hazardous and toxic chemicals are pesticides and petroleum products/by-products. Identify in the CNMP appropriate practices that ensure chemicals that are not part of the normal agricultural practice at the production site and other contaminants handled at the CAFO are not disposed of in any CAFO waste or storm water storage or treatment system. Records documenting the proper management of chemicals to prevent their introduction into the CAFO waste storage structures, storm water storage, or treatment system, shall be reported on the "CAFO Inspection REPORT ~~Record~~" and kept in the CNMP for a minimum of 5 years from the date of creation.

f. Inspection, Proper Operation, Maintenance, and Reporting
The permittee shall develop and implement an Inspection, Operation, and Maintenance Program that includes periodic visual inspections, proper operation, and maintenance of all CAFO waste-handling equipment including piping and transfer lines, and all runoff management devices (e.g., cleaning separators, barnyards, catch basins, screens) to prevent unauthorized discharges to surface waters and groundwaters of the state. A copy of the program shall be included in the CNMP. Specific inspection requirements include, but are not limited to, all of the following:

1) Weekly visual inspections of all clean storm water diversion devices and runoff diversion structures and practices as described in Part I.B.2.b.

2) Daily visual inspections of water lines, including drinking water and cooling water lines, and above-ground piping and transfer lines, or an equivalent method of checking for water line leaks that incorporates the use of water meters, pressure gauges, or some other monitoring method.

3) Weekly inspections of all CAFO waste-handling equipment including piping and transfer lines, all runoff management devices, and devices channeling contaminated stormwater to storage and containment structures shall be accessible such that required visual inspections may occur. This may necessitate frequent removal of vegetation, snow, or other obstructions.

4) Any deficiencies shall be corrected as soon as possible.

5) Records of these inspections and records documenting any actions taken to correct deficiencies shall be recorded on the "CAFO Inspection Record" form provided by the Department and shall be kept in the CNMP for a minimum of five years from the date of creation. Deficiencies not corrected within 30 days must be accompanied by an explanation of the factors causing the delayed

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correction.

3. Land Application of CAFO Waste

a. Field-by-Field Assessment

The permittee shall conduct a field-by-field assessment of all land application areas. Each field shall be assessed prior to use for land application of CAFO waste. The assessment shall include field maps with location information (section, township, county, and crossroads, latitude and longitude of field center), and identify field-specific conditions, including, but not limited to, slopes, soil type, locations of tile outlets, tile risers and tile depth, conservation practices, and offsite conditions, such as buffers and distance or conveyance to surface waters of the state. The assessment shall also identify areas which, due to topography, activities, or other factors, have a potential for erosion. The assessment shall also identify fields, or portions of fields, that will be used for surface application of CAFO waste without incorporation or injection to frozen or snow-covered ground in accordance with Part III, Department 2005 Technical Standard for the Surface Application of CAFO Waste on Frozen or Snow-Covered Ground Without Incorporation or Injection. The results of this assessment, along with consideration of the form and source of the CAFO waste and all nutrient inputs in addition to those from CAFO waste, shall be used to ensure that the amount, timing, and method of application of CAFO waste:

~~A~~1) does not exceed the capacity of the soil to assimilate the CAFO waste;

~~B~~2) is in accordance with field-specific nutrient management practices that ensures appropriate agricultural utilization of the nutrients in the CAFO waste;

~~C~~3) does not exceed the maximum annual land application rates specified in Part I.B.3.c. of this permit; and THE BASIS (TECHNOLOGY, OR SAMPLING METHODS AND RESULTS) OF ANY PLANNED USE OF ADDITIONAL NITROGEN ABOVE THAT RATE SHALL BE PROVIDED WITH THE FIELD-FIELD ASSESSMENT.

~~D~~4) will not result in unauthorized discharges.

All assessments shall be kept in the CNMP for a minimum of 5 years from the date of creation. A particular field may be deleted from the CNMP once the field is no longer used for land application of CAFO waste; however, the field assessments must be kept in the CNMP for 5 years from the date created.

Any new fields shall be assessed prior to their use for land application activities. The Department shall be notified of the new fields prior to their use through submittal of a permit modification request via MiWaters (https://miwaters.deq.state.mi.us) that includes the field-by-field assessment REQUIRED ABOVE, ~~a map showing the entire field, its size in acres, location information (section, township, county, crossroads, and latitude and longitude of field center),~~ current (within the last three years) soil tests, planned crops, and realistic crop yield goals. The request will be public noticed for 15 CALENDAR days via MiWaters (https://miwaters.deq.state.mi.us). The permittee may use the field 18 calendar days after submittal of the request unless notified otherwise by the Department.

b. Field Inspections

Prior to conducting land application of CAFO waste to fields determined to be suitable under Part I.B.3.a. above, the permittee shall perform the following inspections at the indicated frequency to ensure that unauthorized discharges do not occur as a result of the land application of CAFO waste. Records of inspections, monitoring, and sampling required by this section shall be recorded in the Land Application Log required by Part I.B.3.d.

1) CAFO waste shall be sampled a minimum of once per year to determine nutrient content and analyzed for total kjeldahl nitrogen (TKN), ammonium nitrogen, and total phosphorus. CAFO waste shall be sampled in a manner that produces a representative sample for analysis. Guidance for

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CAFO waste sampling protocols can be found in ~~Bulletin NCR 567~~ THE NORTH CENTRAL REGIONAL EXTENSION PUBLICATION 567 (1995) available from Michigan State University Extension. Analytical methods shall be as required by Part II.B.2. The CAFO waste test results shall be used to determine land application rates as described in Part I.B.3.c. below. Records of the nutrient levels and analysis methods shall be kept in the Land Application Log and in the CNMP for a minimum of 5 years from the date of creation.

2) Soils at land application sites shall be sampled a minimum of once every three years, analyzed to determine phosphorus levels, and the soil test results shall be used to determine land application rates as described in I.B.3.c. below. Sample soil using an 8-inch vertical core and take 20 or more cores in a random pattern spread evenly over each uniform field area. A uniform field area shall be no greater than 20 acres or it can be up to 40 acres if that field has one soil map unit and has been managed as a single field for the last ten years. The 20 cores shall be composited into one sample and analyzed using the Bray P1 method.

   GRID OR ZONE SAMPLING ARE ALSO ACCEPTABLE METHODS FOR SAMPLING SOILS AT LAND APPLICATION SITES. IF GRID OR ZONE SAMPLING METHODS ARE USED, METHODS SHALL FOLLOW MICHIGAN STATE UNIVERSITY EXTENSION BULLETIN E498S (2006). THE PERMITTEE SHALL INCLUDE INDIVIDUAL SOIL SAMPLE RESULTS AND INFORMATION DOCUMENTING HOW SOIL SAMPLE ZONES ARE DETERMINED, AND MANURE APPLICATION RATES ARE CALCULATED.

   Records of the phosphorus levels shall be kept in the Land Application Log and in the CNMP for a minimum of 5 years from the date of creation. ~~Additional information on soil sampling can be found in Michigan State University Extension Bulletins E2904 and E498.~~

3) The permittee shall inspect each field no earlier than 48 hours prior to each land application of CAFO waste to that field to evaluate the current suitability of the field for application. This inspection shall include, at a minimum, the state of all tile outlets, evidence of soil cracking, the moisture-holding capacity of the soil, crop maturity, and the condition of designated conservation practices (i.e., grassed waterways, buffers, diversions). Results and findings of all inspections shall be recorded in the ~~Land Application Log~~ DAILY MANURE APPLICATION RECORD.

4) The permittee shall visually inspect all tile outlets draining a given field immediately prior to the land application of CAFO wastes to that field. Tile outlets shall be inspected again upon completion of the land application to the field, or at the end of the working day should application continue on that field for more than one day. Include in the ~~Land Application Log~~ DAILY MANURE APPLICATION RECORD written descriptions of tile outlet inspection results and observe and compare color and odor of tile outlet effluents before and after land application.

5) All tiled fields to which CAFO wastes have been applied in the prior 30 days shall be visually inspected within 24 hours after the first rain event of one-half inch or greater, for signs of a discharge of CAFO waste. Written descriptions of tile inspection results shall be ~~retained~~ RECORDED in the ~~Land Application Log~~ DAILY MANURE APPLICATION RECORD. If an inspection reveals a discharge with color, odor, or other characteristics indicative of an unauthorized discharge of CAFO waste, the permittee shall immediately notify the Department in accordance with the reporting procedures set forth in ~~Part II.C.6 of this permit and the monitoring requirements of Part I.A.2.~~ PART I.C. AND MONITOR THE DISCHARGE IN ACCORDANCE WITH PART I.A.2. of this permit. A copy of the ~~report~~ DAILY MANURE DISCHARGE APPLICATION RECORD shall be kept with the Land Application Log.

6) The permittee shall inspect all land application equipment daily during use for leaks, structural integrity, and proper operation and maintenance. Land application equipment shall be calibrated annually to ensure proper application rates. Written records of inspections, date of inspections, and calibrations shall be retained in the ~~Land Application Log~~ DAILY MANURE APPLICATION

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RECORD.

c. Maximum Annual Land Application Rates

~~During the period beginning on the effective date of this permit and the effective date of an individual COC and lasting until the date identified on the COC,~~ The permittee may use EITHER the Bray P1 numerical limits or the Michigan Phosphorus Risk Assessment (MPRA) tool (Version 2.0, Nov. 2012) AND THE EGLE MPRA GUIDANCE DOCUMENT to determine maximum annual land application rates. The permittee must use one system for ALL ~~its entire~~ land application area. For purposes of this permit, the MPRA is for rate calculations only and "Distance to surface water and/or surface inlets" is interpreted as described in Part I.B.3.h. below. The permittee shall comply with all of the following land application rates:

1) Land Application Rate Prohibitions and Restrictions
All of the following land application rate prohibitions apply.

a) If the Bray P1 soil test result is ~~150~~ 135 parts per million (ppm) phosphorus (P) or more, AND THE FIELDS ARE NOT LOCATED WITHIN A WATERSHED(S) COVERED BY AN APPROVED PHOSPHORUS OR NITROGEN TOTAL MAXIMUM DAILY LOAD (TMDL), CAFO waste applications shall be discontinued until nutrient use by crops reduces the Bray P1 soil test result to less than ~~150~~ 135 ppm P including when MPRA is used. IF THE BRAY P1 SOIL TEST RESULT IS 120 PPM P OR MORE, AND THE FIELDS ARE LOCATED IN A WATERSHED(S) COVERED BY AN APPROVED PHOSPHORUS OR NITROGEN TMDL, CAFO WASTE APPLICATIONS SHALL BE DISCONTINUED, UNTIL NUTRIENT USE BY CROPS REDUCES THE SOIL TEST RESULT TO LESS THAN 120 PPM P INCLUDING WHEN MPRA IS USED.

b) Fields where the MPRA risk is HIGH, CAFO waste shall not be applied.

c) The application rate shall not exceed the nitrogen (N) fertilizer recommendation (removal value for legumes) for the first crop year grown after the CAFO waste is applied as specified in Part I.B.3.c.2) b) below.

d) The application rate shall not exceed four years of P for each of the four crops planned for the next four years as calculated in Part I.B.3.c.2) b) below.

e) The total amount of N and P, regardless of source (manure, organic waste, commercial fertilizer, etc.), shall not exceed the first crop year nutrient requirements unless applying multiple crop years of P as allowed in 2) below. Only one year of N can be applied as stated in c) above, unless samples or other relevant data shows additional N is needed for or will be beneficial to the crop. Documentation justifying additional N must be kept in the CNMP for a minimum of 5 years from the date of creation.

2) Phosphorus Levels

a) If the Bray P1 soil test result is ~~75~~ 68 ppm P or more, but less than ~~150~~ 135 ppm P AND THE FIELDS ARE NOT LOCATED WITHIN A WATERSHED(S) COVERED BY AN APPROVED PHOSPHORUS OR NITROGEN TMDL, or a MPRA risk of MEDIUM, application rates shall be based on the maximum rates of P in annual pounds per acre as calculated using the ~~following formula~~ METHOD DESCRIBED BELOW.~~:~~ IF THE BRAY P1 SOIL TEST RESULT IS 60 PPM P OR MORE, BUT LESS THAN 120 PPM P AND THE FIELDS ARE LOCATED IN A WATERSHED(S) COVERED BY AN APPROVED PHOSPHORUS OR NITROGEN TMDL, OR A MPRA RISK OF LOW, APPLICATION RATES SHALL BE BASED ON THE MAXIMUM RATE OF P IN ANNUAL POUNDS PER ACRE AS CALCULATED USING THE METHOD DESCRIBED BELOW.

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The realistic yield goal per acre, using the units specified in Table 1 below, for the planned crop multiplied by the number in the P column for that crop. The maximum annual application rates as calculated above shall be achieved by using the CAFO waste test results for P to determine the amount of CAFO waste that may be land applied per acre per year.

The result is the maximum annual pounds per acre of P that may be applied for the first crop planned after application of CAFO waste. If the one-year rate is impractical due to spreading equipment or crop production management, the permittee may apply up to two years of P at one time, but no P may be applied to that field for the second year. The two-year P application rate shall be the results calculated using the formula above for each of the two crops planned for the next two years and those two annual results shall be added together to determine the maximum P application rate. In no case may the application rate exceed the N application rate as specified below.

b) If the Bray P1 soil test result is less than ~~75~~ 68 ppm P AND THE FIELDS ARE NOT LOCATED WITHIN A WATERSHED(S) COVERED BY AN APPROVED PHOSPHORUS OR NITROGEN TMDL, OR 60 PPM P AND THE FIELDS ARE LOCATED IN A WATERSHED(S) COVERED BY AN APPROVED PHOSPHORUS OR NITROGEN TMDL, or a MPRA risk of LOW, the annual rate of CAFO waste application shall not exceed the N fertilizer recommendation (removal value for legumes) for the first crop year grown after the CAFO waste is applied. Information to determine N fertilizer recommendations or removal values can be found in Michigan State University Extension Bulletin E2904. THE UNIVERSITY OF MINNESOTA EXTENSION BULLETIN "GUIDANCE FOR MANURE APPLICATION RATE" (2019) AND UNIVERSITY OF WISCONSIN BULLETIN A2809 (2012) MAY BE USED FOR N FERTILIZER RECOMMENDATIONS OR REMOVAL RATES FOR LEGUMES. In no case may the application rate exceed four years of P calculated using the METHOD DESCRIBED IN ~~formula per~~ Part I.B.3.c.2)a) above for each of the four crops planned for the next four years and those four annual results shall be added together to determine the maximum application rate. The maximum annual application rates as calculated above shall be achieved by using the CAFO waste test results for N to determine the amount of CAFO waste that may be land applied per acre per year.

~~3) Michigan Phosphorus Risk Assessment (MPRA)~~
~~During the period beginning on the date identified in the individual COC and lasting until the expiration of this permit or termination of the individual COC, the permittee shall comply with the Michigan Phosphorus Risk Assessment (MPRA) tool (Version 2.0, Nov. 2012) to determine maximum annual land application rates. For purposes of this permit, the MPRA is for rate calculations only. The MPRA category "Distance to surface water and/or surface inlets" is interpreted as described in Part I.B.3.h. below.~~

~~The permittee shall comply with all of the following maximum annual land application rates:~~

~~a) Land Application Rate Prohibitions and Restrictions~~
~~All of the following land application rate prohibitions apply.~~

~~(1) if the Bray P1 soil test result is 150 parts per million (ppm) or more, CAFO waste shall not be applied;~~

~~(2) fields where the MPRA risk is HIGH, CAFO waste shall not be applied;~~

~~(3) the application rate shall not exceed the nitrogen (N) fertilizer recommendation for the first crop year grown after the CAFO waste is applied. The N fertilizer recommendations or removal rates for legumes shall be found in Michigan State University Extension Bulletin E2904, August 2009. The maximum annual application rates as calculated for N shall be achieved by using the CAFO waste test results for first year available N to determine the amount of CAFO waste that may be land applied per acre per year;~~

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~~(4) the application rate shall not exceed four years of P for each of the four crops planned for the next four years as calculated using the formula in Part I.B.3.c.3)b)(3) and;~~

~~(5) the total amount of N and P, regardless of source (manure, organic waste, commercial fertilizer, N credit, organic N carryover, etc.), shall not exceed the nutrient requirements as calculated using the MPRA. The allowable P rate is calculated using the MPRA~~.

3) Additionally, only one year of N can be applied as stated in Part I.B.3.c.1) c) above, unless samples or other relevant data demonstrate additional N is needed for, or will be beneficial to, the crop. Prior to application, the demonstration justifying additional N must be submitted to the Department via MiWaters (https://miwaters.deq.state.mi.us) for review. The demonstration will be public noticed for a period of 15 days. The demonstration shall be kept in the CNMP for a minimum of 5 years from the date of creation. The permittee may apply the additional N following 18 calendar days after submittal of the request, unless notified otherwise by the Department.

A~~b~~) Risk Assessment

(1) IF USING MPRA, CAFO waste may only be applied on fields that achieve a MPRA score of LOW or MEDIUM.

(2) In accordance with Part I.C.9., if the field is located in a watershed(S) COVERED BY AN APPROVED ~~with a Nitrogen or~~ Phosphorus OR NITROGEN ~~impairment with an approved Total Maximum Daily Load (~~TMDL~~)~~, CAFO waste may not be applied unless the MPRA risk is LOW.

(3) Allowable application rates of P shall be based on the rates of P in annual pounds (lbs.) per acre (ac) as calculated using the following formula:

Phosphorus Amount (lbs. P/ac) = Realistic Crop Yield Goal/ac x P (lb./unit yield for planned crop)

The annual application rates allowable as calculated above shall be achieved by using the CAFO waste test results (required per Part I.B.3.b.1) for P to determine the amount of CAFO waste that may be land applied per acre per year as calculated using MPRA.

Three and four years of P may only be applied on fields with an MPRA score of LOW.
A multi-year P application rate shall be the results calculated using the formula above for each of the crops planned for the specified years and those annual results shall be added together to determine the maximum P application.

Table 1. PHOSPHATE (P_2O_5) values are included for reference purposes.

Planned Crop	Harvest Form	Unit of Realistic Yield Goal per Acre	P	P_2O_5
			- - lb./unit of yield - -	
Alfalfa	Hay	ton	5.72	13.1
Alfalfa	Haylage	ton	~~1.41~~ 2.38	~~3.2~~ 5.45
Apple	Fruit	ton	0.19	0.44
Asparagus	Shoots	ton	1.1	2.51
Barley	Grain	bushel	0.17	0.38
Barley	Straw	ton	1.41	3.2
Beans (dry edible)	Grain	cwt	0.53	1.2
Beans (green, fresh)	Pods	ton	1.22	2.8
Blueberry	Fruit	ton	0.20	0.46
Bromegrass	Hay	ton	5.72	13
Buckwheat	Grain	bushel	0.11	0.25

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Table 1.		PHOSPHATE (P_2O_5) values are included for reference purposes.		
Planned Crop	**Harvest Form**	**Unit of Realistic Yield Goal per Acre**	**P**	**P_2O_5**
			- - lb./unit of yield - -	
Canola	Grain	bushel	0.40	0.91
Carrots	Root	ton	0.79	1.81
Cherries (sour)	Fruit	ton	0.3	0.69
Cherries (sweet)	Fruit	ton	0.37	0.85
Clover	Hay	ton	4.4	10
Clover-grass	Hay	ton	5.72	13
Corn	Grain	bushel	0.16	0.37
Corn	Stover	ton	3.61	8.2
Corn	Silage	ton	1.45	3.3
Corn	Sweet	ton	1.23	2.8
Cucumbers	Fruit	ton	0.47	1.1
Grapes	Fruit	ton	0.26	0.6
Millet	Grain	bushel	0.11	0.25
Mint	Hay	Ton	3.81	8.72
Oats	Grain	bushel	0.11	0.25
Oats	Straw	ton	1.23	2.8
Onions	Bulb	ton	1.14	2.6
Orchard grass	Hay	ton	7.48	17
Peaches	Fruit	ton	0.24	0.55
Pears	Fruit	ton	0.23	0.53
Peas	Fruit	ton	2.01	4.6
Peppers, Green	Fruit	Ton	0.6	1.37
Plums	Fruit	ton	0.2	0.46
Potato	Tubers	cwt	0.06	0.13
Rye	Grain	bushel	0.18	0.41
Rye	Straw	ton	1.63	3.7
Rye	Silage	ton	0.66	1.5
Sorghum	Grain	bushel	0.17	0.39
Sorghum-Sudangrass	Hay	ton	6.6	15
Sorghum-Sudangrass	Haylage	ton	2.02	4.6
Soybean	Grain	bushel	0.35	0.8
Spelts	Grain	bushel	0.17	0.38
Squash	Fruit	ton	0.76	1.74
Sugar beets	Roots	ton	0.57	1.3
Sunflower	Grain	bushel	0.53	1.2
Timothy	Hay	ton	7.48	17
Tomatoes	Fruit	ton	0.57	1.3
Triticale	Silage	Ton	3.08	7.0
Wheat	Grain	bushel	0.28	0.63
Wheat	Straw	ton	1.45	3.3

For crops not listed in Table 1, the permittee shall provide in the permit application, the harvest form, unit of realistic yield goal per acre, P lb./unit of yield (in a format similar to that of Table 1) and supporting data. The Department will review the proposal, and upon approval, will list the approved numbers in the COC. The permittee may propose alternate land application rates and methodologies in the permit application. The Department will review the proposal and acceptable rates and methods, and upon approval, will public notice the proposal via MiWaters (https://miwaters.deq.state.mi.us) for a 15 day period. The alternate land application rates and methodologies will be included in the COC issued under this permit.

Methodology and calculations consistent with this Part I.B.3.c. and their results, shall be recorded in the Land Application Log.

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d. Land Application Log
The results of land application inspections, monitoring, testing, and recordkeeping shall be recorded in the Department provided forms, "Daily Manure Application Record" and the "Land Application Summary for Previous Crop Year" which shall be kept up-to-date and kept in the CNMP for a minimum of 5 years from the date of creation. The permittee shall document in the log in writing, at a minimum, records required by Part I.B.3. and all of the following information and inspection results in the specified documents:

1) Daily Manure Application Record
   a) The time, date, quantity, method, location (Section, Township, County, latitude and longitude of field center), crop grown, and application rate for each location at which CAFO wastes are land applied.

   b) ~~A written~~ THE description of THE FORECAST AND OF THE weather conditions at the time of application and for 24 hours prior to and following application based on visual observation.

   c) A review of the condition of conservation practices.

   d) A statement whether the land was frozen or snow-covered at the time of application.

2) Land Application Summary for Previous Crop Year
   a) The crop, the realistic yield goal, and actual yield for each location at which CAFO wastes are land applied, and the second-year crop (if applicable).

   b) Methodology and calculations showing the total nitrogen and phosphorus actually applied to each field receiving CAFO waste, identifying each source of manure used to calculate the application rate, identify all sources of nutrients, including sources other than CAFO waste.

   c) The total amount of nitrogen and phosphorus actually applied to each field receiving CAFO waste, irrespective of source, including documentation of calculations for the total amount applied.

   d) The reporting of additional N applied under the demonstration per Part I.B.3.c.3)a).

3) Forecast Records
Printouts or electronically maintained records of weather forecasts from the time of land application. Weather forecasts may also be saved as electronic files, in which case the files do not need to be physically located in the Land Application Log, but the log shall reference the location where the files are stored and shall be made available upon Department request.

e. Land Application Summary
The permittee shall submit the required "Land Application Summary" form via MiWaters (https://miwaters.deq.state.mi.us) within 30 days from each quarter ending March 31, June 30, September 30, and December 31 of each year and will include the following for each field on which CAFO waste was applied:

1) Dates of Application;

2) Field NAME AND Location (latitude and longitude COORDINATES of center of field);

3) Acres applied;

4) Amount and units of manure applied per acre.

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f. Prohibitions
Appropriate prohibitions, in compliance with the following, shall be included in the CNMP:

1) CAFO waste shall not be applied on land that is flooded or saturated with water at the time of land application.

2) CAFO waste shall not be applied during rainfall events.

3) CAFO waste shall not be applied during the months of January, February, or March 1 through March 19. UNLESS THE PERMITTEE SUBMITS A NOTIFICATION AND MEETS THE FOLLOWING CONDITIONS:

4) CAFO waste applications during March 20 to March 31 shall be in compliance with the following:

(a) CAFO waste shall ONLY not be applied on ground that is frozen or snow-covered WHEN WASTE CAN BE INCORPORATED IMMEDIATELY FOLLOWING APPLICATION, OR INJECTED;

(b) CAFO WASTE SHALL NOT BE APPLIED WHEN TWO OR MORE INCHES OF FROST AND/OR FOUR OR MORE INCHES OF SNOW ARE PRESENT AT THE LAND APPLICATION SITE AT THE TIME OF APPLICATION;

d. (C) CAFO WASTE SHALL NOT BE APPLIED WITHIN 100 FEET OF ANY SURFACE WATER OF THE STATE, OPEN TILE LINE INTAKE STRUCTURES, SINKHOLES, AGRICULTURAL WELL HEADS, INCLUDED BUT NOT LIMITED TO ROADSIDE DITCHES THAT ARE CONDUITS TO SURFACE WATERS OF THE STATE (WITH THE EXCEPTION OF SURFACE WATERS OF THE STATE THAT ARE UP-GRADIENT OF THE LAND APPLICATION)24 hours prior to the land application of CAFO waste, the Department shall be notified, through a Department form via MiWaters (https://miwaters.deq.state.mi.us);

(Dc) All land application practices shall follow the requirements per Part I.B.3. MANURE APPLICATION ON FIELDS RECEIVING CAFO WASTE MUST HAVE A SOIL SAMPLE BRAY P1 OF NO GREATER THAN 68 PPM P, OR 60 PPM P IF FIELDS ARE LOCATED IN WATERSHED(S) COVERED BY AN APPROVED PHOSPHORUS OR NITROGEN TMDL.

(E) TWENTY FOUR 24 hours prior to the land application of CAFO waste, the Department shall be notified, through a Department form via MiWaters (https://miwaters.deq.state.mi.us);. THE NOTIFICATION MUST INCLUDE ALL OF THE FOLLOWING:

I) A TOPOGRAPHIC MAP OF THE SPECIFIC LAND APPLICATION LOCATION SHOWING THE DIRECTIONAL FLOW TO SURFACE WATERS;

II) THE PLANNED APPLICATION RATE, WITH NO MORE THAN 1 CROP YEAR OF P THAT CAN BE APPLIED;

III) THE CURRENT TOTAL STORAGE STRUCTURE CAPACITY IN DAYS AT THE CAFO FACILITY.

(F) ALL LAND APPLICATION PRACTICES SHALL FOLLOW THE REQUIREMENTS PER PART I.B.3.

5) CAFO waste shall not be surface applied without incorporation or injection to frozen or snow-covered ground, except in accordance with the Department 2005 "Technical Standard for the Surface Application of CAFO Waste on Frozen or Snow-Covered Ground Without Incorporation or Injection" as required per Part III and to fields where the MARI score is Low or Very Low potential for manure movement from the field.

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4) CAFO waste shall not be transferred to a recipient for land application of the CAFO waste during the months of January, February, or March. LAND APPLICATION DOES NOT MEAN CAFO WASTE THAT IS TRANSFERRED OUT OF STATE, TO A TREATMENT FACILITY, OR COMPOSTING FACILITY.

~~5) CAFO waste shall not be transferred to another person (a recipient as described in Part I.C.8.) where such waste will be surface applied without incorporation or injection to frozen or snow-covered ground unless the recipient agrees to follow Part III. Department 2005 Technical Standard for the Surface Application of CAFO Waste on Frozen or Snow-Covered Ground Without Incorporation or Injection.~~

5) CAFO waste application shall be delayed if rainfall exceeding one-half inch, or less if a lesser rainfall event is capable of producing an unauthorized discharge, is forecasted by the National Weather Service (NWS) during the planned time of application and within 24 hours after the time of the planned application. Forecast models to be used can be found on the internet at http://www.weather.gov/mdl/synop/products.php. Model data to be used for one-half inch shall be THE FOLLOWING:

GFS MOS (MEX) Text Message by Station Forecast: If the Q24 is 4 and the P24 is 70 or more for the applicable time period, or the Q24 is 5 or greater (with any P24 number), then CAFO waste land application shall be delayed until the Q24 is less than 5, or both the Q24 is less than 4 and the P24 is less than 70 for the applicable time period. If the first two Q12 values are 4 and the corresponding P12 values are 70 or more for the applicable time period, or the Q12 values are 5 or greater (with any P12 numbers), then CAFO waste land application shall be delayed until the first two Q12 values are less than 5 or both the Q12 values are less than 4 and the corresponding P12 values are less than 70 for the applicable time period. For further details and instructions, utilize the "Instructions for Determining Precipitation Forecasts for CAFO Permits" located at https://www.michigan.gov/documents/deq/wrd-npdes-CAFO-PrecipitationInstructions_513072_7.pdf . The station to be used shall be that which is closest to the land application area. If no station is close, then use the closest 2 or 3 stations.

Different model data shall be used if it is determined that rainfall less than one-half inch on a particular field is capable of causing an unauthorized discharge. For example, using a Q24 rating of 3 or greater may be appropriate on higher risk fields. If the NWS website is revised and the required forecast models are not available, the permittee shall contact the Department for information on which forecast models to use. Instructions for using this website are available from the Department. Other forecast services may be used upon approval of the Department.

g. Methods
CAFO waste shall be subsurface injected or incorporated into the soil within 24 hours of application. CAFO waste subsurface injected into frozen or snow-covered ground shall have substantial soil coverage of the applied CAFO waste. DURING JANUARY, FEBRUARY, MARCH ALL CAFO WASTE SHALL BE INCORPORATED IMMEDIATELY FOLLOWING APPLICATION, OR INJECTED. The following exceptions apply DURING THE PERIOD APRIL 1 THROUGH DECEMBER 31:

1) Injection or incorporation may not be feasible where CAFO wastes are applied to pastures, perennial crops such as alfalfa, cover crops, or where no-till practices are used. CAFO waste may be applied to pastures or perennial crops such as alfalfa, cover crops, or where no-till practices are used, only if the CAFO waste will not enter surface waters of the state. CAFO waste shall not be applied if the waste may enter surface waters of the state.

2) ~~On ground that is frozen or snow-covered,~~ CAFO waste may be surface applied and not incorporated within 24 hours ON GROUND THAT IS FROZEN OR SNOW-COVERED only if there is a field-by-field demonstration CONDUCTED WITHIN 48 HOURS PRIOR TO APPLICATION. THE DEMONSTRATION SHALL BE CONDUCTED in accordance with Part III. Department 2005 Technical Standard for the Surface Application of CAFO Waste on Frozen or Snow-Covered Ground

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Without Incorporation or Injection, showing that such land application will not result in a situation where CAFO waste may enter surface waters of the state. THE DEMONSTRATION SHALL BE SUBMITTED TO THE DEPARTMENT 24 HOURS PRIOR TO APPLICATION ON FROZEN OR SNOW-COVERED GROUND. Demonstrations shall be kept with the Land Application Log ~~and submitted to the Department prior to use of the field~~. CAFO waste surface applied to ground that is frozen or snow-covered shall be limited to no more than 1 crop year of P per winter season, including pastures, perennial crops such as alfalfa, cover crops, or where no-till practices are used.

h. Setbacks
~~The permittee shall comply with any of the following setback requirements:~~

1) IF USING THE NUMERICAL BRAY P1 METHOD, THE PERMITTEE SHALL COMPLY WITH THE SETBACK REQUIREMENTS IN A) AND B) BELOW.

a) CAFO waste shall not be applied ~~closer~~ WITHIN ~~than~~ 100 feet ~~to~~ OF any SURFACE WATER OF THE STATE, open tile line intake structures, sinkholes, agricultural well heads, INCLUDING BUT NOT LIMITED TO ROADSIDE ~~or any~~ ditches that are conduits to surface waters of the state (with the exception of surface waters of the state that are up-gradient of the land application),

B~~2~~) The permittee ~~may substitute~~ SHALL INSTALL AND MAINTAIN ~~the 100-foot setback required in 1) above, with~~ a 35-foot wide PERMANENT vegetated buffer ALONG ANY SURFACE WATER OF THE STATE, OPEN TILE LINE INTAKE STRUCTURES, SINKHOLES, AGRICULTURAL WELL HEADS, INCLUDING BUT NOT LIMITED TO ROADSIDE OR ANY DITCHES THAT ARE CONDUITS TO SURFACE WATERS OF THE STATE (WITH THE EXCEPTION OF SURFACE WATERS OF THE STATE THAT ARE UP-GRADIENT OF THE LAND APPLICATION), . CAFO WASTE SHALL NOT BE APPLIED WITHIN THE 35-FOOT BUFFER.

2) THE PERMITTEE MAY DEMONSTRATE AN ALTERNATIVE PRACTICES COMPLIANCE ALTERNATIVE CONSISTENT WITH 40 CFR 412.4(C)(5)(I) AND (C)(5)(II) THAT MINIMIZE RISK OF TRANSPORT OF NUTRIENTS TO SURFACE WATERS. THE DEMONSTRATION SHALL BE SUBMITTED VIA MIWATERS (HTTPS://MIWATERS.DEQ.STATE.MI.US) AND BE APPROVED BY THE DEPARTMENT, AND BE IMPLEMENTED PER DEPARTMENT APPROVAL. THIS APPROVED DEMONSTRATION BECOMES A PART OF THE CNMP.

3) IF USING MPRA, SETBACKS AND/OR PERMANENT VEGETATIVE BUFFERS SHALL BE IDENTIFIED IN THE MPRA SCORING WORKSHEET, FIELD-BY-FIELD ASSESSMENT, AND FIELD MAPS. THE PERMITTEE MAY CHOOSE FROM A) OR B) BELOW.

A) CAFO WASTE SHALL NOT BE APPLIED WITHIN 100 FEET OF ANY SURFACE WATER OF THE STATE, OPEN TILE LINE INTAKE STRUCTURES, SINKHOLES, AGRICULTURAL WELL HEADS, INCLUDING BUT NOT LIMITED TO ROADSIDE DITCHES THAT ARE CONDUITS TO SURFACE WATERS OF THE STATE (WITH THE EXCEPTION OF SURFACE WATERS OF THE STATE THAT ARE UP-GRADIENT OF THE LAND APPLICATION), OR

B) THE PERMITTEE MAY CHOOSE TO INSTALL AND MAINTAIN A 35-FOOT WIDE PERMANENT VEGETATED BUFFER AS A SUBSTITUTE FOR 1)B) ABOVE. CAFO WASTE SHALL NOT BE APPLIED WITHIN THE 35-FOOT PERMANENT VEGETATED BUFFER.

~~3~~4) CAFO waste shall not be applied within grassed waterways and swales that are conduits to surface waters of the state.

5) Setbacks AND VEGETATED BUFFER WIDTHS shall be measured from the ordinary high-water mark, where applicable, or from the upper edge of the bank if the ordinary high-water mark cannot be

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determined. Setbacks AND VEGETATED BUFFERS for each field shall be shown on the CNMP field maps.

i. Non-Production Area Storm Water Management

The permittee shall implement practices including preventative maintenance, good housekeeping, and periodic inspections of at least once per year, to minimize and control pollutants in storm water discharges associated with the following areas:

1) Immediate access roads and rail lines used or traveled by carriers of raw materials, waste material, or by-products used or created by the facility.

2) Sites used for handling material other than CAFO waste.

3) Refuse sites.

4) Sites used for the storage and maintenance of material handling equipment.

5) Shipping and receiving areas.

Records and descriptions of non-production area storm water management practices shall be kept in the CNMP for a minimum of 5 years from the date of creation.

4. Comprehensive Nutrient Management Plan (CNMP)

The CNMP shall apply to both production areas and land application areas and shall be a written document that describes the practices, methods, and actions the permittee takes to meet all of the requirements of the Nutrient Management Plan (NMP) per Part I.B.

a. Approval
The CNMP shall be ~~developed and approved~~ CERTIFIED by a Certified CNMP Provider.

b. Submittal
The CNMP shall be submitted to the Department with the application for coverage under this permit. All or parts of the CNMP shall be submitted via MiWaters (https://miwaters.deq.state.mi.us) on the template provided by the Department.

c. Contents
The CNMP submitted to the Department shall include all of the information and requirements specified in the NMP Section per Part I.B., an Executive Summary (a general description of the operation), and a map of the production area that includes all of the items specified in the permit application, THE ANIMAL CONFINEMENT AREA, THE MANURE STORAGE AREA, THE RAW MATERIALS STORAGE AREA, TREATMENT SYSTEMS, AND THE WASTE CONTAINMNET AREAS, and that shows all clean water and production area waste flow paths, contaminated collection areas, pipes, control structures, valves, etc. THE LOCATION OF ANY AREAS USED FOR STORAGE OF RAW MATERIALS, INCLUDING NEW SAND BEDDING, SHALL BE LOCATED IN SUCH A MANNER AS TO PROHIBIT RUNOFF TO SURFACE WATERS OF THE STATE.

d. Annual Review and Report
The permittee shall annually review the CNMP and update the CNMP as necessary to meet the requirements of Part I.B.

The permittee shall submit an annual report for the preceding January 1 through December 31 (reporting period) to the Department by April 1 of each year. The annual report shall be submitted via MiWaters (https://miwaters.deq.state.mi.us) on the "Annual Report Form for Concentrated Animal Feeding Operations (CAFO)" provided by the Department. The annual report shall include, but is not limited to, all of the following:

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1) the average number of animals, maximum number of animals at any one time, and the type of animals, whether in open confinement or housed under roof (beef cattle, broilers, layers, swine weighing 55 pounds or more, swine weighing less than 55 pounds, mature dairy cows, dairy heifers, veal calves, sheep and lambs, horses, turkeys, other);

2) estimated amount of total CAFO waste generated by the CAFO during the reporting period (tons or gallons);

3) estimated amount of total CAFO waste transferred to other persons (manifested waste) by the CAFO during the reporting period (tons or gallons);

4) total number of acres for land application covered by the CNMP developed in accordance with this permit;

5) total number of acres under control of the CAFO that were used for land application of CAFO waste during the reporting period;

6) a field-specific spreading plan which identifies where and how much CAFO waste will be applied to fields for the upcoming 12 months, what crops will be grown on those fields, and the realistic crop yield goals of those crops. The plan must account for all CAFO waste expected to be generated in the upcoming 12 months including waste to be transferred under manifest;

7) the Land Application Summary for Previous Crop Year per Part I.B.3.d.2.;

8) a statement indicating whether the current version of the CAFO's CNMP was developed and approved by a certified CNMP provider; and

9) a summary of all CAFO waste discharges from the production area that have occurred during the reporting period, including date, time, and approximate volume.

e. CNMP Revisions
Prior to revisions to the CNMP, the CAFO owner or operator must provide the most current version of the CNMP and identify changes from the previous version to the Department for review. If the Department determines the revisions are significant, the Department must notify the public and make the changes available for review and comment. Significant revisions of the CNMP shall be public noticed for a PERIOD OF 15 CALENDAR day(S) ~~period~~ and may result in a permit modification. The CNMP shall be submitted via MiWaters (https://miwaters.deq.state.mi.us). Significant change includes the following:

1) Addition of new land application areas not previously included in the CAFO's CNMP per Part I.B.3.a.

2) Any changes to the maximum field-specific annual rates of application or to the maximum amounts of nitrogen and phosphorus derived from all sources for each crop, as expressed in accordance with the narrative rate approach per Part I.B.3.c.

3) Addition of any crop or other uses not included in the terms of the CAFO's CNMP and corresponding field-specific rates of application per Part I.B.3.c.3) ~~b)~~.

4) Changes to site-specific components of the CAFO's CNMP, where such changes are likely to increase the risk of nitrogen and phosphorus transport from the site to surface waters of the state per Part I.B.3.c.

5) An increase in the number of animals that results in a 10 percent or greater increase in the volume of either the manure alone or the total CAFO waste generated per year as compared to the

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volumes identified in the application or the most recently submitted Significant Change due to this Part I.B.4.e.5).

6) An increase in the number of animals that results in a 10 percent or greater decrease in the waste storage capacity time, as identified in the application or the most recently submitted Significant Change due to this Part I.B.4.e.6) or results in a waste storage capacity of less than 6 months.

7) The construction or procurement of a new animal housing facility or waste storage facility.

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1. Reporting of Overflows and Discharges from CAFO Waste Storage Structures and Land Application

If, for any reason, there is an overflow from CAFO waste storage structures and/or a discharge of pollutants to a surface water of the state from CAFO waste storage structures, production areas, or land application areas, the permittee shall report the overflow and/or discharge to the Department in accordance with the reporting requirements set forth in Part II.C.6. Discharges to surface waters shall also be reported to the Clerk of the local unit of government and the County Health Department within 24 hours after the discharge begins. The permittee shall also submit the completed "CAFO Discharge Monitoring Report" form to the Department via MiWaters (https://miwaters.deq.state.mi.us). In addition, the permittee shall keep a copy of the report in the CNMP for a minimum of 5 years from the date of creation. The report shall include all of the following information:

a. a description of the overflow and/or discharge and its cause, including a description of the flow path to the surface water of the state;

b. the period of overflow and/or discharge, including exact dates and times, the anticipated time it is expected to continue, and steps taken or planned to reduce, eliminate, and prevent recurrence of the overflow and/or discharge;

c. monitoring results as required by Part I.A.2.;

d. in the event of a discharge through tile lines, the permittee shall identify and document, for field(s) from which the discharge occurred, the location of tile and depth of tile. The permittee shall also document field conditions at the time of the discharge, determine why the discharge occurred, and how to prevent future discharges; and

e. if the permittee believes that the discharge is an authorized discharge, the permittee shall include a demonstration that the discharge meets the requirements of Part I.A.1.a. and/or Part I.A.1.b., as appropriate.

2. Construction or Procurement of New Waste Storage Structures or Facilities

Before the construction, ~~procurement, or~~ alteration, OR WITHIN 30 DAYS OF PROCUREMENT of a waste storage structure, facility, or portions thereof, notification shall be submitted to the Department via MiWaters (https://miwaters.deq.state.mi.us). New waste storage and transfer structures shall be built to NRCS 313 2017 Standard. Complete as-built plans, specifications, drawings, etc. shall be kept in the CNMP. As-built plans must be signed and stamped by a licensed professional engineer and state that the structure was built to the NRCS 313 2017 standard. Signed and stamped design drawings do not constitute as-built plans. Required supporting documentation may include soils reports documenting suitability of liner material, groundwater investigations reports, pictures, survey notes, concrete batch tickets, etc.

3. Closure of Structures and Facilities

The following conditions shall apply to the closure of lagoons, CAFO waste storage structures, earthen or synthetic lined basins, other manure and wastewater facilities, and silage facilities (collectively referred to as "structure(s)" for the remainder of this Part I.C.3.

No structure shall be permanently abandoned. Structures shall be maintained at all times until closed in compliance with this section. All structures must be properly closed if the permittee ceases operation. In addition, any structure that is not in use for a period of twelve (12) consecutive months must be properly closed, unless the permittee intends to resume use of the structure at a later date and either: (a) maintains the structure as though it were actively in use, to prevent compromise of structural integrity and ensure compliance with final effluent limitations, or (b) removes CAFO waste to a depth of one foot or less and refills the structure with clean water to preserve the integrity of the synthetic or earthen liner. In either case, the permittee shall conduct routine inspections, maintenance, and recordkeeping in compliance with this permit as though the structure were in use. The permittee shall notify the Department via MiWaters (https://miwaters.deq.state.mi.us) 30 days prior

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to closing structures, or upon deciding that the structures will be maintained as specified in (a) or (b) above. Thirty days prior to restoration of the use of the structure, the permittee shall notify the Department via MiWaters (https://miwaters.deq.state.mi.us) and provide the opportunity for inspection.

The permittee shall accomplish closure by removing all waste materials to the maximum extent practicable. This shall include agitation and the addition of clean water as necessary to remove the waste materials. The permittee shall utilize as guidance the closure techniques contained in NRCS Conservation Practice Standard No. 360, Waste Facility Closure. All removed materials shall be utilized or disposed of in accordance with the permittee's approved CNMP, unless otherwise authorized by the Department.

Unless the structure is being maintained for possible future use in accordance with the requirements above, completion of closure for structures shall occur as promptly as practicable after the permittee ceases to operate or, if the permittee has not ceased operations, 12 months from the date on which the use of the structure ceased, unless otherwise authorized by the Department.

4. Standards, Specifications and Practices

The published standards, specifications, and practices referenced in this permit are those which are in effect upon the effective date of this permit, unless otherwise provided by law. NRCS Conservation Practice Standards referred to in this permit are currently contained in Section IV, Conservation Practices and Michigan Construction Specifications, of the Michigan NRCS Field Office Technical Guide.

5. Facility Contact

The "Facility Contact" was specified in the application. The permittee may replace the facility contact at any time and shall notify the Department via MiWaters (https://miwaters.deq.state.mi.us) within 10 days after replacement (including the name, address, and telephone number of the new facility contact). The Department shall be notified in writing within 10 days after a change in any of the contact information (such as address or telephone number) from what was specified in the application.

a. The facility contact shall be any of the following (or a duly authorized representative of this person):
   - For a corporation or a company, a principal executive officer of at least the level of vice president, or a designated representative, if the representative is responsible for the overall operation of the facility from which the discharge described in the permit application or other NPDES form originates.
   - For a partnership, a general partner.
   - For a sole proprietorship, the proprietor.
   - For a municipal, state, or other public facility, either a principal executive officer, the mayor, village president, city or village manager or other duly authorized employee.

b. A person is a duly authorized representative only if both of the following requirements are met:
   - The authorization is made in writing to the Department by a person described in paragraph a. of this section.
   - The authorization specifies either an individual or a position having responsibility for the overall operation of the regulated facility or activity such as the position of plant manager, operator of a well or a well field, superintendent, position of equivalent responsibility, or an individual or position having overall responsibility for environmental matters for the facility (a duly authorized representative may thus be either a named individual or any individual occupying a named position).

Nothing in this section obviates the permittee from properly submitting reports and forms as required by law.

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6. Expiration and Reissuance

On or before October 1, 2024 a permittee seeking continued authorization to discharge under this permit beyond the permit's expiration date shall submit to the Department an application for reissuance via MiWaters (https://miwaters.deq.state.mi.us). Without a timely application for reissuance, the permittee's authorization to discharge will expire on April 1, 2025. With a timely application for reissuance, the permittee shall continue to be subject to the terms and conditions of the expired permit until the Department takes action on the application, unless this permit is terminated or revoked. Upon determination by the Department to grant or deny coverage under this permit, the proposed decision will be public noticed for a period of 15 CALENDAR days via MiWaters (https://miwaters.deq.state.mi.us)

If this permit is terminated or revoked, the Department will notify the permittee in writing and all authorizations to discharge under the permit shall expire on the date of termination or revocation. If this permit is modified, the Department will notify the permittee in writing of any required action. Upon the effective date of the modified permit, the permittee shall be subject to the terms and conditions of the modified permit, unless the Department notifies the permittee otherwise.

If the discharge authorized under this permit is terminated, the permittee shall submit to the Department an NPDES Permit Notice of Termination request via MiWaters (https://miwaters.deq.state.mi.us). However, the permittee may submit a request for termination via MiWaters (https://miwaters.deq.state.mi.us) if all the following are met:

a. the facility has ceased operation; AND/OR IS NO LONGER A CAFO;

b. ~~the facility is no longer a CAFO; and~~ the permittee has demonstrated to the satisfaction of the Department that there is no remaining potential for a discharge of CAFO waste that was generated while the operation was a CAFO.

7. Requirement to Obtain Individual Permit

The Department may require any person who is authorized to discharge by a COC and this permit to apply for and obtain an individual NPDES permit if any of the following circumstances apply:

a. the discharge is a significant contributor to pollution as determined by the Department on a case-by-case basis;

b. the discharger is not complying, or has not complied, with the conditions of the permit;

c. a change has occurred in the availability of demonstrated technology or practices for the control or abatement of waste applicable to the point source discharge;

d. effluent standards and limitations are promulgated for point source discharges subject to this permit; or

e. the Department determines that the criteria under which the permit was issued no longer apply.

Any person may request the Department to take action pursuant to the provisions of Rule 2191 (Rule 323.2191 of the Michigan Administrative Code).

8. Requirements for Land Application Not Under the Control of the CAFO Permittee

In cases where CAFO waste is sold, given away, or otherwise transferred to another person (recipient) such that the land application of that CAFO waste is no longer under the operational control of the CAFO owner or operator that generates the CAFO waste (generator), the "Manifest for CAFO Waste" form shall be completed and used to track the transfer and use of the CAFO waste. THE "MANIFEST FOR CAFO WASTE" FORM SHALL BE KEPT WITH THE CNMP FOR 5 YEARS FROM THE DATE OF CREATION. CAFO waste shall not be transferred to a recipient for land application of that waste during the months of January, February, or March.

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a. Prior to transfer of the CAFO waste, the CAFO owner or operator shall utilize the “Manifest for CAFO Waste” form provided by the Department to record all of the following:

1) a manifest document number;

2) the generator's name, mailing address, and telephone number;

3) the name, address, and contact information of the recipient of the CAFO waste;

4) the generator shall provide to the recipient, the nutrient content of the CAFO waste to be transferred, in sufficient detail to be used in determining the agronomic land application rates;

5) the total quantity, by units of weight or volume, and the number and size of the loads or containers used to transfer that quantity of CAFO waste;

6) a statement that informs the recipient of his/her responsibility to properly manage the land application of the CAFO waste as necessary to ensure there is no illegal discharge of pollutants to surface waters of the state;

7) the following certification by the generator: "I hereby declare that the CAFO waste is accurately described above and is suitable for land application";

8) other certification statements as may be required by the Department;

9) the latitude and longitude center of the site or sites used by the recipient for land application or other disposal or use of the CAFO waste; and

10) signatures of the generator and recipient with dates of signature.

b. Prior to manifesting CAFO waste, the generator shall receive from the recipient, the soil phosphorus levels using the Bray P1 test method, no older than three years, that the recipient will use to determine the agronomic rates of land application of the CAFO waste.

c. The generator shall do all of the following with respect to the manifest:

1) sign and date the manifest certification prior to transfer of the CAFO waste;

2) obtain a dated signature of the recipient on the manifest and the date of acceptance of the CAFO waste;

3) obtain a copy of the completed signed “Manifest for CAFO Waste” form;

4) obtain the completed “Daily Manure Application SUMMARY ~~Record~~” ~~per Part I.B.3.d.1)~~ from the recipient for each field on which the generator’s CAFO waste was applied;

5) provide a signed copy to the recipient; and

6) advise the recipient of his or her responsibilities to complete the “Manifest for CAFO Waste” form; if not completed at time of delivery, obtain a copy of the “Manifest for CAFO Waste” form from the recipient within 30 days of the transfer of the CAFO waste.

d. One “Manifest for CAFO Waste” form may be used for multiple loads or containers of the same CAFO waste transferred to the same recipient. The “Manifest for CAFO Waste” form shall list separately each address or location (latitude and longitude of field center) used by the recipient for land application or other disposal or use of the CAFO waste. Each separate address or location listing shall include the quantities of CAFO waste transferred to that location and dates of transfer.

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e. The generator shall not sell, give away, or otherwise transfer CAFO waste to a recipient if any of the following are true:

   1) the recipient fails or refuses to provide accurate and complete information on the manifest in a timely manner;

   2) the “Manifest for CAFO Waste” form indicates improper land application, use, or otherwise transferred;

   3) the generator learns that there has been improper land application, use, or otherwise transferred of the manifested CAFO waste; and/or

   4) appropriate jurisdiction has determined that the recipient has improperly land applied, used, or otherwise transferred of a manifested CAFO waste.

f. If the generator has been prohibited from selling, giving, or otherwise transferring CAFO waste to a particular recipient under Part I.C.8.e, above, and the generator wishes to resume selling, giving, or otherwise transferring CAFO waste to that particular recipient, then one of the following shall be accomplished:

   1) For improper paperwork only, such as incomplete or inaccurate information on the “Manifest for CAFO Waste” form, the recipient must provide the correct, complete information.

   2) For improper land application, use, or disposal of the CAFO waste by the recipient, the generator must submit a demonstration, to the Department via MiWaters (https://miwaters.deq.state.mi.us), that the improper land application, use, or disposal has been corrected, and the Department has responded to the demonstration with its approval of the demonstration.

g. The CAFO generator shall submit the required ”Land Application Summary” form for fields on which the recipient applied the generator’s CAFO waste via MiWaters (https://miwaters.deq.state.mi.us) within 30 days from each quarter ending March 31, June 30, September 30, and December 31 of each year and will include the following:

   1) recipient name and phone or e-mail contact information;

   2) date of transfer; and

   3) If CAFO waste is used for land application of manure:

      a) dates of land application;

      b) field location (latitude and longitude of center of field);

      c) soil test results (and year of test) of fields;

      d) amount (and units) of manure applied; and

      e) manure source; or

      F) AND NUMBER OF ACRES APPLIED.

   4) If CAFO waste is not used for land application of manure:

      a) other use (digestor, composting, broker, etc.);

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b) volume or tons of CAFO waste transferred.

h. The requirements of Part I.C.8. do not apply to quantities of CAFO waste less than one (1) pickup truck load, one (1) cubic yard, or one (1) ton per recipient per day.

9. Total Maximum Daily Load (TMDL) Waters

a. Nitrogen or Phosphorus TMDL
The Department expects that full compliance with the conditions of this permit will allow the permittee to meet the pollutant loading capacity(ies) set forth for nitrogen or phosphorus in an approved Total Maximum Daily Load (TMDL). The permittee's COC will indicate if the permittee's production area or land application areas are located within a watershed(s) covered by an approved nitrogen or phosphorus TMDL.

b. *E. coli*, Biota, Dissolved Oxygen TMDL.
The permittee's COC will indicate if the permittee's production area or land application areas are located within a watershed(s) covered by an approved *E. coli*, biota, or dissolved oxygen TMDL. The Department has developed and published the "Total Maximum Daily Load (TMDL) Guidance for Concentrated Animal Feeding Operations (CAFO)" regarding how to evaluate operations and determine additional pollutant control measures. The permittee shall complete the following actions within 24 months of receiving notification from the Department:

1) Conduct a comprehensive evaluation of its operations. A comprehensive evaluation shall identify sources of pollutants that have the potential to reach surface waters from production areas and/or land application areas.

2) Determine whether additional pollutant control measures need to be identified and implemented to meet the permittee's pollutant loading (or "concentration" in the case of *E. coli*) capacity(ies) set forth in the approved TMDL. Pollutant control measures, shall at a minimum, include those that prevent surface runoff and subsurface drainage of CAFO waste from land application areas.

3) Submit a written TMDL Evaluation Report via MiWaters (https://miwaters.deq.state.mi.us) to the Department based on one of the following:

a) If the permittee, based on the comprehensive evaluation, determines that the pollutant loading or concentration allocation(s) established in the approved TMDL are being met, then the written TMDL Evaluation Report justifying that determination shall be submitted to the Department for approval, or

b) If the permittee determines that the pollutant loading or concentration allocation(s) established in the approved TMDL is being exceeded, then the written TMDL Evaluation Report submitted to the Department shall identify additional pollutant control measures that need to be implemented by the permittee to achieve compliance with the pollutant loading or concentration allocation(s) established in the approved TMDL. The permittee's written TMDL Evaluation Report shall also include an implementation schedule for each identified additional pollutant control measure.

Upon approval of the Department, and if the written report identifies needed additional pollutant control measures, the permittee shall implement the additional pollutant control measures according to the implementation schedule. The approved written TMDL Evaluation Report detailing the additional pollutant control measures and the associated implementation schedule shall be kept in the CNMP for a period of 5 years from the date of creation, and shall be an enforceable part of this permit.

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10. Treatment System

The CAFO may include an anaerobic digester-based treatment system. The application for coverage under this permit shall include a description of the construction and operation of the anaerobic digester-based treatment system, including a schematic or flow diagram of the process, a listing of all outside materials (non-CAFO waste) to be added to the digester, the percentage input to the digester comprised of outside materials, and a contingency plan in the event of system failures including computer malfunctions. The contingency plan shall address the actions to be taken by the permittee if the digester-based treatment system must be bypassed for any reason, including handling and storage of partially digested contents, and notifications per Part II.C.9.c. and d. of this permit.

Outside materials up to 20 percent the total digester volume may be added to the digester to enhance operation. Quantities of outside materials more than 5 percent of the total digester volume will be listed in the COC issued under this permit. The Department may prohibit the use of certain outside materials. The permittee shall keep in the CNMP for a minimum of 5 years from the date of creation, the reports of the quantities and identity of outside materials added to the digester. Outside materials not listed in the application shall not be added to the digester without prior approval from the Department. The outputs from the treatment system shall be stored and managed in accordance with the permit. The digester shall be operated consistently with the information provided in the application for coverage under this permit.

11. Document Availability

Copies of all documents required by this permit, including the CNMP, Land Application Log, inspection records, soil tests received by the recipient of manifested CAFO waste, etc., shall be kept at the permitted facility for a minimum of 5 years from the date of creation and made available to the Department upon request.

PART II

Section A. Definitions

Animal Feeding Operation (AFO) means a lot or facility that meets both of the following conditions:
1. Animals, other than aquatic animals, have been, are, or will be stabled or confined and fed or maintained for a total of 45 calendar days or more in any 12-month period.
2. Crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over the portion of the lot or facility where animals are confined. Two or more AFOs under common ownership are considered to be a single AFO if they adjoin each other or if they use a common area or system for the disposal of wastes. Common area includes land application areas.

Concentrated Animal Feeding Operation (CAFO) means any AFO that requests coverage under the permit for which the Department determines that this permit is appropriate for the applicant's operation. A CAFO includes both production areas and land application areas.

CAFO Process Wastewater means water directly or indirectly used in the operation of a CAFO for any of the following:
1. Spillage or overflow from animal or poultry watering systems.
2. Washing, cleaning, or flushing pens, barns, manure pits, or other AFO facilities.
3. Direct contact swimming, washing, or spray cooling of animals.
4. Dust control.
5. Any water which comes into contact with, or is a constituent of, any raw materials, products, or byproducts, including manure, litter, feed, milk, eggs, or bedding.

CAFO Waste means CAFO process wastewater, manure, production area waste, effluents from the properly and successfully operated treatment system, or any combination thereof.

Certificate of Coverage (COC) is a document, issued by the Department, which authorizes a discharge under a general permit.

Certified CNMP Provider is a person that attains and maintains certification requirements through a program approved by the United States Department of Agriculture Natural Resources Conservation Service (NRCS).

CNMP means Comprehensive Nutrient Management Plan and is the plan developed by the permittee to implement the requirements of the NMP.

Department means the Michigan Department of Environment, Great Lakes, and Energy (Formerly Michigan Department of Environmental Quality).

Discharge as used in this permit means the addition of any waste, waste effluent, wastewater, pollutant, or any combination thereof to any surface water of the state.

Grassed Waterway means a natural or constructed channel for storm water drainage that originates and is located within a field used for growing crops, and that is used to carry surface water at a non-erosive velocity to a stable outlet and is established with suitable and adequate permanent vegetation.

Incorporation means a mechanical operation that physically mixes the surface-applied CAFO waste into the soil so that a significant amount of the surface-applied CAFO waste is not present on the land surface within one hour after mixing. Incorporation also means the soaking into the soil of "liquids being used for irrigation water" such that liquids and significant solid residues do not remain on the land surface. "Liquids being used for irrigation water" are contaminated runoff, milk house waste, or liquids from CAFO waste treated to separate liquids and solids. "Liquids being used for irrigation water" does not include untreated liquid manures.

Land Application means spraying or spreading of biosolids, CAFO waste, wastewater and/or derivatives onto the land surface, injecting below the land surface, or incorporating into the soil so that the biosolids, CAFO waste, wastewater and/or derivatives can either condition the soil or fertilize crops or vegetation grown in the soil.

Land Application Area means land under the control of an AFO owner or operator, whether it is owned, rented, leased, or subject to an access agreement to which CAFO waste is or may be applied. Land application area includes land not owned by the AFO owner or operator but where the AFO owner or operator has control of the land application of CAFO waste.

PART II

Section A. Definitions

Large CAFO is an AFO that stables or confines as many as or more than the numbers of animals specified in any of the following categories:

1. 700 mature dairy cattle (whether milked or dry cows)
2. 1,000 veal calves
3. 1,000 cattle other than mature dairy cows or veal calves. Cattle include heifers, steers, bulls, calves, and cow/calf pairs
4. 2,500 swine each weighing 55 pounds or more
5. 10,000 swine each weighing less than 55 pounds
6. 500 horses
7. 10,000 sheep or lambs
8. 55,000 turkeys
9. 30,000 laying hens or broilers, if the AFO uses a liquid manure handling system
10. 125,000 chickens (other than laying hens), if the AFO uses other than a liquid manure handling system
11. 82,000 laying hens, if the AFO uses other than a liquid manure handling system
12. 30,000 ducks, if the AFO uses other than a liquid manure handling system
13. 5,000 ducks, if the AFO uses a liquid manure handling system

Large CAFOs are required to obtain NPDES permits under Michigan Rule No. 323.2196.

Manure means animal excrement and is defined to include bedding, compost, and raw materials, or other materials commingled with animal excrement or set aside for disposal.

Maximum Annual Phosphorus Land Application Rate means the maximum quantity, per calendar year, of phosphorus (usually expressed in pounds per acre) that is allowed to be applied to crop fields where CAFO waste is spread, including the phosphorus contained in the CAFO waste.

~~**MGD** means million gallons per day.~~

New CAFO means a CAFO that is newly built and was not in production (i.e., animals were not on site) prior to January 30, 2004. New CAFO also means existing facilities where, due to expansion in production, the process or production equipment is totally replaced or new processes are added that are substantially independent of an existing source at the same site, after February 27, 2004. This does not include replacement due to acts of God or upgrades in technology that serve the existing production. This definition does not apply to “New” as used for swine, poultry, and veal facilities in Part I.B.1.a.3).

NMP means Nutrient Management Plan and is the section in the permit that sets forth requirements and conditions to ensure that water quality standards are met.

No-Till Practices means where the field will not receive tillage from time of land application until after harvest of the next crop.

NRCS means the Natural Resources Conservation Service of the United States Department of Agriculture.

NRCS 313 means the NRCS Michigan Statewide Technical Guide, Section IV, Conservation Practice No. 313, Waste Storage Facility, dated either June 2003, November 2005,August 2014, or November 2017.

Overflow means a release of CAFO waste resulting from the filling of CAFO waste storage structures beyond the point at which no more CAFO waste or storm water can be contained by the structure.

Pastureland is land that is primarily used for the production of forage upon which animals graze. Pastureland is characterized by a predominance of vegetation consisting of desirable forage species. Sites such as loafing areas, confinement areas, or feedlots which have animal densities that preclude a predominance of desirable forage species are not considered pastureland. Heavy-use areas within pastures adjacent to, or associated with, the CAFO are part of the pasture and are not part of the production area. Examples of heavy-use areas include animal travel lanes and small areas immediately adjacent to feed and watering stations.

Perennial means a plant that has a life cycle of more than two years.

PART II

Section A. Definitions

Production Area is the portion of the CAFO that includes all areas used for animal product production activities. This includes but is not limited to the animal confinement area, the manure storage area, the raw materials storage area, treatment systems, and the waste containment areas. The animal confinement area includes open lots, housed lots, feedlots, confinement houses, stall barns, free stall barns, milk rooms, milking centers, cow yards, barnyards, medication pens, walkers, animal walkways (not within pasture areas), and stables. The manure storage area includes lagoons, runoff ponds, storage sheds, stockpiles, under-house or pit storages, liquid impoundments, static piles, and composting piles. The raw materials storage area includes feed silos, silage bunkers, and bedding materials (including new sand used for bedding). The waste containment area includes settling basins and areas within berms and diversions which separate uncontaminated storm water. Also included in the definition of "production area" is any egg washing or egg processing facility, and any area used in the storage, handling, treatment, or disposal of mortalities. Production areas do not include pasture lands or land application areas.

Production Area Waste means manure and any waste from the production area and any precipitation (e.g., rain or snow) which comes into contact with, or is contaminated by, manure or any of the components listed in the definition for "production area." Production area waste also includes treatment system feedstock and runoff from treatment system areas. Production area waste does not include clean water that is diverted, nor does it include water from land application areas.

Realistic Crop Yield Goals means expected crop yields based on soil productivity potential, the crop management practices utilized, and crop yield records for multiple years for the field. Yield goals shall be adjusted to counteract unusually low or high yields. When a field's history is not available, another referenced source shall be used to estimate yield goal. A realistic crop yield goal is one which is achievable in three out of five crop years. If the goal is not achieved in at least three out of five years, then the goal shall be re-evaluated and revised.

Regional Administrator is the Region 5 Administrator, United States Environmental Protection Agency (USEPA), located at R-19J, 77 West Jackson Boulevard, Chicago, Illinois 60604.

Silage Leachate means a liquid, containing organic constituents, that results from the storage of harvested plant materials, which usually has a high-water content.

Solid Stackable Manure means manure and manure mixed with bedding that can be piled up or stacked and will maintain a piled condition. It will also have the characteristic that it can be shoveled with a pitchfork.

Swale means a shallow, channel-like, linear depression within a field used for growing crops that is at a low spot on a hillslope and is used to transport storm water. It may or may not be vegetated.

Waste Storage Structure means both pond-type storage structures and fabricated storage structures.

Tile means a conduit, such as corrugated plastic tubing, tile, or pipe, installed beneath the ground surface to collect and/or convey drainage water.

Vegetated Buffer means a narrow, permanent strip of dense perennial vegetation, established parallel to the contours of and perpendicular to the dominant slope of the field, for the purposes of slowing water runoff, enhancing water infiltration, and minimizing the risk of any potential nutrients or pollutants from leaving the field and reaching surface waters of the state.

Water Quality Standards means the Part 4 Water Quality Standards developed under Part 31 of Act No. 451 of the Public Acts of 1994, as amended, being Rules 323.1041 through 323.1117 of the Michigan Administrative Code.

25-year, 24-hour rainfall event or **100-year, 24-hour rainfall event** means the maximum 24-hour precipitation event with a probable recurrence interval of once in 25 years or 100 years, respectively as determined by the "NOAA ATLAS-14 Precipitation Frequency Data Server (PFDS)" https://hdsc.nws.noaa.gov/hdsc/pfds/).

PART II

Section B. Monitoring Procedures

1. Representative Samples

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. Test Procedures

Test procedures for the analysis of pollutants shall conform to regulations promulgated pursuant to Section 304(h) of the Federal Act (40 CFR Part 136 – Guidelines Establishing Test Procedures for the Analysis of Pollutants), unless specified otherwise in this permit. Test procedures used shall be sufficiently sensitive to determine compliance with applicable effluent limitations. Requests to use test procedures not promulgated under 40 CFR Part 136 for pollutant monitoring required by this permit shall be made in accordance with the Alternate Test Procedures regulations specified in 40 CFR 136.4. These requests shall be submitted to the Manager of the Permits Section, Water Resources Division, Michigan Department of Environment, Great Lakes, and Energy, P.O. Box 30458, Lansing, Michigan, 48909-7958. The permittee may use such procedures upon approval.

The permittee shall periodically calibrate and perform maintenance procedures on all analytical instrumentation at intervals to ensure accuracy of measurements. The calibration and maintenance shall be performed as part of the permittee's laboratory Quality Control/Quality Assurance program.

3. Instrumentation

The permittee shall periodically calibrate and perform maintenance procedures on all monitoring instrumentation at intervals to ensure accuracy of measurements.

4. Recording Results

For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information: 1) the exact place, date, and time of measurement or sampling; 2) the person(s) who performed the measurement or sample collection; 3) the dates the analyses were performed; 4) the person(s) who performed the analyses; 5) the analytical techniques or methods used; 6) the date of and person responsible for equipment calibration; and 7) the results of all required analyses. Records shall be kept in the CNMP for a minimum of five years from the date of creation.

5. Records Retention

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained for a minimum of five (5) years from the date of creation, or longer if requested by the Regional Administrator or the Department.

PART II

Section C. Reporting Requirements

1. Start-up Notification

If the permittee will not populate with animals during the first 60 days following the effective date of the certificate of coverage issued under this permit then the permittee shall notify the Department within 14 days following the effective date of the certificate of coverage issued under this permit. Subsequently, the Department shall be notified 60 days prior to population with animals.

2. Submittal Requirements for Self-Monitoring Data

Part 31, ~~Water Resources Protection,~~ of the NREPA, (specifically Section 324.3110(~~3~~7)), and R 323.2155(2) of Part 21, Wastewater Discharge Permits, promulgated ~~pursuant~~ UNDER ~~to~~ Part 31, ~~Water Resources Protection,~~ of the NREPA, allow~~s~~ the Department to specify the forms to be utilized for reporting the required self-monitoring data. Unless instructed on the effluent limitations page to conduct "Retained Self-Monitoring" the permittee shall submit self-monitoring data via the Department's ~~Electronic Environmental Discharge Monitoring Reporting (e2-DMR)~~ MIWATERS system.

The permittee shall utilize the information provided on the ~~e2-Reporting~~ MIWATERS website at https://~~secure1~~MIWATERS.DEQ.state.mi.us~~/e2rs/~~, to access and submit the electronic forms. Both monthly summary and daily data shall be submitted to the Department no later than the 20th day of the month following each month of the authorized discharge period(s). The permittee may be allowed to submit the electronic forms after this date if the Department has granted an extension to the submittal date.

3. Retained Self-Monitoring Requirements

If instructed on the effluent limits page (or otherwise authorized by the Department in accordance with the provisions of this permit) to conduct retained self-monitoring, the permittee shall maintain a year-to-date log of retained self-monitoring results and, upon request, provide such log for inspection to the staff of the Department. Retained self-monitoring results are public information and shall be promptly provided to the public upon request.

The permittee shall certify, in writing, to the Department, on or before January 10th (April 1st for animal feeding operation facilities) of each year, that: 1) all retained self-monitoring requirements have been complied with and a year-to-date log has been maintained; and 2) the application on which this permit is based still accurately describes the discharge. With this annual certification, the permittee shall submit a summary of the previous year's monitoring data. The summary shall include maximum values for samples to be reported as daily maximums and/or monthly maximums and minimum values for any daily minimum samples.

Retained self-monitoring may be denied to a permittee by notification in writing from the Department. In such cases, the permittee shall submit self-monitoring data in accordance with Part II.C.2., above. Such a denial may be rescinded by the Department upon written notification to the permittee. Reissuance or modification of this permit or reissuance or modification of an individual permittee's authorization to discharge shall not affect previous approval or denial for retained self-monitoring unless the Department provides notification in writing to the permittee.

4. Additional Monitoring by Permittee

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report. Such increased frequency shall also be indicated.

Monitoring required pursuant to Part 41, Sewerage Systems, of the NREPA, or Rule 35 of the Mobile Home Park Commission Act (Public Act 96 of 1987) for assurance of proper facility operation shall be submitted as required by the Department.

PART II

Section C. Reporting Requirements

5. Compliance Dates Notification

Within 14 days of every compliance date specified in this permit, the permittee shall submit a notification to the Department via MiWaters (https://miwaters.deq.state.mi.us) indicating whether or not the particular requirement was accomplished. If the requirement was not accomplished, the notification shall include an explanation of the failure to accomplish the requirement, actions taken or planned by the permittee to correct the situation, and an estimate of when the requirement will be accomplished. If a report is required to be submitted by a specified date and the permittee accomplishes this, a separate notification is not required.

6. Noncompliance Notification

Compliance with all applicable requirements set forth in the Federal Act, Parts 31 and 41 of the NREPA, and related regulations and rules is required. All instances of noncompliance shall be reported as follows:

a. 24-Hour Reporting
Any noncompliance which may endanger health or the environment (including maximum and/or minimum daily concentration discharge limitation exceedances) shall be reported, verbally, within 24 hours from the time the permittee becomes aware of the noncompliance. A submission via MiWaters (https://miwaters.deq.state.mi.us) shall also be provided within five (5) days.

b. Other Reporting
The permittee shall report, via MiWaters (https://miwaters.deq.state.mi.us), all other instances of noncompliance not described in a. above at the time monitoring reports are submitted; or, in the case of retained self-monitoring, within five (5) days from the time the permittee becomes aware of the noncompliance.

Reporting shall include: (1) a description of the discharge and cause of noncompliance; and (2) the period of noncompliance, including exact dates and times, or, if not yet corrected, the anticipated time the noncompliance is expected to continue, and the steps taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

7. Spill Notification

The permittee shall immediately report via MiWaters (https://miwaters.deq.state.mi.us) any release of any polluting material which occurs to the surface waters or groundwaters of the state, unless the permittee has determined that the release is not in excess of the threshold reporting quantities specified in the Part 5 Rules (R 324.2001 through R 324.2009 of the Michigan Administrative Code), by calling the Department at the number indicated on the second page of this permit (or, if this is a general permit, on the COC); or, if the notice is provided after regular working hours, call the Department's 24-hour Pollution Emergency Alerting System telephone number, 1-800-292-4706.

Within ten (10) days of the release, the permittee shall submit to the Department via MiWaters (https://miwaters.deq.state.mi.us), a full written explanation as to the cause of the release, the discovery of the release, response (clean-up and/or recovery) measures taken, and preventative measures taken or a schedule for completion of measures to be taken to prevent reoccurrence of similar releases.

8. Upset Noncompliance Notification

If a process "upset" (defined as an exceptional incident in which there is unintentional and temporary noncompliance with technology based permit effluent limitations because of factors beyond the reasonable control of the permittee) has occurred, the permittee who wishes to establish the affirmative defense of upset, shall notify the Department by telephone within 24 hours of becoming aware of such conditions; and within five (5) days, provide in writing, the following information:

a. that an upset occurred, and that the permittee can identify the specific cause(s) of the upset;

b. that the permitted wastewater treatment facility was, at the time, being properly operated and maintained (note that an upset does not include noncompliance to the extent caused by operational error,

Section C. Reporting Requirements

improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation); and

c. that the permittee has specified and acted on all responsible steps to minimize or correct any adverse impact in the environment resulting from noncompliance with this permit.

No determination made during administrative review of claims that noncompliance was caused by upset, and before an action for noncompliance, is final administrative action subject to judicial review.

In any enforcement proceedings, the permittee, seeking to establish the occurrence of an upset, has the burden of proof.

9. Bypass Prohibition and Notification

a. Bypass Prohibition
Bypass is prohibited, and the Department may take an enforcement action, unless:

1) bypass was unavoidable to prevent loss of life, personal injury, or severe property damage;

2) there were no feasible alternatives to the bypass, such as the use of auxiliary treatment facilities, retention of untreated wastes, or maintenance during normal periods of equipment downtime. This condition is not satisfied if adequate backup equipment should have been installed in the exercise of reasonable engineering judgment to prevent a bypass; and

3) the permittee submitted notices as required under 9.b. or 9.c. below.

b. Notice of Anticipated Bypass
If the permittee knows in advance of the need for a bypass, it shall submit prior notice to the Department, if possible, at least ten (10) days before the date of the bypass and provide information about the anticipated bypass as required by the Department. The Department may approve an anticipated bypass, after considering its adverse effects, if it will meet the three (3) conditions listed in 9.a. above.

c. Notice of Unanticipated Bypass
The permittee shall submit notice to the Department of an unanticipated bypass by calling the Department at the number indicated on the second page of this permit (if the notice is provided after regular working hours, use the following number: 1-800-292-4706) as soon as possible, but no later than 24 hours from the time the permittee becomes aware of the circumstances.

d. Written Report of Bypass
A written submission shall be provided within five (5) working days of commencing any bypass to the Department, and at additional times as directed by the Department. The written submission shall contain a description of the bypass and its cause; the period of bypass, including exact dates and times, and if the bypass has not been corrected, the anticipated time it is expected to continue; steps taken or planned to reduce, eliminate, and prevent reoccurrence of the bypass; and other information as required by the Department.

e. Bypass Not Exceeding Limitations
The permittee may allow any bypass to occur which does not cause effluent limitations to be exceeded, but only if it also is for essential maintenance to ensure efficient operation. These bypasses are not subject to the provisions of 9.a., 9.b., 9.c., and 9.d., above. This provision does not relieve the permittee of any notification responsibilities under Part II.C.11. of this permit.

PART II

Section C. Reporting Requirements

f. Definitions

1) Bypass means the intentional diversion of waste streams from any portion of a treatment facility.

2) Severe property damage means substantial physical damage to property, damage to the treatment facilities which causes them to become inoperable, or substantial and permanent loss of natural resources which can reasonably be expected to occur in the absence of a bypass. Severe property damage does not mean economic loss caused by delays in production.

10. Bioaccumulative Chemicals of Concern (BCC)

Consistent with the requirements of R 323.1098 and R 323.1215 of the Michigan Administrative Code, the permittee is prohibited from undertaking any action that would result in a lowering of water quality from an increased loading of a BCC unless an increased use request and antidegradation demonstration have been submitted and approved by the Department.

11. Notification of Changes in Discharge

The permittee shall notify the Department, via MiWaters (https://miwaters.deq.state.mi.us), as soon as possible but no later than 10 days of knowing, or having reason to believe, that any activity or change has occurred or will occur which would result in the discharge of: (1) detectable levels of chemicals on the current Michigan Critical Materials Register, priority pollutants or hazardous substances set forth in 40 CFR 122.21, Appendix D, or the Pollutants of Initial Focus in the Great Lakes Water Quality Initiative specified in 40 CFR 132.6, Table 6, which were not acknowledged in the application or listed in the application at less than detectable levels; (2) detectable levels of any other chemical not listed in the application or listed at less than detection, for which the application specifically requested information; or (3) any chemical at levels greater than five times the average level reported in the complete application (see the first page of this permit, for the date(s) the complete application was submitted). Any other monitoring results obtained as a requirement of this permit shall be reported in accordance with the compliance schedules.

12. Changes in Facility Operations

Any anticipated action or activity, including but not limited to facility expansion, production increases, or process modification, which will result in new or increased loadings of pollutants to the receiving waters must be reported to the Department by a) submission of an increased use request (application) and all information required under R 323.1098 (Antidegradation) of the Water Quality Standards or b) by notice if the following conditions are met: (1) the action or activity will not result in a change in the types of wastewater discharged or result in a greater quantity of wastewater than currently authorized by this permit; (2) the action or activity will not result in violations of the effluent limitations specified in this permit; (3) the action or activity is not prohibited by the requirements of Part II.C.10.; and (4) the action or activity will not require notification pursuant to Part II.C.11. Following such notice, the permit or, if applicable, the facility's COC may be modified according to applicable laws and rules to specify and limit any pollutant not previously limited.

13. Transfer of Ownership or Control

In the event of any change in control or ownership of facilities from which the authorized discharge emanates, the permittee shall submit to the Department via MiWaters (https://miwaters.deq.state.mi.us) within 30 days of the actual transfer of ownership or control a written agreement between the current permittee and the new permittee containing: (1) the legal name and address of the new owner; (2) a specific date for the effective transfer of permit responsibility, coverage and liability; and (3) a certification of the continuity of or any changes in operations, wastewater discharge, or wastewater treatment.

If the new permittee is proposing changes in operations, wastewater discharge, or wastewater treatment, the Department may propose modification of this permit in accordance with applicable laws and rules.

PART II

Section C. Reporting Requirements

14. Operations and Maintenance Manual

For wastewater treatment facilities that serve the public (and are thus subject to Part 41 of the NREPA), Section 4104 of Part 41 and associated Rule 2957 of the Michigan Administrative Code allow the Department to require an Operations and Maintenance (O&M) Manual from the facility. An up-to-date copy of the O&M Manual shall be kept at the facility and shall be provided to the Department upon request. The Department may review the O&M Manual in whole or in part at its discretion and require modifications to it if portions are determined to be inadequate.

At a minimum, the O&M Manual shall include the following information: permit standards; descriptions and operation information for all equipment; staffing information; laboratory requirements; record keeping requirements; a maintenance plan for equipment; an emergency operating plan; safety program information; and copies of all pertinent forms, as-built plans, and manufacturer's manuals.

Certification of the existence and accuracy of the O&M Manual shall be submitted to the Department at least sixty days prior to start-up of a new wastewater treatment facility. Recertification shall be submitted sixty days prior to start-up of any substantial improvements or modifications made to an existing wastewater treatment facility.

15. Signatory Requirements

All applications, reports, or information submitted to the Department in accordance with the conditions of this permit and that require a signature shall be signed and certified as described in the Federal Act and the NREPA.

The Federal Act provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance, shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than 6 months per violation, or by both.

The NREPA (Section 3115(2)) provides that a person who at the time of the violation knew or should have known that he or she discharged a substance contrary to this part, or contrary to a permit, COC, or order issued or rule promulgated under this part, or who intentionally makes a false statement, representation, or certification in an application for or form pertaining to a permit or COC or in a notice or report required by the terms and conditions of an issued permit or COC, or who intentionally renders inaccurate a monitoring device or record required to be maintained by the Department, is guilty of a felony and shall be fined not less than $2,500.00 or more than $25,000.00 for each violation. The court may impose an additional fine of not more than $25,000.00 for each day during which the unlawful discharge occurred. If the conviction is for a violation committed after a first conviction of the person under this subsection, the court shall impose a fine of not less than $25,000.00 per day and not more than $50,000.00 per day of violation. Upon conviction, in addition to a fine, the court in its discretion may sentence the defendant to imprisonment for not more than 2 years or impose probation upon a person for a violation of this part. With the exception of the issuance of criminal complaints, issuance of warrants, and the holding of an arraignment, the circuit court for the county in which the violation occurred has exclusive jurisdiction. However, the person shall not be subject to the penalties of this subsection if the discharge of the effluent is in conformance with and obedient to a rule, order, permit, or COC of the Department. In addition to a fine, the attorney general may file a civil suit in a court of competent jurisdiction to recover the full value of the injuries done to the natural resources of the state and the costs of surveillance and enforcement by the state resulting from the violation.

16. Electronic Reporting

Upon notice by the Department that electronic reporting tools are available for specific reports or notifications, the permittee shall submit electronically via MiWaters (https://miwaters.deq.state.mi.us) all such reports or notifications as required by this permit, on forms provided by the Department.

PART II

Section D. Management Responsibilities

1. Duty to Comply

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit, more frequently than, or at a level in excess of, that authorized, shall constitute a violation of the permit.

It is the duty of the permittee to comply with all the terms and conditions of this permit. Any noncompliance with the Effluent Limitations, Special Conditions, or terms of this permit constitutes a violation of the NREPA and/or the Federal Act and constitutes grounds for enforcement action; for permit or Certificate of Coverage (COC) termination, revocation and reissuance, or modification; or denial of an application for permit or COC renewal.

It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

2. Facilities Operation

The permittee shall, at all times, properly operate and maintain all treatment or control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit. Proper operation and maintenance include adequate laboratory controls and appropriate quality assurance procedures.

3. Power Failures

In order to maintain compliance with the effluent limitations of this permit and prevent unauthorized discharges, the permittee shall either:

a. provide an alternative power source sufficient to operate facilities utilized by the permittee to maintain compliance with the effluent limitations and conditions of this permit; or

b. upon the reduction, loss, or failure of one or more of the primary sources of power to facilities utilized by the permittee to maintain compliance with the effluent limitations and conditions of this permit, the permittee shall halt, reduce or otherwise control production and/or all discharge in order to maintain compliance with the effluent limitations and conditions of this permit.

4. Adverse Impact

The permittee shall take all reasonable steps to minimize or prevent any adverse impact to the surface waters or groundwaters of the state resulting from noncompliance with any effluent limitation specified in this permit including, but not limited to, such accelerated or additional monitoring as necessary to determine the nature and impact of the discharge in noncompliance.

5. Containment Facilities

The permittee shall provide facilities for containment of any accidental losses of polluting materials in accordance with the requirements of the Part 5 Rules (R 324.2001 through R 324.2009 of the Michigan Administrative Code). For a Publicly Owned Treatment Work (POTW), these facilities shall be approved under Part 41 of the NREPA.

PART II

Section D. Management Responsibilities

6. Waste Treatment Residues

Residuals (i.e. solids, sludges, biosolids, filter backwash, scrubber water, ash, grit, or other pollutants or wastes) removed from or resulting from treatment or control of wastewaters, including those that are generated during treatment or left over after treatment or control has ceased, shall be disposed of in an environmentally compatible manner and according to applicable laws and rules. These laws may include, but are not limited to, Part 31, Water Resources Protection; Part 55, Air Pollution Control; Part 111, Hazardous Waste Management; Part 115, Solid Waste Management; Part 121, Liquid Industrial By-Products; Part 301 Inland Lakes and Streams; and Part 303 Wetlands Protection, of the NREPA. Such disposal shall not result in any unlawful pollution of the air, surface waters, or groundwaters of the state.

7. Right of Entry

The permittee shall allow the Department, any agent appointed by the Department, and the Regional Administrator or their designee, upon the presentation of credentials and, for animal feeding operation facilities, following appropriate biosecurity protocols:

a. to enter upon the permittee's premises where an effluent source is located or any place in which records are required to be kept under the terms and conditions of this permit; and

b. at reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect process facilities, treatment works, monitoring methods and equipment regulated or required under this permit; and to sample any discharge of pollutants.

8. Availability of Reports

Except for data determined to be confidential under Section 308 of the Federal Act and Rule 2128 (R 323.2128 of the Michigan Administrative Code), reports prepared in accordance with the terms of this permit and required to be submitted to the Department, shall be available for public inspection via MiWaters (https://miwaters.deq.state.mi.us). As required by the Federal Act, effluent data shall not be considered confidential. Knowingly making any false statement on any such report may result in the imposition of criminal penalties as provided for in Section 309 of the Federal Act and Sections 3112, 3115, 4106 and 4110 of the NREPA.

9. Duty to Provide Information

The permittee shall furnish to the Department via MiWaters (https://miwaters.deq.state.mi.us), within a reasonable time, any information which the Department may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or the facility's COC, or to determine compliance with this permit. The permittee shall also furnish to the Department, upon request, copies of records required to be kept by this permit.

Where the permittee becomes aware that it failed to submit any relevant facts in a permit application or submitted incorrect information in a permit application or in any report to the Department, it shall promptly submit such facts or information.

PART II

Section E. Activities Not Authorized by this Permit

1. Discharge to the Groundwaters

This permit does not authorize any discharge to the groundwaters. Such discharge may be authorized by a groundwater discharge permit issued pursuant to the NREPA.

2. POTW Construction

This permit does not authorize or approve the construction or modification of any physical structures or facilities at a POTW. Approval for the construction or modification of any physical structures or facilities at a POTW shall be by permit issued under Part 41 of the NREPA.

3. Civil and Criminal Liability

Except as provided in permit conditions on "Bypass" (Part II.C.9. pursuant to 40 CFR 122.41(m)), nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance, whether or not such noncompliance is due to factors beyond the permittee's control, such as accidents, equipment breakdowns, or labor disputes.

4. Oil and Hazardous Substance Liability

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee may be subject under Section 311 of the Federal Act except as are exempted by federal regulations.

5. State Laws

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable state law or regulation under authority preserved by Section 510 of the Federal Act.

6. Property Rights

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize violation of any federal, state or local laws or regulations, nor does it obviate the necessity of obtaining such permits, including any other Department of Environment, Great Lakes, and Energy permits, or approvals from other units of government as may be required by law.

PART III

Technical Standard for the Surface Application of Concentrated Animal Feeding Operations Waste on Frozen or Snow-Covered Ground Without Incorporation or Injection

When Concentrated Animal Feeding Operation (CAFO) waste is surface-applied to frozen or snow-covered ground, without incorporation or injection, and that application is followed by rainfall or temperatures rising above freezing, the CAFO waste can run off into lakes, streams, or drains. Documented evidence shows that this runoff can cause resource damage to the surface waters of the state. Therefore, in accordance with Title 40 of the Code of Federal Regulations, Section 123.36, Establishment of Technical Standards for Concentrated Animal Feeding Operations, and State Rule 323.2196(5), CAFO Permits, the Michigan Department of EnvironmentAL QUALITY ~~Great Lakes, and Energy~~ (DEQ ~~EGLE~~), Water Bureau, establishes the following Technical Standard. This Technical Standard shall be used for field-by-field assessments, as required by National Pollutant Discharge Elimination System permits issued to CAFOs, to ensure that the land application of CAFO waste to frozen or snow-covered ground, without incorporation or injection, will not result in CAFO waste entering the waters of the state.

Based on the frozen and/or snow-covered conditions, the minimal settling and breaking down of the waste during these conditions, and the inability to predict or control snowmelt and rainfall, there are no practices that can ensure the runoff from fields with surface-applied waste on frozen or snow-covered ground will not be polluted. This standard assumes that surface runoff from snowmelt and/or rainfall will occur, and that the runoff will be polluted if CAFO waste is surface-applied on frozen or snow-covered ground. Therefore, the way to prevent these discharges is to apply CAFO waste only to fields, or portions of fields, where the runoff will not reach surface waters.

A field-by-field assessment must be completed, and all of the following requirements must be met and documented:

1. The Natural Resources Conservation Service's Manure Application Risk Index (MARI)* has been completed to identify fields, or portions of fields, that scored 37 or lower on the MARI.

2. An on-site field inspection of the entire field, or portion of field, that scored 37 or lower under the MARI has been completed. The inspection will take into consideration the slope and location of surface waters, tile line risers, and other conduits to surface water.

3. Based on the on-site field inspection, the Comprehensive Nutrient Management Plan (CNMP) will include documentation on topographic maps, the fields or portions of fields where the runoff will not flow to surface waters, and designate those areas as the only areas authorized for surface application without incorporation to frozen or snow-covered ground.

4. The findings of the inspection and documentation in the CNMP will be approved by a certified CNMP provider.

This assessment must be incorporated into the CNMP, and submitted as part of the CNMP Executive Summary each year.

* Grigar, J., and Lemunyon, J. A Procedure for Determining the Land Available for Winter Spreading of Manure in Michigan. NRCS publication. (Available on the EGLE NPDES website)

__ORIGINAL SIGNED________________ April 19, 2005

Richard A. Powers, Chief
Water Bureau

Date

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EXHIBIT 30

Clark Hill

Zachary C. Larsen
T (517) 318-3053
F (517) 318-3066
Email:zlarsen@clarkhill.com

Clark Hill
215 South Washington Square
Suite 200
Lansing, MI 48933
T (517) 318-3100
F (517) 318-3099

June 8, 2022

Via E-mail, ONLY, to MOAHR-GA@Michigan.gov
Michigan Office of Administrative Hearings and Rules
Ottawa Building – 2nd Floor
611 W. Ottawa Street
Lansing, MI 48909

Re: *In the matter of the Petition of the Michigan Farm Bureau, et al.*
Docket No. 20-009773

Dear MOAHR:

Enclosed please find Petitioners' Post-Hearing Brief and Proof of Service for filing in the above-referenced matter.

Thank you for your assistance in this regard. Please let us know should you require anything further at this time.

Sincerely,

CLARK HILL

/s/ Zachary C. Larsen
Zachary C. Larsen

ZCL:pkm
Enclosure

cc: Parties of Record w/Encl.

STATE OF MICHIGAN
MICHIGAN OFFICE OF ADMINISTRATIVE HEARINGS AND RULES

In the matter of:	Docket No.: 20-009773
Petition of Michigan Farm Bureau; the Michigan Milk Producers Association; Michigan Pork Producers Association; Michigan Allied Poultry Industries; Foremost Farms USA; Dairy Farmers of America; Select Milk Producers, Inc.; and 165 Identified Livestock Farms.	Permit No.: MIG010000 Part: 31, Water Resources Protection Agency: Department of Environment, Great Lakes, and Energy Case Type: Water Resources Division

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<u>PETITIONERS' POST-HEARING BRIEF</u>

CLARK HILL PLC

Michael J. Pattwell (P72419)
Zachary C. Larsen (P72189)
215 S. Washington Square, Ste. 200
Lansing, MI 48933
(517) 318-3100
MPattwell@clarkhill.com
ZLarsen@clarkhill.com

Dated: June 8, 2022

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INTRODUCTION

This contested case concerns the industrywide farm standards that EGLE has established to govern the operations of the just under 300 large livestock farms that qualify as "Concentrated Animal Feeding Operations" ("CAFOs") for the next five years. EGLE's adoption of these new mandatory, industrywide standards that purport to implement Part 31 of the Natural Resources and Environmental Protection Act ("NREPA"), MCL 324.3101 *et seq*., constitute "rules" under the Administrative Procedures Act ("APA") that should have been promulgated prior to incorporation into the 2020 CAFO General Permit. See MCL 24.207. For that reason alone, this Tribunal should strike the new standards from EGLE's final permit, leaving in place the comparable 2015 standards that are based on Michigan Administrative Code, Rule 323.2196 ("Rule 2196").

Beyond this procedural problem, EGLE's new farm standards conflict with that rule, simply are not factually or scientifically justified, go beyond the agency's statutory authority, and arbitrarily restrict environmentally beneficial farm practices. On the first, EGLE must comply with its own rules, yet it has deviated from and contradicted Rule 2916 here. Additionally, Part 31 of NREPA allows EGLE the ability to set those standards that are necessary "to assure compliance with" existing state and federal regulations. MCL 324.3106. But EGLE's standards are not necessitated by any existing state or federal regulations. Worse still, several will result in unintended consequences that are bad for water quality. At best, EGLE proposes to significantly restrict standard industry practices without any proven accompanying water-quality benefit.

For all of those reasons, this Tribunal should issue a Proposal for Decision recommending that EGLE's new farm standards be stricken from the 2020 CAFO General Permit and that the permit issue without them.

STATEMENT OF FACTS

The Land Application of Manure Builds Soil Health and Reduces Nutrient Runoff

Crop farmers have been utilizing manure as a fertilizer "since the dawn of agriculture." (Vol. XII, 3233:9–10.) And with good reason. The land-application of manure to a farm field is not only beneficial for growing crops, but it also provides important benefits to the soil itself. (3233:6–9.) That ultimately improves water quality through soil stabilization, the development of soil macropores, and other material changes to the soil that lessen runoff. (Vol. IX, 2181:19–2182:7; Ex. P-15.)

Manure is a valuable and complete source of nutrients. (Vol. IV, 889:23; Vol. IX, 2179:17–18; 2811.) That includes "essential nutrients" like nitrogen, phosphorus, potassium, and sulfur. (Vol. IV, 894:5-6; Vol. X, 2811:9–11.) But it also includes "a lot of micronutrients that crops need," (Vol. XI, 2921:24; Vol. IX, 894:7-8), such as calcium, magnesium, sulfur, iron, manganese, zinc, copper, and boron. (Vol. VIII, 1969:17–23; Vol. IX, 2180:5–10.) Importantly, manure also contains microbes that "liberate" nutrients, enhance the uptake of nutrients by crops, and increase crop yields as a result. (Vol. X, 2811:11–16.) Because of this liberation process, "[r]esearch has shown that soils fertilized by manure over long periods show much higher nutrient levels and resultant higher yields than unfertilized soils." (Vol. X, 2811:9–16.) Indeed, the land-application of manure "improves crops' nitrogen use efficiency because of its benefits to soil microbial activity . . . ." (Vol. X, 2517:8–10.) The release of these nutrients provides "a positive impact on crop yield as it provides needed nutrients for crop growth." (Vol. IX, 2180:5–14.) Significantly, "[s]ince manure is an organic product, the breakdown and release of the nutrients in the manure occurs through the season, mimicking the plant's needs . . . ." (Vol. XII, 3233:20–23.) Without this recycling of the nutrients harvested in their crops through the land-application of manure, farmers would have to replace the nutrients extracted from the soil by crops with chemical fertilizers. (Vol. XII, 3233:11–13.)

And, although highly soluble commercial fertilizer *could* be used to provide the same nutrients, "[c]ommercial fertilizer does not contain organic matter." (Vol. IX, 2181:4–5; Vol. IV, 945:11-19.) "Manure does." (Vol. IX, 2181:5.) Manure thus "builds soil carbon and organic matter." (Vol. X, 2517:7–8; Vol. IV, 945:11–19.) That is important to soil health and also to water-quality concerns because "[o]rganic matter is key to increasing the water-holding capacity of soil and increasing infiltration of water . . . and to enhancing the retention of nutrients in the soil," and it also "promotes beneficial organisms." (Vol. IX, 2181:7–11; 2181:18) ("When manure is applied, it is a soil amendment to feed the biological life and build healthier soils."). Manure increases the water-holding capacity of soil through this addition of soil structure. (Vol. IV, 894:9–12; Vol. IX, 2182:8–Vol. X, 2184:16.) Good soil structure permits storm water to "enter into the pores and infiltrate" rather than "runoff" and erode the soil. (Vol. IX, 2183:21–25.)

Or, explained a little bit differently:

> Manure application benefits the soil biology by providing a diverse feedstock for the microbes in the soil. Manure application also helps build soil organic matter levels because a large portion of manure is usually undigested feed and fiber that passes through the animal's guts. This leftover feed becomes food for microorganisms in the soil who use it for growth. Biological activity in the soil helps build soil structure by forming soil aggregates (crumbs) of soil that are more resistant to physical breakdown. These aggregates trap the organic matter inside and are an important method for building soil carbon (i.e., organic matter). High quality soils have structures that resist erosion. These structures are built by the action of soil microorganisms, plants, and the seasonal cycles. [Vol. XII, 3234:17–3235:5.]

In other words, the microbes and the "undigested feed and fiber" in manure provide soil structure and quality, and in turn, high-quality and stable soil resists erosion. (*Id.*)

Science confirms the benefit of the land-application of manure in decreasing erosion and reducing the runoff of sediments. For example, one study concluded that fertilizing land with poultry litter not only increased particulate organic matter and several other measures of soil quality but also improved the soil's resistance to erosion and its water-holding capacity. (Vol. IX, 2181:19–2182:7; Ex. P-15.) Specifically, "[e]ach 1% increase in soil organic matter helps soil hold 20,000 gallons more water per acre." (Vol. IX, 2184:5–6; Ex. P-16.) And the relationship between water-holding capacity and runoff is obvious and well-established: "[t]he more water that can be held in the soil structure, the less water is moving off the field and carrying sediment and nutrients with it." (Vol. IX, 2184:11–13.) Thus, the "long-term manure application can mitigate the loss of soil organic matter that results from ongoing cultivation." (Vol. X, 2811:24–2812:1.)

These benefits of land-applied manure have a direct implication for phosphorus-related water-quality concerns. Phosphorus leaves fields either through plant uptake, leaching, or surface runoff. (Vol. X, 2812:8–13.) "Runoff and erosion are the principal means of phosphorus loss. Excluding plant uptake, phosphorus loss by leaching is minimal compared to the amount of loss from runoff and erosion." (Vol. X, 2810:21–25.) So actions that increase plant uptake reduce the likelihood of leaching or surface runoff of phosphorus, (Vol. X, 2812:14–17), because crops remove otherwise available nutrients from the soil. (Vol. IX, 2184:13–16.) And manure's ability to increase the water-holding capacity of soil reduces nutrient losses due to runoff. (Vol. IV, 894:17–20; Vol. IX, 2181:19–2182:7; Ex. P-15.) This conclusion is bolstered by findings indicating that the application of manure not only "can boost grain yields by more than 10 percent" but also can "reduce nitrogen losses to the atmosphere and to groundwater by up to 25 percent, and can reduce soil erosion losses by up to 2/3 over [commercial] fertilizer use alone by building soil aggregate structure." (Vol. X, 2517:10–15; Ex P-85.)

The ability to land-apply manure to fields is extremely valuable to crop farmers. "Farmers love manure because their crops respond to manure and their soil is enhanced. Manure has an advantage over commercial fertilizer in that it has a broad spectrum of nutrients in one source and promotes healthy soil biological activity." (Vol. IX, 2179:25–2180:4.) Indeed, manure has a measurable value in the replacement cost of nutrients provided by manure: it costs between $10,000 to $12,000 to purchase the commercial nutrients provided by manure, (Vol. X, 2516:1–2), and the value of micronutrients provided by manure is about "$5,900 for a 205-acre, average-sized Michigan farm." (Vol. X, 2516:18–9; 2515:10–16; Vol. VIII, 2076:15–22 (noting that the costs of micronutrients provided by manure run from $15,000 to $20,000).)

Manure is thus valuable for all crop farming. But it is *even more* significant for organic farming where manure serves as "the primary economically efficient means of obtaining organic-compliant soil fertilizer." (Vol. IX, 2151:1–3.) Organic farms, like all crop farms, must fertilize the soil in order to maximize yield. (Vol. IX, 2150:23–2151:10.) Yet the National Organic Program prohibits the use of most synthetic fertilizers. (Vol. IX, 2147:7–15; 2149:11–14; 2152:7–11; 2156:8–15; Ex. P-12); see also 7 CFR 205.203(e)(1) & 7 CFR 205.601(j). Those same requirements apply to livestock farmers, who cannot use feed grown with synthetic fertilizers. (Vol. IX, 2149:6–18.) Thus, a symbiotic relationship has been forged between organic farmers (who need a natural source of nutrients) and livestock animal farms (who produce natural, nutrient-rich manure). (Vol. IX, 2150:18–22; 2150:24:2151–3.)

As an example, "[m]ost poultry litter is sold as organic fertilizer, and it is sold at a bit of a premium . . . ." (Vol. IX, 2152:24–2153:2.) So important is this connection between manure and organic farming that Mr. Caleb Stewart, an organic crop farmer, testified in this matter that, at his livestock farm, "[m]anure is not simply a byproduct. Manure *is* the product." (Vol. IX, 2150:18–19) (emphasis in original). Indeed, Stewart testified that he is "a large CAFO principally in order to create manure" because being a CAFO is "the most economical means of manure production."

(Vol. IX, 2149:21–23.) As Stewart further explained, "[w]ithout manure, organic farming *does not work*." (Vol. IX, 2150:24) (emphasis added).

Because of the great value of manure as a fertilizer (and, in the case of organic farming, the primary source of fertilization), (Vol. IX, 2150:23–2151:10), farmers do not want to waste or indiscriminately dispose of manure. (Vol. VIII, 2097:1–4; Vol. IX, 2151:13–20.) Stewart explained he tries "to stretch my available manure so that I can spread it on as many acres as possible while providing crops with the nutrition that they need." All "[f]armers pay close attention to the manure application rates on their crop fields" and "want to make the best use of the nutrients they have." (Vol. XII, 3235:23–3235:25.) Farmland is not renewable and is in limited supply. (Vol. XI, 2896:18–20.) Farmers do not want to "wreck their land base" by an excess application of manure. (Vol. XII, 3235:25–3236:1.) "And they want to match the nutrient needs of the crops to the amounts of nutrients that apply in the manure." (Vol. XII, 3236:21–3236:3.)

Importantly, plants will only yield as much as least available nutrient allows—that is a limitation known as "Liebig's law of the Minimum." (Vol. IX, 2199:2–4.) The necessary nutrients for plant growth are like the planks in a barrel that is holding water. (2199:4–10.) Just as the amount of water a barrel can hold is limited by the shortest plank, the amount of a plant's crop growth is restricted by the least available nutrient. (2199:10–12.) Thus, a farmer must balance the nutrient needs of the different nutrients needed for its crops when land-applying manure. (*Id.*; Vol. IX, 2180:11–14.)

Assimilation of Manure and Phosphorus into the Soil

When manure is surface-applied to the soil, it "begins to assimilate into the soil by the biological activity of the microbes and earthworms." (Vol. XI, 2921:4–6.) How quickly it does so "depends on the type of manure, moisture of the manure, available water holding capacity of the soil, timing and amount of rainfall." (2921:6–9.) Assimilation of manure into the soil takes "as little as a few days or as much as several weeks depending on a number of factors." (Vol. XI, 2922:13–15.) Because "[s]oil is literally alive," "[s]oil science is very complex and dynamic . . . ." (Vol. IX, 2180:17–18.) "There are chemical and biological impacts that convert nutrients from being inert in the soil to being biologically available (and vice versa). This is true not just for phosphorus but also for other nutrients. As there are changes in chemistry, it impacts the release of phosphorus but also for other nutrients." (Vol. XI, 2921:12–17.)

When manure is land-applied, "phosphorus attaches to open sites on the soil particles." (Vol. XI, 2923:2–3.) Phosphorus has a strong affinity to adsorb to soil particles. (Vol. IV, 891:22–25; Vol. VII, 1889:25–1890:3; Ex. R-112, p. 4 & 6.) That means that soil readily holds phosphorus up to a certain point. (Vol. IV, 891:1–25; Vol. X, 2773:7–16.) The degree to which soil will hold phosphorus is known as "phosphorus-adsorption capacity" or "PAC." (Vol. IV, 869:19–25; Vol. VII, 1844:4–8.) "The assimilation of phosphorus into the soil depends on the type of contact of the manure with the soil. The placement or mixing in the soil will reduce movement. Assimilation of phosphorus into the soil also depends on the saturation or water holding capacity of the soil at the time of application, including the timing and amount of any rainfall." (Vol. XI, 2923:12–18.) Phosphorus is also "relatively immobile in the soil and accumulates near the surface," (Vol. IX, 2201:1–7; Vol. XI, 2811:3–4)—and it is less mobile than most contaminants in migrating through soil. (Vol. VII, 1800:3–9.)

Though the phosphorus-adsorption-capacity depends on soil type, soil testing shows that "on average" "at the 8-inch depth soil sample, [soil] begins to lose the ability to hold onto phosphorus" at Soil Test Phosphorus levels of 150 parts per million phosphorus under the Bray P1 testing method. (Vol. XI, 2924:22–24.) That means phosphorus will "stay in solution for longer periods of time" at that level and higher losses of phosphorus can occur above that level. (Vol. XI, 2924:25–2925:1 & 2926:8–10.) Below that level, there is a non-linear relationship between nutrient application and phosphorus losses. (Vol. XI, 2925:5–7.) Moreover, nutrients that are placed in low-nutrient subsoils can attach "even at higher levels than what is sampled for the topsoil." (Vol. XI, 2926:13–21.)

Large Livestock Farms Regulated as "CAFOs" are Family Owned Farms

Even though manure is an extremely valuable resource for farmers, its use in agriculture is heavily regulated—but only for a certain subset of farms who qualify as "Concentrated Animal Feeding Operations" or "CAFOs." The areas of livestock farms that stable or confine animals on a lot or facility for more than 45 days per year are designated by regulatory vernacular as "Animal Feeding Operations" or "AFOs." Mich Admin Code, R 323.2102(b). "AFOs" that are "defined as a large CAFO or medium CAFO" by their numbers or are otherwise designated by EGLE as a small or medium CAFO per Mich Admin Code, R 323.2196(3) are regulated as "CAFOs." Mich Admin Code, R 323.2102(i). CAFOs are often family owned and often operated as multigenerational family farms. (Vol. X, 2503:15–2504:20.) Indeed, each of the farmers testifying in this matter run family owned farms. (Vol. VIII, 1947:20–1948:4; Vol. VIII, 2070:10–18; Vol. XI, 2885:9–13.)

That testimony from individual farmers in this matter is consistent with agricultural statistics. Michigan-specific statistics similarly reveal that 92% of all farms are owned by a single person, family, or partnership and of those farms owned by corporations, 95% of those corporations are family-owned. (Vol. X, 2503:20–23; Ex. P-68.) That level of family ownership holds true for large livestock farms as well. (2503:23–2504:3; Ex. P-68.) In other words, "virtually all of Michigan farms are family farms, regardless of their tax organization and regardless of the farm's size or number of animals." (2504:10–12.) Moreover, because the United States Department of Agriculture ("USDA") defines a "large-scale" farm as those with $1 million or more in gross receipts, most CAFOs are relatively speaking still "small businesses" and are defined as such using the 250 employee-size and $6 million revenue-size definitions of Michigan's APA. (Ex. P-73; see also Vol. XI, 2504:21–2505:19 (noting that "virtually all Michigan farms are small businesses, including CAFOs" based on USDA statistics on farm employment); MCL 24.207a (defining small business as a business with "fewer than 250 full-time employees" or "gross annual sales of less than $6,000,000.00.").

Most farms that have grown into CAFOs do so in order to produce healthier animals, to act as better environmental stewards, and to absorb the regulatory costs imposed by the State as a matter of economies of scale. (Vol. VIII, 1949:22–1950:2; 2070:25–2071:18.) Regulatory compliance is costly. Unique to manure regulations, MSU has estimated that dairy CAFOs spend between $116 and $129 per cow per year on hauling liquid manure for application—an annual cost per farm of between $81,000 and $450,000 per year. (Vol. X, 2513:1–2514:2; Ex. P-75.) Further, when the cost of manure storage is added, the total cost increases to $306 per cow for "total manure storage, handling, and application costs for dairy CAFOs ranging between $214,000 and $1,071,0000 annually." (2514:10–16; Ex. P-78.) Many swine farms must also use below-the-floor liquid manure storage structures that "can increase total storage structure costs to $1,400,000, and total manure, storage, handling, and land application costs to nearly $2,00,000 annually. (2514:17–2515:1; Ex. P-79.) Those are just a few examples. That "does not include costs for CNMP writing, recordkeeping, daily and weekly inspections of equipment and facilities, construction costs for permit-approved feed, mortality, stormwater, and chemical handling, or the many other costs CAFOs incur to remain compliant with their permits and which vary widely." (2515:2–7.)

Partly in response to regulation-driven cost concerns, many family farms choose to expand to the size of "Large CAFOs." (Vol. VIII, 1949:23–1950: 2; 2071:2–11); Mich Admin Code, R 323.2103(g). As Mr. Rick Sietsema testified, "to absorb . . . regulatory costs and operating costs, we needed to operate as a larger-scale livestock farm." (Vol. VIII, 2071: 9–11.) Sietsema's experience is consistent with the national trend: "today's farmers are producing nearly double the amount of pork they previously produced with 78% less land." (2071:19–25; Ex. P-2.) That change facilitates animal health, environmental, and economic benefits.

For example, Dykhuis Farms' operation as a CAFO in part is driven by the need to efficiently raise cohorts of pigs by separating them into sites in a manner in order to isolate and minimize the spread of disease. (Vol. VIII, 1950:3–1951:5.) Greater economies of scale also improves animal treatment by "significant improvements on the barns that smaller farms could not afford," including air filters for the sow units and showers and offices at the barns. (1951:6–15.) Those economies similarly allow farms to "invest resources for a more environmentally friendly and sustainable operations." (2071:4–6.)

These economies achieved by larger-scale farming also help feed Michigan (and America). (2071:12–14.) "[T]he cost of production falls as herd size increases," and it does so in measurable ways. (Vol. X, 2505:22–23.) For example, a dairy farm with more than 2,000 cows has an average of 16% lower cost per cow than a farm with between 1,000 to 1,999 cows and a 24% lower cost per cow than a farm with 500 to 999 cows. (2505:24–2506:2; Ex. P-71.) For pigs, a swine farm with more than 2,000 swine achieves a 35% reduction in its cost-per-animal. (2506:4–7; Ex. P-71.) Those cost savings are necessary to compete in a globally competitive market and to keep prices low to efficiently feed Americans. (2506:19–23.) Accordingly, at a time when food costs are soaring for most Americans and fertilizer prices are rising for farmers,[1] CAFOs play an important role in keeping America fed.

Importantly, many CAFOs are not simply livestock farmers; they are most often *both* crop farmers and livestock farmers. (2887:5–7) (noting "Bruce at one point commented that he 'wished we had more crop farmers' involved in the process" but "we tried to explain that 'we,' the CAFOs, 'are crop farmers.'"). That is true for each of the farmers who testified in this matter. (Vol. VIII, 1949:4–9; 2072:12–17; Vol. IX, 2144:14–2145:22; Vol. XI, 2887:5–7.)

Process of Developing the General Permit

EGLE requires livestock farms who are defined as "CAFOs" to obtain coverage under either EGLE's CAFO General Permit or under a similar individual permit unless specifically exempted. Mich Admin Code, R 323.2196(1)(b). Michigan administrative rules allow EGLE to issue "general permits" for categories of discharge "[u]pon a determination by the department that certain discharges are appropriately and adequately controlled by a general permit . . . ." Mich Admin Code, R 323.2191(1). Thus, a general permit applies to a category of "discharges." *Id.* Though the number of farms varies at any given time, approximately 255 of the 277 non-exempt CAFOs are subject to the general permit. (Vol. X, 2503:8–14.) In other words, the General Permit sets standards directly for roughly 92.4% of CAFOs. (*Id.*)

Farms do not have much choice about which permit they obtain. (Vol. X, 2503:5–7) ("Whether a farm operates under a General Permit or an Individual permit depends on EGLE's

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[1] See, e.g., *With food prices climbing, the U.N. is warning of crippling global shortages* (noting the U.N.'s recent warning "of 'the specter of a global food shortage in the coming months' without urgent international action"), https://www.npr.org/2022/05/23/1100592132/united-nations-food-shortages, accessed May 25, 2022; see also *Fertilizer shortage could cause food shortages in Michigan*, https://www.wilx.com/2022/05/03/fertilizer-shortage-could-cause-food-shortages-michigan/, accessed May 25, 2022.

determination."). EGLE first determines who may obtain coverage under the general permit by granting or denying an applicant's request for coverage under the general permit. Mich Admin Code, R 323.2191(3)–(6). EGLE thereafter maintains complete discretion by administrative rule to require a farm to obtain either an individual permit or coverage under the general permit. Mich Admin Code, R 323.2191(3) & (4). Where EGLE determines that an individual is ineligible for coverage under a general permit, it is generally because the agency believes an individual applicant's circumstances require greater behavioral restrictions or higher standards than those included in that general permit. See Mich Admin Code, R 323.2191(3)(a) & (3)(b) (allowing EGLE to require an individual permit in cases where "[t]he discharge is a significant contributor to pollution as determined by the department on a case-by-case basis" or where "[t]he discharger is not complying, or has not complied, with the conditions of the general permit.") CAFOs who exceed 5,000 animal units, for example, move outside of an exemption for regulating groundwater discharges, so those CAFOs trigger a groundwater discharge standard different from that legally required for CAFOs under the General Permit, Mich Admin Code, R 323.2210(f), and cannot obtain coverage under a general permit.

Nonetheless, EGLE also holds unbridled discretion to require even a regulated entity who generally qualifies for and even prefers to be covered by an individual permit to seek coverage under an applicable general permit. For example, Michigan Administrative Code, Rule 323.2191(5) explains that "[t]he department may deny an application for an individual national permit *if [EGLE] determines that the general permit is more appropriate*." (Emphasis added). In the inverse, Michigan Administrative Code, Rule 323.2192(d) provides that "[t]he department may terminate the individual national permit and include the discharge under the coverage of the general permit *if the department determines that the general permit is more appropriate*."

(Emphasis added). As a case in point, Mr. Dykhuis testified that Dykhuis Farms was "forced into the General Permit by EGLE's predecessor, the MDEQ." (Vol. VIII, 1949:20–21.)

General permits are imposed for five years. Mich Admin Code, R 323.2150. For CAFOs, Michigan issued an initial general permit in 2002 and has issued its general permit every five years for the last 15 years. (Vol. I, 81:14–16; 94:14–18; Vol. II, 427:5–15.) Those permits have historically incorporated many of the existing regulatory requirements for CAFOs and apply those standards to a farm under Part 31 of NREPA when a certificate of coverage issues. (Vol. I, 104:18–25 & 127:3–7.) And the general permit sets a standard for individual permits within that sector, such that "individual permits for any sector will be consistent with" the related general permit. (110:14–20.)

The Livestock Committee's Policy-Based Decisions

EGLE's new farm standards originated from the long-held policy preferences of the agency's Livestock Committee. (Vol. II, 323:13–21.) Mr. Bruce Washburn explained that he "began working on the 2020 CAFO General Permit before the [2015] permit was final." (391:22–25.) As a starting point, he used an existing priorities list that had been in-process since at least 2015. (392:1–6.) He noted that this list was an ongoing, regularly updated "living document" reflecting the Livestock Committee's policy priorities as "an extension of the 2015 and potentially even 2010 permit." (Vol. II, 392:1–13; 467:2–8; 472:22–25; 474:10–475:21.) Some of the policy priorities for the 2020 CAFO General Permit existed even before the 2015 CAFO General Permit was issued but reflected policies that had not been adopted in 2015. As Washburn explained, a winter ban was a policy priority "going back to the 2010 permit" "from a [Livestock] committee standpoint." (Vol. III, 641:10–16.) And the Livestock Committee had sent a Memorandum in September 2014 recommending a winter ban to superiors in EGLE. (Vol. II, 464:17–466:8; Ex. R-65.) Thus, this issue remained the Committee's top policy priority. (*Id.*)

In gearing up for the 2020 CAFO General Permit, the Livestock Committee was directed by Phil Argiroff, the then Assistant Director of EGLE's Water Resources Division, to create a list of its top 10 priorities for revision of the permit. (Vol. II, 333:25–335:15, 473:18–474:6; Vol. V, 1105:11–14.) The Committee drafted 11 instead. (*Id.*) That Top-11 list was established by the Livestock Committee "early on in the permit development process," (Vol. V, 1046:14–22), sometime around late 2018 or early 2019. (Vol. II, 322:15–17.) The Committee created this policy priority list via a straw-poll process whereby EGLE's Livestock Committee members identified policy priorities by placing Starburst candies on each member's "topics of priority." (Vol. II, 479:19–480:8; Vol. V, 1046:21–24.) Based on that straw polling, the Committee's top priority was to establish a winter ban. (1047:4–10; Ex. P-29.) Lowering the Soil Test P threshold was also near top of list at #4. (Ex. P-29; Vol. V, 1047:4–10; Vol. II, 488:11–23.) The justification for this P-threshold change at that early stage was unclear. Notes from the meeting indicate EGLE was still looking for both a rationale and result, asking and answering: "Why? Vermont." (Ex. P-29.) Nonetheless, Bruce Washburn testified that he did "not know what makes up the animal agriculture in Vermont," (Vol. II, 488:22–23), and that EGLE did not consider the Soil-Test Phosphorus numbers used in other Great Lakes states. (Vol. II, 489:1–7.)

More broadly, the Livestock Committee's priority list was developed before *any* discussion of water-quality data, studies, or sampling. (Vol. II, 339:23–340:12.) Sylvia Heaton did not see any assessment of the relationship between *E. coli* TMDLs and agriculture from Molly Rippke before the development of priority list. (Vol. VI, 1111:6–15.) (Indeed, the exhibit later relied on by EGLE at the hearing didn't exist.) (Ex. R-39 (dated "Feb 12, 2021").) Neither did the Committee see Sarah Holden's evaluation of a connection between nutrient TMDLs at that time, (1112:16–25), or Aaron Parker's map. (Likewise, those didn't exist at the time.) (Ex. R-47 (date

"Feb 12, 2021") and Ex. R-27 (dated "1/11/2021").) Instead, EGLE simply developed its priority list based on the voted-on policy priorities of the Livestock Committee's members. (479:19–480:8; Vol. V, 1046:21–24.)

Stakeholder Meetings

Between March and June 2019, EGLE held three stakeholder meetings to discuss the changes to the 2020 CAFO General Permit. (Vol. II, 306:10–15.) Bob Dykhuis explained that: "Compared to previous experiences, the stakeholder meeting for the 2020 General Permit was not really an 'input' session. Rather, it was an opportunity for EGLE to explain what the agency intended to do and why they intended to do it much more than it involved listening to the practical concerns of farmers or providing an opportunity for feedback." (Vol. VIII, 1958:2–8.) Similarly, Scott Henry testified that EGLE simply "presented the permit the way the agency saw it." (Vol. XI, 2886:16–20.) And, when questioned about why these changes were necessary and what was wrong with the current permit, EGLE responded that the 2015 CAFO General Permit "works but we want to make it a little better." (2886:23–2887:1.)

EGLE did not appear interested in "stakeholder" input or the practical impact of their new standards on farmers' ability to operate. Rather, Mr. Bob Dykhuis testified that changes were made without considering the practical implications for the regulated community. As an example, on winter spreading, Dykhuis "explained that if we could not do spreading in March, it would move the land application of that manure intro April . . . [and] planting into May . . ." EGLE responded simply "that 'it is our job to protect the waters of the state, not to make it possible that you can plant your crops.'" (Vol. VIII, 1958:18–1959:1.) Ms. Laura Campbell of Michigan Farm Bureau similarly echoed that EGLE "presented information about water quality impairments . . . examples of permit violations by some farms, and the need for . . . tighter permit restrictions" but "did not address" farmers' concerns about the additional cost of reporting, paperwork, and other permit requirements or respond to the assertion that EGLE's concerns involved *non-compliance* with the existing permit rather than failures of those conditions to protect water quality. (Vol. X, 2519:1–15.)

These meetings also did not disclose all that EGLE had in mind for the permit. Instead, "EGLE shared very few details of their plans for changes to [the] 2020 CAFO General Permit, which made identifying potential concerns with permit conditions difficult." (2520:1–3.) As Scott Henry testified that: "Although I had been involved in the stakeholder meeting group, there were a lot of issues that popped up in the GP that we did not even hear about during the process," including, as an example, nitrogen noticing. (Vol. XI, 2887:24–2888:8.) Similarly, Laura Campbell testified that "[w]e were never shown any of the lists that EGLE's staff had developed of priorities for permit condition changes" even though "EGLE had identified the changes it intended to make before the stakeholder process began." (Vol. X, 2520:5–12; Ex. P-29.) So, "when the draft General Permit was released for public comment in late October 2019, much of its contents were a surprise to me despite having attended and participated in these stakeholder meetings." (Vol. X, 2520:13–17.)

Drafting the General Permit

After the stakeholder meetings, EGLE used the Livestock Committee's priority list as the initial framework for drafting the revised 2020 CAFO General Permit. (Vol. I, 138:6–20; Vol. II 335:13–15; Vol. V, 1038:19–21.) The principal scrivener for the language of the permit was Ms. Sylvia Heaton. (Vol. V, 1104:10–17.) But in drafting Ms. Heaton also worked alongside Megan McMahon (for "permit writing" or wordsmithing) and Bruce Washburn (for "technical compliance" aspects of the permit). (Vol. II, 308:22–309:6; 478:3–14.) Heaton explained that she would "creat[e] draft permit conditions and then would run them by WRD Management (Christine Alexander), the EPA (Julianne Soscha), and the staff person in my unit who was helping with the CAFO permit (Megan McMahon), and CAFO Specialist (Bruce Washburn) for final review and revisions." (Vol. V, 1038:1–5.) During this time, Christine Alexander "reviewed draft permit language, participated in meetings with EPA, and kept upper management updated on the proposed changes to the general permit," and also worked with "technical staff on proposed permit language." (Vol. I, 83:9–13.) McMahon was the lead for processing the permit. (Vol. II, 326:2–7.)

Several draft permits were created. First, following the stakeholder meeting, a draft was created to share with U.S. EPA for their review and comment. (Vol. V, 1038:19–20; Ex. R-98.) Then, after changes were made to reflect EPA's comments, a draft was created for public notice. (1038:21–24; Ex. R-71.) Revisions were made when the public notice-and-comment period was over, which were reflected in a redline. (Ex. R-99.) Lastly, with those changes implemented, "the permit document . . . was ultimately made final and issued." (Vol. V, 1039:1–4; Ex. R-45.)

In U.S. EPA's review of the drafting, EPA provided certain comments and recommendations. (Ex. R-110 & Ex. R-111.) Per EPA's authorization, Michigan's NPDES permits must include conditions that are at least as stringent as federal standards, and EPA has authority to issue permits over the State if not at least as stringent. 40 CFR 123.44 (65:7–15 & 67:13-17.) Christine Alexander explained that EPA provides feedback in three forms: as "general comments, recommendations, and objections." (Vol. I, 66:22–24 & 218:14–20.) EGLE "may issue an NPDES permit without making a recommended change . . . ." (Vol. I, 66:24–25 & 219:8–10.) But it "may not issue a permit over the EPA's objections." (Vol. I, 67:1–2 & 219:5–9.) EPA did not lodge any objections to the 2020 CAFO General Permit. (Vol. II, 219:11–13.)

Among the key staff for drafting the permit, most had not been involved in drafting prior CAFO general permits. Sylvia Heaton "was in a different section . . . at the time the 2015 CAFO permit was developed and issued." (Vol. V, 1034:22–24.) Megan McMahon was not involved in developing any of the prior CAFO general permits. (Vol. II, 319:17–22.) Nor was Christine Alexander. (Vol. I, 94:14–18.) In fact, Alexander was involved in only one CAFO individual permit prior to the development of the general permit. (Vol. I, 93:21–23.)

Changes in State or Federal Law Since the 2015 General Permit

Nothing has changed in either the state or federal regulations applicable to CAFOs since EGLE issued its 2015 CAFO General Permit. The federal regulations were not amended. (Vol. V, 1133:6–14); see, e.g., 40 CFR 122.23, 40 CFR 122.42(e), & 40 CFR 412.1–412.46. Specifically, none of the federal rules addressing setback requirements, vegetated buffers, or compliance alternative have changed. (Vol. III, 707:20–21.) On the state side, EGLE's existing Part 21 administrative rules governing CAFOs did not change. (Vol. V, 1134:3–6.) Nor did any of EGLE's relevant Part 4 Water Quality Standards change. (1134:7–11); see also Mich Admin Code, R 323.1041 *et seq*. Thus, there is no newly adopted legal requirement justifying EGLE's actions with respect to this permit.

New Conditions of the General Permit

Though nothing has changed in the law, much has changed in EGLE's CAFO General Permit from the 2015 CAFO General Permit. This Tribunal is now familiar with those changes in detail from the lengthy, 13-day hearing in this matter. As a high-level overview, those changes include: (1) imposing a presumptive ban on land applying manure during the winter months, (*Id*. at Section I.B.3.f.3); (2) outright banning the transferring (or "manifesting") manure during the winter months, (*Id*. at Section I.C.8); (3) mandating that farms *both* (a) avoid applying manure "within 100 feet of any surface water of the state, open tile line intake structures, sinkholes, [or] agricultural well heads, including but not limited to roadside ditches that are conduits to surface waters of the state" and (b) "install and maintain a 35-foot wide *permanent* vegetated buffer along any surface water of the state, open tile line intake structure, sinkholes, agricultural well heads, including but not limited to roadside or any ditches that are conduits to surface waters of the state," (*id*. at Section I.B.3.h.); (4) reducing the limits on the amount of phosphorus allowed in land to which manure is land applied, (General Permit, Sections I.B.3.C.1.a, I.B.3.C.2.a., & I.B.3.C.2.b), and further reducing those limits for farms who are located within a Total Maximum Daily Load (TMDL) watershed, (*id*.); (5) requiring additional applications of nitrogen to be publicly noticed for a minimum of 15 days prior to application; and (6) mandating additional but unspecified permit restrictions for many farms located within a TMDL, (*id*. at Section I.C.9.b.)—among other significant changes. The text of these conditions and EGLE's justification for each will be discussed in turn.

Presumptive Winter Ban

One of the most significant changes for the 2020 CAFO General Permit is that, for the months of January, February, and March, "[t]here is a prohibition on land application . . . unless specific requirements are met." (Ex. R-112, p. 31; Ex. 45, Section I.B.3.f.3.) In other words, there is a presumptive ban on spreading manure during those months. (*Id.*) The General Permit proscribes that: "CAFO waste *shall not be applied during the months of January, February, or March unless* the permittee submits a notification and meets the following conditions: (a) CAFO waste shall only be applied when waste can be incorporated immediately following application, or injected; (b) CAFO waste shall not be applied when two or more inches of frost and/or four or more inches of snow are present at the land application site at the time of application; (c) CAFO waste shall not be applied within 100 feet of any surface water of the state, open tile line intake structures, sinkholes, agricultural well heads, included but not limited to roadside ditches that are conduits to surface waters of the state (with the exception of surface waters of the state that are up-gradient of the land application); (d) Manure application on fields receiving CAFO waste must have a soil sample Bray P1 of no greater than 68 ppm P, or 60 ppm P if fields are located in watershed(s) covered by an approved phosphorus or nitrogen TMDL; (e) Twenty-four (24) hours prior to the land application of CAFO waste, the Department shall be notified, through a Department form via MiWaters . . . ." (Ex. R-45, 2020 General Permit, Section I.B.3.f.3.)

A farm cannot apply manure unless all of these conditions are met. (1197:16–20.) And, taken together, these conditions effectively prohibit manure application during those months at many fields and for many farms. As just one example, the 68-ppm limitation (or 60-ppm for fields in TMDLs) will effectively prohibit land application on many fields because "there are almost no fields with phosphorus that low for livestock farms." (Vol. VIII, 1964:12–13; 2086:18–23.) As Rick Sietsema testified, "a ban on land applying to fields above that threshold is a practical ban on land application during that time period." (2087:1–4.) Scott Henry similarly testified that "[a]lmost all of the fields that are included in our CNMP will be above 60 parts per million." (Vol. XI, 2891:5–6.) Even EGLE staff acknowledged that many farm fields are above this level—or otherwise could not dispute this fact. (Vol. III, 577:17–578:3; Vol. IV, 893:7–10, 893:24–894:2.) As a baseline for comparison, Dykhuis Farms purchased land that needed to be cleared and, in forested areas that had never had fertilizer or manure applied, the test results exceeded these levels. (Vol. VIII, 1964:17–25; Ex. P-1.) CNMP Provider Allison Brink estimated based on a review of her clients' CNMPs that most farms would experience somewhere between a 34–65% shift in fields available for land application based on that reduced threshold. (Vol. IX, 2205:24–2206:1.)

And that does not even account for the remaining restrictions that are independent prerequisites to land apply during those months, such as that manure must be incorporated "immediately," (I.b.3.f.3.a), which EGLE defines as "having a tractor follow along the spreader." (Vol. III, 649:8–14.) Not all CAFOs will have equipment capable of following this mandate. (648:5–649:3.) So, for a farm without the right equipment, this is an effective ban. Overall, "[g]iven the lengthy list of conditions" in the 2020 CAFO General Permit, CNMP Provider Allison Brink opined that this condition "will result in a practical ban of land applications in the winter." (Vol. IX, 2204:6–10.)

Not only are these conditions unduly restrictive and an effective ban, but there is no reason to require a lower soil phosphorus limit in the winter. (Vol. X, 2564:23–2565:15.) Since the manure is required to be incorporated and it is being land-applied under the same conditions as it would be the rest of the year (when soil phosphorus limits are higher), this additional limitation is completely arbitrary since manure is not being surface-applied during these times. (*Id.*)

EGLE's implementation of this condition follows several unsuccessful attempts to ban winter application via legislation. (2017 SB 639, 2017 HB 4418, 2019 SB 247, 2019 SB 4418; Vol. X, 2560:6–13.) It is also contrary to the popular will as surveys show that two thirds of Michiganders opposed winter land application restrictions and were not willing to pay higher food prices for agricultural policies like it. (2553:15–24; Ex. P-96.) And it departs significantly from past practice in the 2015 General Permit (and all prior CAFO permits), which did not impose any calendar-based restrictions and long allowed winter applications but *only* if they meet the strict 2005 Technical Standard. (Vol. IX, 2201:18–2203:21; Ex. R-96; Vol. X, 2558:15–2559:5.) In other words, those permits made manure application dependent on field-specific conditions by prohibiting land application to saturated soils and following rain events, (I.B.3.e.1 & I.B.3.e.2), and otherwise requiring manure to be subsurface injected or incorporated within 24 hours following application in many instances. (I.B.3.f.) Further, if manure was surface-applied to frozen or snow-covered ground, farms were required to comply with EGLE's 2005 Technical Standard for Surface Application of CAFO Waste on Frozen and Snow-Covered ground (I.B.3.a.) Because "[t]here are not many fields who meet the current requirements . . . those fields that do meet the requirements have a very low risk" of discharge. (Vol. IX, 2203:19–21.)

Nonetheless, Christine Alexander testified that this condition was required in part because EGLE "received complaints and verified that *many* discharge events occurred in 2019" as a result of winter spreading. (62:12–14) (emphasis added). But she admitted on cross-examination that those "many" discharges were just six discharges among the nearly 300 farms that are CAFOs. (Vol. I, 165:17–25; 220:15–17; Ex. R-106, p. 33.) Moreover, EGLE has not quantified how many discharges or what quantity of discharges occur in the winter months. (Vol. III, 561:22–562:13.) Simply put, the data does not support the change. Instead, EGLE's principal justification was its policy judgment that these months were at greater risk of discharges. (Vol. I, 79:7–11.) As Bruce Washburn testified, EGLE's Livestock Committee had been pursuing such a change since as early as 2010. (Vol. III, 641:10-16; see also Vol. II, 458:14–459:12 & Ex. R-65.)

Manifesting Ban

Complementing EGLE's presumptive winter ban on land application, the 2020 General Permit also proposes a total ban on the transfer of manure from CAFOs during the winter. Section I.C.8 provides that "[i]n cases where CAFO waste is *sold, given away, or otherwise transferred* to another person (recipient) such that the land application of that CAFO waste is no longer under the operational control of the CAFO owner or operator that generates the CAFO waste (generator), the 'Manifest for CAFO Waste' form shall be completed and used to track the transfer and use of the CAFO waste," but mandates that "CAFO waste *shall not be transferred to a recipient for land application of that waste during the months of January, February, or March*." (Emphasis added).

This prohibition prevents not only sales but also voluntary transfers—i.e., giving manure away. (Vol. I, 192:18–193:10; 270:18–271:4.)

EGLE staff did not agree on exactly *when* this ban occurs. Christine Alexander argued that the ban prevents transfer during those months, so a farm can transfer manure in December for application during those months but cannot transfer during those months for application *after*. (Vol. I, 191:7–192:17; Vol. II, 270:1–6.) Bruce Washburn read the proposed condition differently—arguing that manure "can't be land applied in those months" "regardless of when it gets manifested . . . ." (Vol. III, 680:4–6.) The intent of this ban is to prevent non-CAFO farms from land-applying manure during those months. (679:12–20.) But non-CAFOs are not subject to this restriction. (Vol. I, 194:5–9.)

Michigan Phosphorus Risk Assessment

EGLE also initially proposed mandating that farms use the Michigan Phosphorus Risk Assessment ("MPRA") index to determine whether they could land-apply manure in a field. (Ex. R-71, Section I.B.3.c.3.; Ex. P-18.) The MPRA is a phosphorus risk index that "was developed by NRCS as a decision assistance tool to identify potential risk of nutrient loss from fields . . . ." (Vol. X, 2522:23–2523:1.) The MPRA assesses "qualitative risk factors" and then "assigns a quantitative or numerical value to those factors related to [Phosphorus] transport and sources." (Vol. IX, 2192:18–20.) For example, under the "transport" factor, a field greater than 300 feet from a surface water or inlet scores zero points while a field within 50 feet of a surface water scores eight points, and a field with a 35-foot, permanent vegetated buffer scores one point but a field without a buffer scores eight. (Ex. P-18.) Similarly, under the "source" factors, fields are scored from zero to eight points based on their Bray P1 Soil Test P scores, the type of fertilizer used, and the method of land application (if applying manure), and the scoring of the RUSLE2 and Runoff Curve Number (both of which address soil type, slope, and other factors related to the field that are outside of the farmer's control). (*Id.*) Those numbers are then aggregated to a risk category of "Low" (0–11 points), "Medium" (12–18 points), or "High" (18 or more points). (*Id.*) The initial proposed draft permit sought to bar land application for any field scoring a "High" and for any field within a TMDL scoring a "Medium." (Ex. R-71, Section I.B.3.c.3.1.b.)

The MPRA was not intended to be used as a regulatory tool, and it has not been evaluated for that purpose. (Vol. IX, 2194:19–2194:8.) Although the MPRA was "an option" in the 2015 general permit as a voluntary alternative, "no one used it." (Vol. IX, 2193:17–18; Vol. X, 2523:4–9.) And even Bruce Washburn noted he was "not aware of any" farms who used the MPRA. (Vol. II, 418:19–22.)

EGLE's proposed use of the MPRA was met by harsh criticism from several public actors. Michigan State University's College of Agriculture and Natural Resources explained that the MPRA's statement that it is "not for regulatory use" "recognizes the complexity of predicting the fate and transport of [phosphorus] using a simplified index." (Ex. R-11, p. 4.) MSU criticized the limited testing done on the MPRA, noting that "site-specific conditions are very diverse and additional evaluation is needed to verify and validate the MPRA." (*Id.*) Further, MSU observed that "the risk value for each factor considered in the MPRA are added to each other assuming no interaction between them." (*Id.*, Vol. IV, 878:5–11.) Thus, MSU concluded that "the use of the MPRA in an NPDES permit must be carefully assessed as *generalizations for heterogeneous crop land may* fail to protect surface water or *be excessively conservative to the point of causing farm hardships that do not result in surface water improvements*." (*Id.*) (emphasis added).

Although omitted from EGLE's administrative record, its sister agency the Michigan Department of Agriculture and Rural Development ("MDARD"), submitted comments critical of EGLE's MPRA mandate. (Vol. V, 1165:19–21; Ex. P-26.) MDARD noted that "[n]either the sensitivity analysis nor validation has been completed for the MPRA," and that "[t]he initial results of MPRA scoring" "illustrates a skewed distribution and an overwhelming number of MPRA 'high' risk ratings." (*Id.*, p. 4.) As Laura Campbell explained, these comments "expressed alarm that the MPRA has not been formally calibrated or validated, and that it was built exclusively on the professional judgment of NRCS staff." (Vol. X, 2604:13–16.) And 70% of fields assessed by MDARD would be unable to apply manure using MPRA, "even before factoring in whether the watershed in which the fields were located had phosphorus or nitrogen TMDLs . . . ." (2605:5–16.)

In response, EGLE revised the proposed permit to no longer mandate the MPRA's use. (Ex. R-45.) Nonetheless, EGLE inserted new conditions to obtain "approximately the same end point" as the MPRA. (Vol. V, 1256:12–1257:4.) Those conditions are addressed next.

Setback and Buffer Mandate

As part of removing the MPRA, EGLE not only reduced soil test phosphorus thresholds (as discussed further below) but also mandated that any farm that does not use the MPRA must *both*: (a) install 35-foot vegetated buffers of permanent, perennial vegetation, *and* (b) apply 100-foot setbacks from certain features. (Ex. R-45, Section I.B.3.h.) EGLE's 2015 General Permit required only that CAFOs adopt either measure at their prerogative. (Ex. R-96, Section I.B.3.g.) That had been the case in all prior permits. (Vol. X, 2576:16–21.) And that is what the federal rules require because EPA considers the two "compliance alternatives" to be "equivalent" practices, and EPA long ago "decided not to require all fields receiving manure, litter, or other process wastewaters to have a vegetated buffer because *that would unnecessarily require CAFOs to take that portion of the cropland out of production*." 40 CFR 412.4(c)(5); (Vol. X, 2568:9–15 & 2568:20–24) (emphasis added), quoting 68 Fed Reg 7211. Thus, EGLE's new requirement marks a substantial departure.

Beyond its "both-and" mandate, EGLE also expanded the definition of where setbacks and buffers must exist. Buffers and setbacks must exist not only along "along any surface water of the state, open tile line intake structures, sinkholes, agricultural well heads" but also adjacent to any "roadside or any ditches that are conduits to surface waters of the state (with the exception of surface waters of the state that are up-gradient of the land application)." (Ex. R-45, Section I.B.3.h.1.a.) As Bob Dykhuis explained, this means that although his buffer strips were previously compliant with the 2015 General Permit if placed along edges of surface waters, such as county drains, streams, and water-carrying ditches, and along tile intakes, EGLE now requires buffers along any "roadside ditches that are conduits to surface waters of the state"—regardless of the continuous occurrence of water. (Vol. VIII, 1966:3–12.) Practically, these changes mean, that in some cases, farms may be required to place buffers along all edges of the field as well as along both sides of any ditch or drain that bisects the field. (Vol. I, 199:19–200:9.)

Soil Test P Limit Reduction

EGLE also significantly reduced the allowable amount of Soil Test P (or phosphorous) that may exist within a field where manure is applied. Previously, a farm could apply manure to any field with up to 150-ppm phosphorus. (Vol. I, 139:1–11; Ex. R-96, Section I.B.3.c.1.a.) But it was limited to a "one-year application rate" for any field with over 75-ppm Soil Test P. (*Id.*, Section I.B.3.c.2.a; 139:12–140:1.) In other words, fields above that lower threshold could receive only the amount of phosphorus that was necessary to apply for the next crop based on a calculation of crop needs incorporated into the general permit and set using MSU research. (Vol. I, 140:7–141:11; 2197:19–2198:13; Ex. R-96, I.B.3.c.2.b.) At one-year application rates, it is expected that land will maintain soil test P levels. (Vol. IX, 2198:14–20.) And, at 150-ppm or above, absolutely no manure could be applied to a field. (Vol. VIII, 1928:24–1929:2; 2605:1–5.) This is a self-limiting system because farms above acceptable levels would utilize the nutrients applied. (Vol.

IX, 2195:20–25; 2199:22–2200:4; 2219:14–18; 2245:1–12; Vol. XII, 3336:19–3337:2.) It is also a conservative system that has generally led to a reduction of phosphorus levels over time. (Vol. IX, 2199:13–18; Vol. XII, 3171:11–17.)

These levels have been set since the beginning of CAFO General Permits in Michigan. (Vol. X, 2535:3–13.) The levels exist in all farm (and non-farm) compliance programs—from USDA NRCS to GAAMPS, in EGLE's biosolids, in the MPRA, in NRCS guidance, and elsewhere. (Vol. IX, 2196:21–2197:18; 2256:18–23; Vol. X, 2539:10–2541:11.) That is because these levels are based on established scientific research from the USDA and from researchers at major Midwest universities (including Purdue, Ohio State, and Michigan State University) that concluded that, at 150-ppm Soil Test P levels, there was an increase in the amount of phosphorus moving in solution. (Vol. X, 2536:10–2539:9; Vol. Xi, 2917:1–2919:19; see also Ex. P-88, Sharpley, USDA, pp. 16–18, Figs. 34-12 & 34-13 (noting a "change point in the relationship between soil and surface runoff P").) Thus, that is a logical break that is representative of an increased risk of phosphorus transport and thus the level is protective of water quality. (Vol. X, 2541:12–22; Vol. Xi, 2924:8–2925:5; Ex. P-88, p. 17.) But below those levels, the relationship between Soil Test Phosphorus and movement from the soil is non-linear. (2925:5–7.) That means that further reduction below those levels is not directly correlated with decreased risk of phosphorus loss from the soil. (2925:8–21.)

Despite these long-established and rationally placed levels, EGLE departed from this standard by reducing soil test phosphorus limits to 135 ppm in non-impaired watersheds, 120 ppm for watersheds with phosphorus or nitrogen TMDLs (numbers that are halved during the months of January through March as discussed above). (Vol. X, 2543:1–6.) Those numbers represented a 10-percent and 20-percent reduction of the existing threshold, respectively. (2542:2–18 & 2543:7–

10.) The numbers were not based on a specific scientific rationale. (Vol. IX, 2196:12–20; Vol. X, 2543:22–2544:3; 2687:9–11; Vol. XI, 2925:17–18; 2939:10–12.) Rather, EGLE simply sought to lower the Soil Test P thresholds, (Vol. II, 266:24–25), and it arrived at these numbers through a purported "compromise" (as discussed in more detail below). (Vol. I, 144:23; 146:10–15; Vol. II, 489:8–11.)

Nitrogen Noticing

EGLE also added a condition to the permit requiring addition of nitrogen beyond that previously planned to be publicly noticed for a period of 15 calendar days (and forbidding its application for 18 days). (Ex. R-45, I.B.3.c.3.) The 2015 permit allowed that if "*samples* or other relevant data *demonstrate additional N is needed for, or will be beneficial to, the crop*" then the additional nitrogen could be applied. (Ex. R-96, Section I.B.3.c.1) (emphasis added). In other words, if a farmer realizes from soil tests or tissue tests that a crop needs or can benefit from an additional application of nitrogen, then it was permissible to apply it based on that demonstrated need. (See 2898:2–22; 2899:22–2900:21.) In the proposed permit, EGLE has added a requirement that the "[t]he demonstration" must be publicly noticed for 15 days, and application can take place only after 18 days. (Ex. R-45, I.B.3.c.3.) This condition applies even if plant tissue tests show a need at a particular point in time. (Vol. II, 209:20–210:7.) This addition is untenable and undermines the purpose of the exception to allow for cases were "additional N is needed for, or will be beneficial to, the crop . . . ." (*Id.*; 2215–2216:1; 2581:1–5; 2898:14–17; 3247:11–16.)

TMDL Restrictions

EGLE also added a vague condition to the permit noting that fields within Total Maximum Daily Load ("TMDL") watersheds would need to implement "additional pollutant control measures" based on a "comprehensive evaluation" and report submitted to EGLE. (Ex. R-45, I.C.9.b.3.a.) Those "additional pollutant control measures" require *either*: (1) that farms must "install and operate a treatment system"; or (2) that they are mandated to implement "at a minimum" certain other identified "best management practices" including: (a) installing 50-foot vegetated buffers "along the perimeter of the field" *and* utilizing 150-foot setbacks; (b) limiting land application rates to "1/4 inch of liquid manure equivalent" (or 1/8 inch for some tiled fields); (c) waiting 48 hours between applications; and/or other measures approved by EGLE. (Ex. R-45, p. 4; Vol. VII, 1182:19–21; 1184:19–1185:6.) Whether a farm is subject to these requirements will be identified in their Certificate of Coverage. (Vol. I, 80:17–25.) But what exactly is required will not be known until the farm conducts a study and that is reviewed by EGLE.

Jurisdictional Reach of Manifesting ("Operational Control")

One item that *did not* change that should have changed is EGLE's definition of when a CAFO has "operational control" over the land-application of manure. Both the 2015 General Permit and the proposed 2020 General Permit provide that "[i]n cases where CAFO waste is sold, given away, or otherwise transferred . . . . such the land-application of waste is *no longer under the operational control of the CAFO owner*" then a manifest is required. (Ex. R-45, I.C.8.) (emphasis added). But those fields need not be included in the CNMP for CAFOs. EGLE's Livestock Committee identified providing a definition of "operational control" as a priority on its Priorities List. (Vol. III, 681:18–25; Ex. P-29.) And Bruce Washburn testified that he believes a definition is necessary for "clarity amongst us as regulators and for farms, both recipients and receivers." (682:19–22.) Nonetheless, EGLE did not make any such change.

Alleged "Compromise" Claim About Soil Test P Reductions

EGLE has alleged that its reduction of Soil Test Phosphorus threshold levels in the 2020 CAFO General Permit resulted from a "compromise." (Vol. I, 144:23; 146:10–15; Vol. II, 489:8–11.) In this regulatory setting, EGLE was not engaged in any contractual negotiation. Rather, as Ms. Allison Brink explained, EGLE was pushing for the "mandatory use of the MPRA," which “was not good for our farms” nor for EGLE. (Vol. IX, 2191:17–18.) The original draft permit put on public notice mandated the use of the MPRA. (Ex. R-71, Section I.B.3.c.3.) EGLE told farmers that the MPRA was “non-negotiable” and “that the permit would be changing in this regard” but that the CNMP providers “could offer *our opinion* on what those changes should look like and [EGLE] would *consider it*.” (Vol. IX, 2191:22–24.) Accordingly, the CNMP Providers felt like they had no choice but to offer *something* as an alternative to EGLE’s proposed MPRA mandate. (Vol. X, 2705:1–8; 2796:19–25; 2756:10–15; Vol. XII, 3336:3–9.) Christine Alexander agreed that this was the case, explaining that the CNMP providers “knew that the Department was looking for a decrease in phosphorous concentrations in soils.” (Vol. II, 266:24–25.)

With that context of EGLE demanding that “something has to change,” (Vol. IX, 2246:1–7), and declaring its intent to forcibly change the standards in any event, (Vol. IX, 2191:17–18; Ex. R-71, Section I.B.3.c.3.), the CNMP Providers sent EGLE a letter. Their letter recommended that, rather than mandate the use of the MPRA, EGLE should adopt an alternative of reducing the Soil Test phosphorus thresholds thus keeping the Bray P1 soil testing structure in place. (Ex. P-17; 2195:13–20.) No attorneys were involved in drafting this letter. (Vol. IX, 2287:22–23.) Nor did the CNMP providers seek client approval before sending this document. (Vol. IX, 2243:10–11.) Rather the CNMP providers simply made these suggestions based on their collective experience and judgment as to what was preferable to EGLE’s alternative mandate of the MPRA. (2242:2–11.) This letter was no “compromise” and there was “no negotiation” over the reduction of Soil Test P thresholds. (2241:7–11; 2243:25–2244:5.) As Allison Brink explained, “We did not have any negotiations. We submitted a recommendation and then we waited until the final permit was released to know” EGLE’s decision. (2246:25–2247:3.)

Significantly, EGLE did not simply adopt the recommendation from the CNMP providers. (Vol. XII, 3338:11; 2299:8–9.) Rather, EGLE "added on to it." (3338:11–23; 2299:8–10.) In the revised, "final" version of the 2020 General Permit, EGLE not only reduced the Soil Test P threshold, but EGLE also added the "both-and" requirement of the 100-foot setback and 35-foot vegetated buffer. (Vol. IX, 2299:8–18.) EGLE did so expressly to obtain what it viewed as the same qualitative "benefits" of the MPRA. (Vol. V, 1256:12–1257:4.) In other words, even if EGLE's regulatory actions are viewed through a quasi-contractual lens, EGLE "counter-offered" and thereby rejected any proposal from the CNMPs. (Vol. XII, 3338:11–23); see, e.g., *Pakideh v Franklin Commercial Mortg Group, Inc*, 213 Mich App 636, 640; 540 NW2d 777 (1995) ("Unless an acceptance is unambiguous and in strict conformance with the offer, no contract is formed.").

Alleged Justification for Changes to the Permit

Much of EGLE's testimony presented after-the-fact justifications for EGLE's Livestock Committee's policy decisions in making changes to the general permit. The reports, exhibits, and conclusions of these witnesses were largely drawn up purely for the purposes of this contested case. Even more importantly, that testimony made significant logical leaps, conflating correlation and causation, and did not present a sufficient factual basis to support any opinions that land-application by CAFOs are a cause of nutrient pollution or harmful algal blooms. MRE 702. This Tribunal should give that opinion testimony no weight for the reasons identified in Agricultural Petitioners' earlier filed Motion to Strike Correlation Claims dated August 16, 2021.

Nutrient TMDLs and "Agriculture"

First, EGLE sought to correlate CAFOs and nutrient TMDLs via the testimony of Ms. Sarah Holden. Holden produced maps in an effort to draw this correlation generally and particularly with respect to Lake Macatawa. (Vol. VI, 1461:15–1462:8; Ex. R-47 & R-48.) Ms. Holden opined that "CAFOs *contribute to* phosphorus pollution in Michigan." (1478:6) (emphasis added). But she qualified that opinion by noting that CAFOs are only "*one component* of the well-documented impact of agricultural activities on nutrient loading to aquatic systems." (1477:22–25) (emphasis added).

Holden offered only generalized opinions about the source of phosphorus for TMDLs. For example, she stated equivocally that "the most severe source of excess phosphorus are ***urban*** ***<u>and</u>*** ***agricultural*** areas of the state." (1472:4–5) (emphasis added). She also observed that "[i]n individual waterbodies, the largest source of phosphorus ***varies based on the land use in the watershed*** . . . ." (1472:3–7) (emphasis added). She acknowledged that there are numerous different sources of phosphorus that discharge into Michigan surface waters, including fertilizer, animal waste, wastewater treatment, storm water, illicit discharges, and others. (Vol. VI, 1504:2–10.) She also agreed that septic systems are also a source of phosphorus discharges and conceded that there are around 1.3 to 1.4 million onsite systems, mostly in agricultural areas. (1517:6–9 & 1517:22–1518:3.) But EGLE does not have jurisdiction over "small" septic systems. (1517:10–12.)

With respect to "agricultural" sources, she noted that "agriculture" is not synonymous with CAFOs but instead encompasses all potential agricultural sources. (1500:8–14.) And she could not identify specific contributions from those sources. (1502:13–23.) Rather, with respect to non-point sources of nutrients, Holden noted there is no information on specific discharges, so "they're all sort of potential sources." (1499:13–25.) Among the scientific literature that discusses agriculture as a source of nutrients for impaired waters, most studies do not differentiate between CAFOs and non-CAFO areas. (1544:1–3.)

Indeed, to Holden's knowledge, EGLE has not quantified any nutrient impacts from CAFOs to the phosphorus loading of any impaired surface water. (1503:3–13.) EGLE has no monitoring data and has not done any studies to determine the effectiveness of the treatment techniques in the 2015 CAFO General Permit in managing nutrients. (1497:13–20.) No studies have been done to establish the effectiveness of the proposed treatment techniques in the 2020 CAFO General Permit in managing nutrients. (1497:21–1498:3.) Holden agreed that the majority of CAFOs are not located within a nutrient TMDL. (1537:10–15.) And Holden could not imply by Exhibit R-49 that any specific source has caused higher phosphorus concentrations in impaired watersheds. (1539:24–1540:3.) Instead, Holden testified that under existing data there is no correlation between CAFOs and nutrient impaired watersheds. (1537:17–20.) Reviewing Holden's map, Bruce Washburn likewise noted an apparent lack of correlation. (Vol. II, 538:14–22; see also Vol. I, 229:24–231:2 (Alexander addressing similar maps).)

Accordingly, in redirect, Holden merely relied only on the general notion that CAFOs "***can contribute*** to nutrient impairments" and that following the 2020 CAFO GP conditions "***can reduce*** the contributions" by CAFOs—without any definitive support as to how much effect either has on the problems EGLE purports to address by these conditions. (Vol. VI, 1547:11–16) (emphasis added). Even so, other EGLE witnesses noted that other sources such as wastewater treatment plants and urban runoff similarly contribute to nutrient TMDLs. (Vol. V, 1095:2–12.)

Dr. James Averill testified that, contrary to the implicit suggestion of Holden's testimony, he was not aware of any studies demonstrating that CAFOs are the primary cause of nutrient TMDLs in Michigan. (Vol. IX, 2318:25–2319:3.) He noted that a causal connection could only be established by appropriate scientific methods, including microbial source tracking methods and Hill's Causal Criteria. (2319:4–8.) He explained that EGLE cannot reliably infer that CAFOs have caused nutrient TMDLs based merely on a correlation with rural land base. (2324:14–16.) Moreover, he noted that Ms. Holden's map "makes no correlation or causal inference" between

CAFOs and nutrient TMDLs and a more significant scientific study would be needed to identify such a relationship. (2336:5–14.) Contaminant fate and transport expert Mr. David Trainor likewise noted that there were no studies supporting Holden's analysis and that her attempts to link CAFOs to nutrient impairments were "questionable." (Vol. X, 2843:24–2844:2.)

***E. Coli* TMDLs and "Agriculture"**

Molly Rippke similarly sought to draw a connection between *e. coli* impaired TMDL watersheds and "agricultural land cover." But Rippke overstated this connection, omitted any data from evidence, and failed to draw any link directly to CAFOs. Specifically, Rippke testified that "*e. coli* has a strong positive relationship with agricultural land cover in Michigan (Pearson's correlation coefficient of 0.58)" according to a study she performed. (Vol. V, 1301:13–16.) This correlation was only slightly higher than the correlation between *e. coli* TMDLs and urban areas (or "human population density"), which "was also correlated with E Coli concentrations (r=0.53) . . . ." (1302:15–18.) Rippke conceded that, even assuming correlation, that is not sufficient to establish a causal link. (1367:1–18; R-37, p. 21.) Contrary to the requirements of MRE 702, she did not include the data on which she based her testimony or Pearson's correlation coefficient calculation in evidence. (1363:3–14.)

Rippke also noted the limitations of her analysis, confirming that EGLE did not "attribute[e] causation to either septic systems or manure from agriculture." (Vol. VI, 1408:22–1408:1.) With respect to CAFOs, she "did not run any correlation on CAFOs" and *e. coli* TMDLs nor perform any statistical analysis on *that* correlation. (Vol. VI, 1381:21–1382:2 & 1391:8–11.) In fact, she acknowledged that, based on her map, there are large areas of CAFOs outside any *e. coli* TMDLs as well as TMDLs with very few CAFOs. (1390:1–1391:3.) But she had not performed any quantitative analysis on that map. (1391:4–11.) Ultimately, Rippke made no definitive determination on any *e. coli* source, (1391:16–18), and she contended only that CAFOs can be considered "potential sources" of *e coli* "because we generally don't have actual data from their outfalls." (Vol. VI, 1402:6–7.)

These limitations were echoed by Christine Alexander. Alexander confirmed that Rippke's study did not indicate that CAFOs caused any particular impairment. (Vol. I, 213:3–7.) And she noted that Rippke's study related only to "a type of land use" ("agricultural land use") rather than a particular source. (214:4–12.) She also agreed that non-regulated farmers (i.e., non-CAFOs) have no regulatory restrictions on their application of nutrients through commercial fertilizers or other means other than perhaps the GAAMPs. (Vol. II, 281:20–282:2.)

Reviewing this testimony, Dr. James Averill noted that Rippke's Pearson's correlation coefficient analysis did not constitute a strong correlation. Instead, Dr. Averill explained that "[s]tatisticians consider an R-value greater than 0.70 to be a strong correlation," but "R-values of 0.40 to 0.70 are moderate correlation and below 0.40" is a weak correlation. (2330:24–2331:3.) Applied to Rippke's study, Dr. Averill opined that the "correlation of E. coli to agricultural land and population density" has a "moderate correlation" and that the correlation between *e. coli* TMDLs and agriculture and that of TMDLs and population density is "essentially equal in their correlation, demonstrating that the presence of *E. Coli* in Michigan waterways is a multi-factorial issue." (2331:3–8.) In any event, he noted that Rippke's study does not provide sufficient evidence for a causal relationship between E. coli impaired watersheds and CAFOs. (Vol. IX, 2331:12–14.)

Harmful Algal Blooms and CAFOs

Additionally, aquatic biologist Aaron Parker sought to make a more direct connection between CAFOs and harmful algal blooms ("HABs"), but he did so in an utterly unscientific manner that does not meet the expert opinion standards of MRE 702 & MRE 703. Parker started with broad claims that a recent increase in HABs has been observed and attributed to climate change and "more intensive agricultural practices," which he defined as "the increased amount of fertilizer being used on agricultural crop fields and the increased number of CAFOs in the United States . . . ." (Vol. VI, 1573:1–16.) None of these claims were supported by any particular data or scientific literature placed in evidence. (1592:1–7 & 1593:25–1594:9.)

Instead, Parker relied on visual observations from an exhibit a colleague created comparing the locations of CAFOs to HABs. (1574:1–17; 1597:15–16; Ex. R. 27.) That map was created in January 2021—*after* the 2020 CAFO General Permit issued and after this case was filed. (1597:25–1598:5.) Judging visually from that map, Parker opined that "the map appears to show that, for the most part, watersheds with higher densities of CAFOs also have higher densities of confirmed instances of cyanobacteria blooms in them." (1574:3–7.) Nonetheless, even in his direct testimony Parker conceded numerous inconsistencies with this hypothesis. He noted that there are areas like the thumb region with a high density of CAFOs but few HABs. (1574:18–25.) He acknowledged places like Huron River watershed have many HABs but no CAFOs, which he opined was likely due to residential fertilizer use, impervious surfaces, and septic systems. (Vol. VI, 1575:12–16; 1576:5–7; Vol. VII, 1621:20–1623:2.) On cross-examination, Parker was walked through numerous watersheds across Michigan where CAFOs or HABs are present, and it was evident that there is in fact zero correlation between the two. (Vol. VI, 1605:16–1612:11; Ex. R-27.) Instead, even beyond his own concessions in direct, there are many watersheds with few HABs despite numerous CAFOs—and few CAFOS despite many HABs. (*Id.*)

Ultimately, however, Parker could not offer any opinion on whether CAFOs cause HABs (or are even correlated with HABs) because he had no supporting data. Parker could not quantify any loading from a particular CAFO. (Vol. VI, 1601:8–11.) EGLE does not know where anything from a CAFO is going. (1602:15–17.) Parker has not quantified the impact of any particular CAFO to a cyanobacteria bloom, and he admitted "we do not have those data available" . . . . (1604:4–13.) Indeed, EGLE has done nothing other than Parker's visual analysis of a colleague's map, (Ex. R-27), to correlate or quantify the relationship of cyanobacteria and CAFOs. (Vol. VII, 1623:3–7.) And, he acknowledged that the map as Exhibit R-27 did not quantify the contributions of various sources to cyanobacteria blooms. (1623:18–23.) Accordingly, Parker could not say with any certainty that CAFOs cause cyanobacteria blooms, (1600:16–20), but he claimed that "I am absolutely sure that . . . nutrients from manure that are applied to fields enter surface waterbodies and . . . ***some of those nutrients could end up*** in waterbodies that have had cyanobacteria blooms." (Vol. VI, 1600:20–1605:2) (emphasis added). In other words, his opinion—like his visual analysis—was purely based on speculation.

Moreover, he also acknowledged that even his more general claim about a correlation between agriculture and HABs based on unspecified "literature" that was not in evidence was not specifically attributable to CAFOs. Rather, he noted that "agricultural land use" as a potential source of nutrients for HABs included broadly any "land use such as grow[ing] crops" where fertilizers are applied to the land and . . . those nutrients could then run off into surface waters. (Vol. VI, 1592:222–1593:5.) That would encompass septic systems and commercial fertilizer. (1593:6–24.) And Parker could not say how much dissolved reactive phosphorus would be due to manure and how much would be attributable to commercial fertilizer. (1595:12–1597:1.)

Dr. Averill responded to Parker's testimony, noting it was "inconsistent" in several ways. (Vol. IX, 2332:20–23 & 2333:17–18.) That included that: (1) Parker attributed HABs to agricultural practices but later noted the multiple contributing factors, including hydrology, temperatures, sunlight, and nutrients; (2) that Parker admitted a single lake study was inadequate to determine water quality but relied on data regarding Michigan lakes' trophic status where numerous lakes were only sampled once; and (3) his visual correlation of Exhibit R-27 was on its face unsubstantiated and contradicted by his own testimony. (2332:20–2333:23.) Overall, Dr. Averill opined that Parker's reliance on Exhibit R-27 was insufficient to establish any causal relationship. (2334:1–12.) And it would not support massive policy changes by an agency. (2334:13–25.) Likewise, David Trainor opined that Parker's analysis did not establish even a base-level correlation, "the detail of . . . individual instances" on Parker's map "belies the map's premise," and eyeballing a map was "not consistent with scientific principles" in an area like contaminant fate and transport analysis that seeks to determine the source of pollutants. (Vol. 2845:23–2847:7; 2850:4–8.)

Lack of Connection Between Inadequate CAFO Standards and Water Quality Issues

Despite all of EGLE's attempts to connect CAFOs with water quality impairments in an oblique manner, none of the testimony supported a causal connection between CAFOs and the harms discussed. At most, EGLE demonstrated a weak correlation, which would be insufficient to surmise causation without more. (2323:20–10; 2324:17–2325:8.) Nor did EGLE establish that any of those harms are attributable to the inadequacy of the existing 2015 CAFO General Permit's conditions and standards. Just the opposite: the testimony indicated that where problems have been seen, those are attributable to violations of the existing permit that can be resolved via EGLE's enforcement capabilities.

For example, Christine Alexander cited "many" discharges due to winter spreading during 2019 while the permit was being developed as a justification for EGLE imposing a presumptive winter ban. (62:12–14.) But she later clarified that by "many," she meant just six discharges during that year (or roughly 2% of CAFOs). (Ex. R-106, p. 34; 63:5–8; 165:9–166:2.) And she agreed that these discharges would have been violations of the 2015 CAFO General Permit. (224:2–6.)

Bruce Washburn similarly identified certain "violations" that he thought the presumptive winter ban would prevent but noted that these were *already* violations of the 2015 General Permit. (375:9–376:7; 558:16–559:4.) In other words, just as Laura Campbell explained: "When livestock manure contributes to water quality impairments, it is much more likely to originate from practices that were violations of the 2005, 2010, and 2015 General Permit for CAFOs than from the simple presence of CAFOs in or near the watershed. (2593:4–8 & 2593:12–19; see also 3244:5–7 (James DeYoung opining that, if a farm is complying with the 2015 GP, "it is highly unlikely that there would be a discharge of manure into waters of the state.") & 2845:6–14 (Dave Trainor opining that "Best Management Practices, such as those that are currently required under federal regulations and those under the 2015 CAFO General Permit, minimize the transport of dissolved phosphorus discharge via surface flow to nearby waters")).

Ms. Campbell's opinion is backed by practical experience. As Kevin Elder explained, the overall loading of phosphorus to Lake Erie from agricultural sources has been declining over time. (2944:15–16; Ex. P-54, p. 13–14.) Thus, he opined that when farms follow the established Best Management Practices like those enshrined in the federal regulations for CAFOs, the contribution of agricultural farms to HABs or other water quality concerns is minimized as indicated in the Ohio Lake Erie Phosphorus Task Force Report. (2944:8–15.) Accordingly, EGLE has not provided adequate scientific basis to support the underlying rationale for its proposed sweeping regulatory changes. (2325:24–2326:5; 2332:9–15; 2334:13–25; 2336:15–2337:4.)

Additionally, EGLE's tools for compelling compliance are sufficient to compel farms to make operational changes that will ensure future compliance and protect water quality. (3239:14–19.) "No farm wants to receive a violation." (2184:20–21.) Instead, "[m]ost farms have an elevated level of fear or anxiety when dealing with EGLE, largely due to the enforcement authority [EGLE] has." (2185:23–25.) One big violation (or even a few small violations) can push a farm into an Administrative Consent Order that requires significant investment from the farm in addition to stipulated penalties and civil fines. (2185:9–22.) Thus, EGLE has not justified imposing sweeping and more burdensome standards when they lack a demonstrated connection to water quality improvements and the justifications that they have provided for these changes are adequately addressed by enforcement of the existing permit conditions.

Additional Restrictions on Manure Will Shift Fertilizer Usage Towards Environmentally Unfriendly Commercial Products and Encourage Poor Manure Management

Not only are EGLE's changes to the General Permit unjustified, but EGLE's proposed new conditions will actually *adversely* impact the environment and water quality in Michigan. Crop farmers must continue to use fertilizer in one form or another in order to grow crops. (2198:8–10.) The added regulatory burden on manure without sufficient justification "discourages the use of . . . manure by crop farmers by adding time and costs to each purchase compared to [the] use of commercial fertilizer . . . ." (2077:16–18.) Therefore, EGLE's new general permit standards for CAFOs will cause a shift for many crop farmers from using manure to using commercial fertilizer as the means of fertilizing their crops. (2942:14–21; see also 2939:20–25 & 2941:4–21.) In fact, the additional buffer and setback requirements make that shift effectively mandatory for those areas. (1969:2–16; 2062:9–18.)

In studies of Lake Erie, commercial fertilizer accounts for a much greater proportion of phosphorus loadings than manure—about three-to-four times greater than the contributions from beef, poultry, or liquid manure. (2936:14–2937:9; Ex. P-54, pp. 36–40, Figs. 19 & 22.) Commercial fertilizer is not subject to any of the same spreading restrictions as manure. (281:20–282:2; 2085:23–2086:13; 2130:19–22.) And phosphorus applied via commercial fertilizer is more soluble than the phosphorus in manure. (846:13–16; 1880:1–5; 2927:10–18.) As a result, commercial fertilizer is more likely to provide dissolved reactive phosphorus. (1880:6–9.) Commercial fertilizer is also more likely to "mov[e] faster in a rain event because it is more soluble." (2927:10–18.) For those reasons, "[m]anure is environmentally preferable to commercial fertilizer" because "the nutrients in manure are less soluble than commercial fertilizer and therefore present a much lower runoff risk to surface water." (2941:22–2942:3.) Yet, as Kevin Elder opined, EGLE's proposed changes will cause a shift in farmer's use to commercial fertilizer over manure. (2941:16–21.)

That shift is negative not only due to commercial fertilizer's comparatively high solubility but also because of its impact on nutrient runoff. As discussed above, "[s]oil quality has a big impact on nutrient loss." (1955:21.) Manure promotes healthy soil because "[h]ealthy levels of bacteria are naturally provided by manure," and "[b]acteria helps to stimulate soil and release nutrients to the crops." (1955:24–1956:2.) Additionally, the organic content from manure builds soil carbon, thereby reducing erosion of soils and the release of nutrients into surface waters. (2181:7–11; 2181:18; 2221:25–2222:9; 2517:7–15; 2811:24–2812:1; 3234:17–3235:5.) For those reasons, "manure is environmentally preferably to commercial fertilizer." (2941:24–2942:5); (see also 2517:17–19) ("These environmental benefits make manure an important tool in long-term soil health and sustainability of agricultural production."). The experience of Lake Erie is significant on this point where commercial fertilizer has been shown to be the source of roughly 66 percent of the phosphorus input compared to approximately 27 percent from manure. (2936:21–25; Ex. P-54, p. 37, Fig. 19.)

Likewise, EGLE's proposed restrictions on winter manure will discourage good manure management by shifting applications to riskier, spring months where nutrients are more likely to move offsite. (2942:6–10; Ex. P-92, pp. 1–2.) Thus, EGLE's proposed additional permit conditions are not needed. (2217:8–2222:24; 2612:15–2613:14; 2939:5–2942:23.) Instead, the proposed conditions are ultimately counter-productive, and they would prove bad for water quality. (2942:8–23; 2939:20–2940:14; 2941:13–2942:23; 3257:4–13.) EGLE provided no testimony to rebut these concerns about the effect of the General Permit in shifting farm usage to commercial fertilizer.

Impact of 2020 CAFO General Permit Changes on Farms

On top of these negative water-quality impacts, EGLE's new general permit conditions will add significantly to farm cost, possibly endangering the livelihood of a number of CAFO operators as well as the stability of the food supply. Both CNMP providers who testified conducted a review of the farms they serve and noted a substantial burden as a result of EGLE's new permit conditions.

For example, Allison Brink estimated that the Soil Test P reduction for most farms would remove 3% of available acreage from land application, and the reduction for TMDL farms would remove 5–7% of available acreage, while affecting and limiting the application rates for between 34–65% of acres—depending on the farm. (2211:21–2212:11; Ex. P-22.) Mr. James DeYoung likewise concluded that a mandatory vegetated buffer would take 3% of an average farm's land permanently out of production. (3259:22–23.) (In fact, for every 1,200 feet in buffer length a farmer loses an acre of productive land. (2570:22–24.)) And he noted that the other restrictions on land-application would require farms to "find up to 10–15 percent more land" due to reduced application rates. (3261:12–20.)

Similar testimony on the impact of these conditions was provided by the farmers themselves. Mr. Sietsema estimated that a Soil Test P reduction from 150-ppm to 120-ppm in TMDL watersheds would render 61.4 of 800 acres (or 7.7% of his acreage) ineligible for land application. (2161:14–19.) That means manure would either need to be exported to other farms or additional land would need to be purchased at approximately $6,000 per acre. (2161:20–25.) But, due to National Organic Program restrictions, any new purchased or leased land would require three years to transition for organic farming. (2162:3–11.) Additionally, hauling manure further adds significant costs because "a two-mile increase in distance" to a land-application site "doubles our spreading costs." (2162:24–2163:1.)

Caleb Stewart anticipated that the additional buffers required for his field would take 28% of his field areas out of eligibility for manure application and require the addition of N-P-K commercial fertilizers. (2088:1–15.) Because organic farmers cannot use commercial fertilizer, he observed that the added 100-foot setbacks will require organic farmers either to grow crops without the aid of any fertilizer or to remove the farms from production for three years. (2089:5–20.) Likewise, the "100-foot setback would render that 100-foot setback [area] virtually useless for crop production" by organic farmers because "manure cannot be applied" in that area. "Conventional farms are still allowed to apply commercial fertilizer in that area and be able to harvest a crop." But organic farmers "cannot use commercial fertilizer and comply with [National Organic S] standards to maintain . . . certification as an organic farm." Thus, EGLE's both-and mandate prevents organic farmers from using their only source of fertilizer and from growing any crops in that space. (2156:23–2157:14.) This means that the area "simply cannot be economically farmed." (2157:22.) For Stewart, this would remove 71.4 acres of land from production at a purchase cost of about $6,000 per acre (exclusive of the tiling, buffers, and other investments made to the property). (2158:13–18.)

Mr. Dykhuis explained that, although his buffer strips were previously compliant with 2015 General Permit, EGLE's expanded requirements for buffer strips would remove 109 acres from production of crops to install additional buffer strips on places where none were previously required (1966:3–1967:12.) EGLE has “effectively prohibited” growing crops in these areas or putting this acreage to any “economically productive use.” (1967:17–21.) And installing the buffers will also cost around $10,000 in seed cost in addition to labor. (1967:22–1968:21.)

Mr. Henry explained that EGLE’s presumptive winter ban could prevent farms from keeping employees on payroll during down times of the year. He noted that “[i]t can be hard to hold onto farm employees because of idle times where there is no need for their help,” but spreading manure prior to planting allows farms to “keep these employees on the payroll outside of the planting-through-harvest season.” (2892:15–23.) Mr. Henry also noted that the vegetated buffer requirement has an “immense impact” on farms. (2894:3.) Specifically, Mr. Henry reviewed an example 116-acre field and concluded that 12 acres (or 10.3%) would be lost due to buffers, simply applying buffers to areas where setbacks currently exist. (2894:6–9.) Looking at a broader area, he reached a similar conclusion that between 5 to 10 percent would be lost. (2894:9–17.) But EGLE’s expanded definition of areas that need both a buffer and setback would proportionately increase these numbers so, as Henry explained, “this number represents only *the minimum amount* that I know will be taken as a result of EGLE’s new rules.” (2894:19–22) (emphasis added). Mr. Henry likewise calculated that a 10% reduction of Soil Test P will cause an 8–10 percent loss of acreage, (2895:8–15), and that EGLE’s TMDL reductions of 20% would cause about a 25% land loss. (2896:1–5.) Henry further noted that the farm “cannot easily replace any land that is lost” because they are in competition with other farmers. (2896:14–20.) Moreover, these restrictions mean hauling manure further away which “is not feasible” because “crop land is competitive,” and thus, the added restrictions “would increase costs of manure immensely.” (2897:1–17.)

Because the exact requirements for TMDL fields were not all defined, the exact impacts could not be quantified. (1971:10–16.) But Bob Dykhuis noted that “it will be tougher to make long-term commitments to facilities in those areas." (1971:17–19.) Thus, "[i]t is the kiss of death for some business in those areas. Some older farms will not get reinvestment or they will need to become smaller so they are not CAFOs and can avoid those restrictions." (1971:19–23.)

These observations of significant added costs from the farmers and CNMP providers was confirmed by the survey conducted by Michigan Farm Bureau. (Ex. P-27; Vol. IV, 2326:6–2329:19.) That survey concluded "that the proposed changes to EGLE's 2020 General Permit for CAFOS will economically impact Michigan large livestock operations and will lower the number of acres to which manure can be applied." (2328:15–19.) Nearly half of survey respondents anticipated a "greater than five percent" increase in their operating budget—a number that U.S. EPA has used to indicate "jeopardy of going out of business." (2328:22–2329:4; see also 2614:5–8 & 17–21.) And the median cost of compliance with the added conditions would be nearly $500,000. (2613:24–2614:4.) Accordingly, based on these results, Dr. James Averill opined that "[o]verall, EGLE's proposed 2020 General Permit for CAFOs will likely lead to many large livestock operations being forced to sell or close their businesses and will negatively impact the sustainability of the food supply." (2329:15–19.)

ARGUMENT

I. The Revised Conditions of the 2020 CAFO General Permit Are Rules That Were Not Properly Promulgated Prior to Their Incorporation Into the Permit.

EGLE's adoption of sweeping new farm standards applicable to nearly all CAFOs via the 2020 CAFO General Permit constitute "rules" under the APA. MCL 24.207. Those rules were admittedly never promulgated. The rules also exceed the scope of EGLE's limited, Part 31 rulemaking authority. They are thus *invalid* rules, and they cannot be enforced by the agency against the industry. For those reasons, this Tribunal should strike EGLE's new and unpromulgated farm standards from the 2020 CAFO General Permit. Instead, this Tribunal should recommend that the General Permit issue consistent with the terms of the 2015 CAFO General Permit until such time as EGLE has properly promulgated any permissible new standards.

A. *Rules Include Any Agency "Regulation . . . Standard, Policy, Ruling or Instruction of General Applicability" That "Implements or Applies Law Administered by the Agency . . . ."*

"Rules" are defined as *any* "agency regulation, statement, standard, policy, ruling, or instruction of general applicability that applies law enforced or administered by the agency"—with some limited exceptions. MCL 24.207. And those exceptions are construed narrowly. *American Federation of State, Co & Muni Employees (AFSCME), AFL-CIO v Dep't of Mental Health*, 452 Mich 1, 10; 550 NW2d 190 (1996). "[I]n order to reflect the APA's preference for policy determinations pursuant to rules, the definition of 'rule' is to be broadly construed, while the exceptions are to be narrowly construed." *Id*. Importantly, the definition of a "rule" does not hinge on whether or not a "rule" is promulgated. *Id*.; MCL 24.207.

To ensure that an agency's exercise of quasi-legislative policymaking decisions that can impact the livelihoods and well-being of Michiganders are subject to appropriate oversight, agencies must submit those decisions through the rulemaking process. MCL 24.226; MCL

24.243(1). The Legislature's prescribed "elaborate procedure for rule promulgation" under the APA serves to "ensure that none of the essential functions of the legislative process are lost in the course of performance by agencies of many law-making functions once performed by our legislatures." *Detroit Base Coalition for Human Rights of Handicapped v Dep't of Social Servs*, 431 Mich 172, 178; 428 NW2d 335 (1988). So important is this process that adherence to promulgation procedures determines a rule's procedural validity. *Mich Charitable Gaming Ass'n v Michigan*, 310 Mich App 584, 594; 873 NW2d 827 (2015) ("[a]n agency's failure to follow the process outlined in the APA renders a rule invalid"), citing *Faircloth v Family Independence Agency*, 232 Mich App 391, 402; 591 NW2d 314 (1998). Accordingly, appellate courts have routinely scrutinized or invalidated promulgated rules that fail to follow the rulemaking process. See, e.g., *id*.; and *Slis v State*, 332 Mich App 312, 340–341; 956 NW2d 569 (2020). And Michigan courts have equally invalidated *unpromulgated* "rules" that fit the definition of MCL 24.207 when an agency has wholly circumvented the rulemaking process. See, e.g., *Palozolo v Dep't of Social Servs*, 189 Mich App 530, 533–34; 473 NW2d 765 (1991).

As examples of Michigan courts invalidating "rules" that were never promulgated, the Michigan Supreme Court in *AFSCME* held that a standard-form contract used by the Department of Mental Health in contracting with a few hundred group home providers constituted "rules" under MCL 24.207. 452 Mich at 5–6. The contract set standards for care and staff training requirements for these group homes. *Id*. at 7–8. And the Department's contract was inflexible, offered to the providers without negotiation. *Id*. at 5–6. The Supreme Court thus held that they were "rules" that were required to be promulgated. *Id*. at 3.

Likewise, the Michigan Court of Appeals held in *Delta County v Department of Natural Resources*, 118 Mich App 458; 325 NW2d 455 (1982) that conditions of a license for solid waste disposal facilities (i.e., what would now be an operating license under Part 115 of NREPA, see MCL 324.11512), that required a licensee's adherence to 31 departmental guidelines and policies were also "rules" under the APA. The Court observed that the agency's conditioning a license on a person's acceptance of such guidelines made the guidelines "effectively . . . rules under the guides of guidelines and policies." *Id.* at 468. The Court rebuked the agency, noting that "[t]he rights of the public may not be determined, nor licenses denied, on the basis of unpromulgated policies." *Id.*, citing *Mallchok v Liquor Control Comm'n*, 72 Mich App 341; 249 NW2d 415 (1976). And the Court admonished that "[t]he rulemaking procedures of the APA may not be circumvented." *Id.*

More recently, the then-Chief Judge of the Court of Appeals—acting as a Court of Claims judge in *Genetski v Benson*, Ct of Claims Docket No 20-000216-MM—invalidated Secretary of State guidance or directives as unpromulgated rules that should have been promulgated under the APA. (Ex. A, *Genetski v Benson*, at 8.) Though that opinion is not binding precedent, it is instructive on an identical issue, and it should be carefully considered. See, e.g., *Stirling v County of Leelanau*, 336 Mich App 575, 579 n 2 (a trial court's legal rulings should be given "careful consideration"). Taken together, these cases illustrate both that "rules" are not defined by whether they are promulgated and also that an unpromulgated rule meeting the definition of MCL 24.207 is procedurally invalid.

B. *The Revised Permit Conditions are Agency Standards, Policies, or Regulations of General Applicability Implementing Law Administered by EGLE.*

The conditions of the 2020 CAFO General Permit are certainly "rules" within the meaning of MCL 24.207. When EGLE set generally applicable farm standards for CAFOs in 2005 prior to the adoption of its 2005 CAFO General Permit, it did so via administrative rule. Mich Admin Code, R 323.2196. The new permit conditions cover many of the same topics as Rule 2196, and they do so in ways that differ from and are inconsistent with that Rule. Nonetheless, EGLE did not promulgate these new standards. Instead, EGLE wrote them directly into its 2020 CAFO General Permit when coverage under the General Permit or an individual permit is mandatory and EGLE maintains full discretion over whether a farm is placed within one or the other. Mich Admin Code, R 323.2196(1)(b) ("All CAFO owners or operators shall apply either for an individual NPDES permit, or a certificate of coverage under an NPDES general permit . . . ."); Mich Admin Code, R 323.2191(3) (any person in a General Permit may be moved to an individual permit); Mich Admin Code, R 323.2192(d) (EGLE has discretion to terminate individual permits and move an individual to a general permit).

As discussed above, an agency policy constitutes a "rule" if it is: (1) a "regulation, statement, standard, policy, ruling or instruction"; (2) it has "general applicability"; (3) it "implements or applies law enforced or administered by the agency"; and (4) it is not specifically exempted under the statute's carveouts. MCL 24.207. EGLE's new conditions for the 2020 CAFO General Permit meet each of these criteria.

First, the new conditions of the 2020 CAFO General Permit set "standards," "polic[ies]," or "regulations" for large livestock farms qualifying as CAFOs. *Id*. EGLE staff acknowledged that these new permit conditions are regulatory in nature. (1176:21–22) ("a permit is a regulatory context"); see also MCL 324.3115(1). These conditions "are not voluntary." (75:3–5.) They are "required" and not a "suggestion or recommendation." (123:8–18.) Ordinarily, general permits apply a set of conditions to similar operations when the agency determines that discharges from those operations can be controlled using similar requirements. (Vol. I, 97:1–3); Mich Admin Code, R 323.2191(1) ("Upon a determination by the department that certain discharges are appropriately and adequately controlled by a general permit, the department may issue a general permit to cover a category of discharge."). And the conditions of a general permit set minimum standards for a particular type of operation or a particular category of discharge. (*Id*. at 97:6–9.)

Second, these standards, policies, and regulations have "general applicability"—as opposed to a more limited, case-by-case quasi-judicial determination. CAFOs are mandated to have an NPDES permit with very few exceptions. Mich Admin Code, R 323.2196(1)(b). "Nearly all" (or 92.4%) of CAFOs are governed by the General Permit. (2503:8–14.) Almost all remaining CAFOs are regulated under EGLE's individual permits which reflect the terms of EGLE's General Permit as a minimum standard. (110:14–20.) And EGLE exercises unbridled control over which farms are issued a General Permit. Mich Admin Code, R 323.2191(5) and R 323.2192(d). Thus, these conditions apply broadly to a class of farms and have "general applicability." *Hinderer v Dep't of Social Servs*, 95 Mich App 716, 725 (1980) (lag budgeting system met this requirement because it affected benefit recipients generally). To that point, EGLE has even called these conditions an exercise of "quasi-legislative power" in briefing in the related declaratory judgment action. (Ex. B, EGLE MSD, p. 15.) That is the very type of action that must be submitted to rulemaking. *Detroit Base Coalition*, 431 Mich at 178.

Even without that acknowledgment, EGLE's actions here were plainly a quasi-legislative exercise of power as the adoption of binding policy that goes beyond the existing regulatory standards. (Ex. A, *Genetski* Opinion, p. 8) ("An agency must utilize formal APA rulemaking procedures when establishing policies that 'do not merely interpret or explain the statute or rules from which the agency derives its authority,' but rather 'establish the substantive standards implementing the program.'"), quoting *Faircloth*, 232 Mich App at 403–404. EGLE's Livestock Committee drafted a list of policy prerogatives. (Ex. P-29.) Those policy prerogatives were discussed and voted on by the Livestock Committee prior to any stakeholder meetings or public hearing. (1046:14–22.) Livestock Committee members then voted on their policy priorities using a Starburst-candy straw poll. (479:19–480:8; Vol. V, 1046:21–24 & 1047:4–10.) Those priorities then served as the basis for the initial drafting of the revised 2020 CAFO General Permit, which incorporated specific language to effectuate the policy changes that EGLE had already determined to make. (Vol. I, 138:6–20; Vol. II 335:13–15; 1038:19–21.)

Second, these conditions "implemen[t] or appl[y] law enforced or administered by the agency." Indeed, EGLE claims that these revisions effect its authority under Part 31 of NREPA, MCL 324.3101 *et seq.* (58:10–16; 63:9–66:3.) Whether the conditions accurately implement Part 31 or not, EGLE has certainly acted under Part 31 in establishing these standards and will enforce them on CAFOs under that Act where the standards serve as mandatory and enforceable permit conditions. Mich Admin Code, R 323.2196(1)(b); MCL 324.3112. As such, the violation of these standards is considered an enforceable violation of Part 31 that is subject to civil penalties and injunctive action. MCL 324.3115(1).

Third, no statutory exemption applies. On this last prong, EGLE previously attempted to rely on MCL 24.207(j) in its Court of Claims' briefing. That subsection exempts "[a] decision by an agency to exercise or not to exercise a permissive statutory power, although private rights or interests are affected." *Id*. But the exemption, which must be narrowly construed, *AFL-CIO*, 452 Mich at 9, protects only an agency's decision *whether* to exercise a permissive statutory authority and does not shield agencies from being required to promulgate rules justifying or exemplifying *how* they apply such power. *Spear v Mich Rehab Servs*, 202 Mich App 1, 4; 507 NW2d 761 (1993) (deciding to employ a welfare needs test was covered by the exemption but the agency needed to promulgate a rule explaining its test). Thus, the agency's decision to employ a general permit for a particular sector may be a "decision . . . to exercise . . . a permissive statutory power." MCL

24.207. But EGLE's writing of new substantive standards into the CAFO General Permit is not. The decision to use a General Permit does not require writing new standards. Nor does it assume that the agency will do so. Indeed, the 2005, 2010, and 2015 CAFO General Permits each evidence that EGLE can make that choice without writing new standards that go beyond those adopted in state and federal rules or statutes and can do so instead by incorporating existing standards.

The conclusion that EGLE's new General Permit conditions are "rules" is consistent with the Michigan court decisions considering whether agency actions are "rules," including the *AFSCME* and *Delta County* decisions discussed above. Like the agencies in both of those cases, EGLE here seeks to fold new, mandatory standards into a form document. Because those standards are generally applicable policies of the agency, they are "rules." MCL 24.207.

Further buttressing this analysis, several courts have found either general permits or the conditions thereof to be "rules." For example, in *National Association of Home Builders v United States Army Corps of Engineers*, 417 F3d 1272 (CADC, 2005), the U.S. Court of Appeals for the D.C. Circuit held that nationwide permits issued by the Army Corps under the Clean Water Act, see 33 USC 1344(e)(1), constituted "rules" subject to the rulemaking provisions of the federal APA. *Id*. at 1284. That court explained:

> Each [nationwide permit] easily fits within the APA's definition of a 'rule.' This is so because each [nationwide permit], which authorizes a permittee to discharge . . . is a legal prescription of general and prospective applicability which the Corps has issued to implement the permitting authority the Congress entrusted to it in section 404 of the CWA. As such, each [nationwide permit] constitutes a rule: An 'agency statement of general or particular applicability and future effect designed to implement, interpret, or prescribe law or policy.' [*Id*. at 1284–85.]

The D.C. Circuit reaffirmed this holding in *Lake Carriers Association v US Environmental Protection Agency*, 652 F3d 1, 6 n 3 (CADC, 2011). See also *NRDC v US EPA*, 279 F3d 1180, 1183 (CA9, 2002) ("[g]eneral permits . . . are issued pursuant to administrative rulemaking procedures"); *Alaska Community Action on Toxics v Aurora Energy Servs, LLC*, 765 F3d 1169, 1172 (CA9, 2014) ("general permits are considered to be rulemakings."). Similarly, an ALJ in North Carolina recently reached the exact same conclusion suggested here—that conditions of that State's CAFO General Permit were rules that require promulgation. (Ex. C, NC ALJ Decision.)

EGLE adopted generally applicable standards that the agency will apply to the livestock farm industry on a widespread basis. These new conditions of the General Permit fall within the definition of "rule" under MCL 24.207. The APA requires EGLE to follow a process in adopting such "rules." *Detroit Base Coalition*, 431 Mich at 178–79 (1988); MCL 24.226; MCL 24.243. EGLE admittedly did not do so.

C. *EGLE's New Conditions Are Procedurally Invalid Because EGLE Did Not Engage in Any of the Required Procedures for Rulemaking.*

Rules are procedurally invalid if they do not follow the procedures required by the APA. *Mich Charitable Gaming Ass'n*, 310 Mich App at 594; *Clonlara, Inc v State Board of Educ*, 442 Mich 230, 247; 501 NW2d 88 (1993). The APA rulemaking process includes, among other requirements: (1) obtaining pre-approval for rulemaking from a central office with direct accountability to the Governor, MCL 24.239(1) & MCL 24.239a; (2) developing cost-benefit analyses requiring estimates of the regulatory burdens on those subject to the rules and expected benefits to the citizens, analysis of the effect of rules on the revenue of state and local government, and more, MCL 24.245(3); (3) providing stakeholder's notice and an opportunity for public comment in the APA-prescribed manner, MCL 24.241 & MCL 24.242; (4) submitting the agency's policies to legislative oversight via the Joint Committee on Administrative Rules consisting of members of both houses in the Legislature, MCL 24.245a; (5) attempting to minimize the impact of the rules on small business, see, MCL 24.240, 24.245, & MCL 24.245a; (6) where applicable, making findings "that there is a clear and convincing need to exceed the applicable federal standard" for each exceedance of the federal standard, MCL 24.232(8); and (7) for EGLE, providing its proposed rules to an Environmental Rules Committee composed of scientific, governmental, and industry experts for their input, MCL 24.266. EGLE here has conceded that it did not follow *any* of the processes required for rulemaking in adopting its new farm standards that were incorporated as conditions into the 2020 CAFO General Permit.

EGLE did not fill out any request for rulemaking. (Vol. I, 128:11–14.) EGLE did not contact ORR. (128:19–22.) EGLE did not draft an RIS. (128:23–25.) Nor did EGLE conduct any cost-benefit analysis. (129:8–130:20.) More specifically, EGLE did not estimate cost of taking fields out of production, (131:1–20); it did not estimate the cost of compliance with added record-keeping (134:25–135:14); it did not estimate the impacts to local units of government or state revenues, (137:6–12); it did not estimate the impacts on small businesses, (137:13–18); it did not calculate how many fields would be impacted by Soil Test P reduction, (143:24–144:9, 201:25–202:5); and it did not quantify any of the environmental benefits of the rules in the way of any reduction of discharges that could be attributed to these new standards. (135:15–19.) EGLE's failure to account costs and benefits is particularly significant given the compliance costs for the proposed conditions discussed above.

Accordingly, there is no factual dispute that EGLE did not follow any of the required processes for rulemaking. If this Tribunal determines that EGLE's new CAFO standards are "rules" under MCL 24.207 (and they are), then they are procedurally invalid rules. MCL 24.226; MCL 24.243; *Mich Charitable Gaming Ass'n*, 310 Mich App at 594. This Tribunal must strike them from the 2020 CAFO General Permit prior to its issuance.

D. *EGLE's New Conditions Are Substantively Invalid Under* Luttrell.

Not only are EGLE's new farm standards for CAFOs procedurally invalid as rules, but they are also substantively invalid. A rule is substantively invalid if it is: (a) outside of the scope of the enabling statute; (b) contrary to the underlying legislative intent; or (c) arbitrary and capricious. *Luttrell v Dep't of Corrections*, 421 Mich 93, 100; 365 NW2d 74 (1984). "[T]he provisions of the rule must, of course, be construed in connection with the statute itself" and, in case of a conflict, the statute governs. *McKibbin v Michigan Corp and Securities Comm'n*, 369 Mich 69; 119 NW2d 557 (1963). And "agencies cannot exercise legislative power by creating law or changing the laws created by the Legislature." *Detroit Edison Co v Dep't of Treasury*, 498 Mich 28, 46; 869 NW2d 910, 819 (2015).

EGLE has conceded that the rulemaking authority it holds under Part 31 of NREPA is very limited. Christine Alexander argued in her direct testimony that EGLE has "not had rulemaking authority [under Part 31] since January 1, 2007." (Vol. I, 68:12–13.) But she agreed that the reality is a bit more nuanced. EGLE has rulemaking authority to the extent necessary to comply with federal law. (124:19–22.) Further, EGLE has promulgated rules in the past, (126:7–12), and EGLE has an existing administrative rule for CAFOs. (126:22–24); Mich Admin Code, R 323.2196. The statute permits those existing rules to remain in place. MCL 324.3103(4). But EGLE may not "promulgate any additional rules" except for: (a) those rules "authorized under section 3112(6); and (b) those rules that "may be necessary to comply with the federal water pollution control act, 33 USC 1251 to 1387 . . . ." MCL 324.3103(2) & (3).

The testimony indicated that EGLE's new farms standards goes well beyond what is required by federal law. (See, e.g., Vol. I, 201:15–21 (setbacks and buffers); Vol. V, 1136:10–11 & Vol. X, 2558:4–14 (winter ban); Vol. X, 2771:12–2772:8 (soil test phosphorus).) In fact, EGLE has only claimed that *one* of its new requirements was required by U.S. EPA—the 15-day public noticing of additional nitrogen. That point is disputed as discussed further below. See Section V.B.3, *infra*. Nonetheless, all the remaining new standards indisputably go well beyond federal law. Accordingly, EGLE has far exceeded the scope of the enabling act in developing these rules. They are substantively invalid.

II. The Revised Conditions of the 2020 CAFO General Permit Are Contrary to its Own Administrative Rules and Therefore Invalid.

Not only was EGLE required to promulgate its rules, but its proposed conditions also contradict the *existing* rule. For those reasons, these conditions are contrary to law and must be stricken from the permit.

Duly promulgated rules have the force and effect of law. *Danse Corp v City of Madison Heights*, 466 Mich 175, 183–184; 644 NW2d 721 (2002). An agency is thus bound to follow its own administrative rules. *Grass Lake Improvement Bd v Dep't of Envt'l Quality*, 316 Mich App 356, 366–367; 891 NW2d 884 (2016). Michigan Administrative Code, Rule 323.2196 is therefore binding on EGLE regarding CAFOs. Accordingly, EGLE's permit conditions must comply with and must be consistent with the provisions of that rule.

To understand that rule, the same canons and rules of statutory interpretation apply to the interpretation of administrative rules. *Airgas Specialty Products v Michigan Occupational Safety & Health Admin*, __ Mich App __; __ NW2d __, 2021 WL 382006, *5. The primary goal is to interpret statutes according to their plain-language meaning and in their grammatical context. *Maxwell v Citizens Ins Co of America*, 245 Mich App 477, 482; 628 NW2d 95 (2001), quoting *Bailey v DAIIE*, 143 Mich App 223; 371 NW2d 917 (1985); *Menard, Inc v Dep't of Treasury*, 302 Mich App 467, 471; 838 NW2d 737 (2013) (statute must be read "in its grammatical context"). That includes looking to the dictionary to define a word. *Cole v Auto Owners Ins Co*, 272 Mich App 50, 53; 723 NW2d 922 (2006) ("To determine the ordinary meaning of a term, we may refer to a dictionary.") Longstanding canons of interpretation also apply to discern a rule's meaning.

City of Coldwater v Consumers Energy Co, 500 Mich 158, 170–171; 895 NW2d 154 (2017) (applying canon of *expressio unius* to a rule).

Here, several of the new conditions in EGLE's 2020 CAFO General Permit conflict with Rule 2196. Consequently, they must be stricken from the General Permit prior to its issuance.

A. *EGLE's Presumptive Winter Ban Conflicts With Rule 2196, Which Permits the Application of Manure to Frozen or Snow-Covered Ground.*

First, EGLE has improperly adopted a presumptive winter ban on the land-application of manure. (Ex. R-45, Section I.B.3.f.3.) But Rule 2196 expressly permits the land-application of manure to frozen or snow-covered ground under appropriate conditions, which are spelled out in detail in that Rule. And it does not apply date restrictions. Rule 2196 states that:

> (5) CAFO NPDES permits **shall include** **all of the following**:
>
> (a) A requirement to develop and implement a comprehensive nutrient management plan (CNMP). At a minimum, a CNMP ***shall include*** *best management practices* . . . ***including all of the following***: . . .
>
> (*ix*) Ensure proper land application ***by complying with all of the following*** conditions: . . .
>
>> (C) Production area waste and CAFO process wastewater ***may be surface-applied to frozen or snow-covered ground*** and not incorporated within 24 hours ***only if there is a field-by-field demonstration in the CNMP showing that such land application will not result in a situation where production area waste and CAFO process wastewater may enter waters of the state.***
>
> [Mich Admin Code, R 323.2196(5)(a)(*ix*)(C).]

Rule 2196(5) thus unambiguously mandates inclusion of certain NPDES permit conditions. It states that "CAFO NPDES permits ***shall*** include" a requirement to develop a CNMP, and in turn, the requirements for that CNMP "***shall*** include . . . the all of the following" conditions. *Id*. The word "shall" "indicates a mandatory directive." *People v Lockridge*, 498 Mich 358, 387; 870 NW2d 502 (2015). Accordingly, EGLE is mandated to include each of those specific provisions for CNMPs within the 2020 CAFO General Permit as with any CAFO NPDES permit.

Included within those mandated conditions, Rule 2196 expressly allows that "production area waste and CAFO process wastewater ***may be*** surface-applied to frozen or snow-covered ground" under appropriate conditions. Mich Admin Code, R 323.2196(5)(a)(*ix*)(C). The practice is permitted when manure "is subsurface injected" or "is surface-applied and incorporated within 24 hours." Mich Admin Code, R 323.2196(5)(a)(*ix*)(B). And it is permitted even without incorporation or injection "if there is a field-by-field demonstration in the CNMP showing that such land application will not result in a situation where . . . waste . . . may enter waters of the state." Mich Admin Code, R 323.2196(5)(a)(*ix*)(C). Neither of these provisions is timebound. This express requirement under Mich Admin Code, R 323.2196 that permits must "compl[y] with all of the following conditions" that *expressly permit* land application under certain conditions is directly at odds with EGLE's presumptive ban on wintertime application in a purported effort to prevent application to frozen or snow-covered ground. Mich Admin Code, R 323.2196(5)(a); (Ex. R-45, Section I.B.3.f.3.) In other words, EGLE cannot prohibit what Rule 2196 expressly permits.

Nor can EGLE expand a prohibition to things not listed in the Rule. Rule 2196 prohibits the application of manure to frozen or snow-covered ground under certain specified and listed conditions. Specifically, the Rule forbids applying to "frozen, or snow-covered ground where the production area waste . . . may enter waters of the state . . . ." Mich Admin Code, R 323.2196(5)(a)(*ix*)(A).The prohibition of land application under those specified conditions thus implicitly permits land application under *different* conditions. *Detroit City Council v Mayor of Detroit*, 283 Mich App 442, 456; 770 NW2d 117 (2009). And in expanding a prohibition that applies to certain in that instance of specified conditions to which a rule applies, "[t]he application of the canon of statutory interpretation *expressio unius est exclusio alterius* directs us to read" such omissions "as meaningful . . . ." *City of Coldwater*, 500 Mich at 170. So EGLE may not prohibit what Rule 2196 allows.

EGLE cannot add a winter ban in conflict with its own rule, which it is bound to apply. *Grass Lake Improvement Bd*, 316 Mich App at 366–367. Holding otherwise would allow EGLE to rewrite its existing administrative rule outside of the rulemaking process.

B. *EGLE's "Immediat[e]" Incorporation or Injection Requirement is Contrary to the 24-Hour Standard of Rule 2196.*

Similarly, EGLE's new permit's "immediate" incorporation requirement contradicts Rule 2196. The new condition requires that "[d]uring January, February, [and] March all CAFO waste shall be incorporated *immediately* following application, or injected." (Ex. R-45, Section I.B.3.g.) Christine Alexander testified that by "immediately" EGLE means "the equipment would be following the application of the manure" and "behind or very near behind" it. (Vol. I, 173:19–23.) Likewise, Bruce Washburn testified that the only ways to comply with this condition are to inject manure or to "hav[e] a tractor follow along the spreader." (Vol. III, 649:8–14 & 653:1.)

Rule 2196 provides to the contrary. A requirement for land-applying manure in NPDES permits "shall" be that, whether frozen or not, "if not subsurface-injected" then manure "shall be incorporated into the soil within 24 hours of application except on no-till fields." Mich Admin Code, R 323.2196(5)(a)(*ix*)(C) & (5)(a)(*ix*)(E). In other words, the rule already provides when incorporation is mandated and under what conditions: on non-frozen ground "within 24 hours" or, where able, on frozen ground within the same timeframe. Mich Admin Code, R 323.2196(5)(a)(*ix*)(B) & (5)(a)(*ix*)(E). Once again, EGLE's new condition circumvents the rule.

C. *EGLE's Manifesting Ban Conflicts With the Express Allowance of Manifesting Under Rule 2196.*

EGLE's new ban on manifesting waste for a quarter of the year is similarly contrary to the existing, binding conditions of Rule 2196. That Rule speaks directly to transfers of manure to other persons, and it places conditions on what must take place when that occurs. It states:

> *[I]n cases where production area waste or CAFO process wastewater is sold, given away, or otherwise transferred to other persons (recipient) and the land application* of that production area waste or CAFO process wastewater *is not under the operational control of the CAFO owner or operator* that generates the production area waste or CAFO process wastewater (generator), *a manifest shall be used* to track the transfer and use of the production area waste or CAFO process wastewater. [Mich Admin Code, R 323.2196(5)(e) (emphasis added).]

The Rule further states "[t]he CAFO owner or operator shall do all of the following: (A) Prepare a manifest for tracking the production area waste . . . [and] (B) Designate on the manifest the recipient of the production area waste . . . ." Mich Admin Code, R 323.2196(5)(e)(*i*)(A) & (5)(e)(*i*)(B).) It requires the CAFO (or "generator") to take certain steps with respect to the manifest. Mich Admin Code, R 323.2196(5)(e)(*iii*). And it explicitly prohibits CAFOs from "sell[ing], giv[ing] away, or otherwise transfer[ing] production area waste or CAFO process wastewater" under certain conditions. Mich Admin Code, R 323.2196(5)(e)(*v*).

None of the conditions placed on the transfer of manure *altogether prohibit* a CAFO from manifesting during three months of the year as EGLE has done in the permit. In fact, the Rule ***does*** prohibit transfer under certain conditions—but a calendar-based prohibition is not among those. Once again, Rule 2196 expressly speaks to the conditions under which manifesting may take place and expressly provides certain conditions when manifesting is prohibited but does not include the months of January through March among those. EGLE cannot prohibit by permit what it permitted by Rule—and thereby circumvent the rulemaking process. *City of Coldwater*, 500 Mich at 170.

D. *EGLE's Added Requirements for the Form of Manifesting Contradict Rule 2196.*

Similarly, the rule provides for exactly the "information" that must be collected in a manifest. Mich Admin Code, R 323.2196(5)(e)(*i*)(A)–(J). Those conditions are extensive and exhaustive, covering a CAFO's personal information, the recipient's information, the nutrient content of the manure, the quantity, and various statements by each party as to what will be done with the manure. *Id*. In the 2020 CAFO General Permit, EGLE has added to this list. (Ex. R-45, Section I.C.8.a.) Again, EGLE cannot do so. The Rule has expressly addressed and listed the content that a manifest must include; EGLE's additional information requests are not among those. *Detroit City Council*, 283 Mich App at 456. EGLE may not add to that list.

E. *EGLE's Addition of Quarterly Reporting is Contrary to Rule 2196.*

Finally, EGLE's addition of quarterly reporting in the general permit also contradicts the explicit requirements of Rule 2196. (Ex. R-45, I.B.3.e.) Mich Admin Code, R 323.2196(5)(f) plainly states "CAFO NPDES permits *shall include* all of the following: . . . (f) A requirement that the CAFO owner or operator shall submit ***annual reports*** to the department." In other words, EGLE has adopted by rule an annual reporting requirement—not quarterly. *Id*. EGLE is not free to deviate from its own rules. *Micu v City of Warren*, 147 Mich App 573; 382 NW2d 823 (1985) ("…once promulgated, the rules made by an agency govern its activity and cannot be violated or waived by the agency that issued the rules."). This condition cannot stand.

III. EGLE Has Prejudiced Petitioners' Rights by Failing to Evaluate the 2020 CAFO General Permit Under the Property Rights Preservation Act.

EGLE has also failed to evaluate whether the conditions of the 2020 General Permit results in a taking contrary to the Property Rights Preservation Act, MCL 24.421 *et seq*. MCL 24.424 requires that "[p]rior to taking a governmental action . . . [EGLE] . . . *shall review the takings assessment guidelines* prepared under section 3 and *shall consider the likelihood that the* *governmental action may result in a constitutional taking*." (Emphasis added). EGLE admittedly did not do that here. (Vol. I, 228:2–8.)

Its failure to consider the takings implication of its new permit conditions is highly prejudicial to petitioners here. EGLE has mandated that fields receiving land-applied manure must install a 35-foot wide, permanent vegetated buffers of perennial vegetation along any watercourse or even "roadside ditch" that might lead to a watercourse, (Ex. R-45, Section I.B.3.h.), and must place a 50-foot buffer "along the perimeter" of any field for many farms within a TMDL that do not install a "treatment system." (Ex. R-95, p. 5.) That eliminates any productive use of those areas and excludes growing traditional cash crops on valuable farmland. (Vol. I, 132:6–134:14; Vol. III, 585:9–586:4; Vol. X, 2568:3–25; 2569:8–10.) Making this requirement a condition of the general permit raises serious questions of committing a taking under both the *Loretto* and *Nollan/Dolan* frameworks. *Loretto v Teleprompter Manhattan CATV Corp*, 458 US 419; 102 SCt 3164; 73 LEd2d 868 (1982); *Nollan v California Coastal Comm'n*, 483 US 825, 837; 107 SCt 3141; 97 LEd2d 677 (1987). In fact, this condition *is* a taking. See Section IV, *infra*.

EGLE's failure to follow the law requires a remedy. Here, suitable remedies are either: (a) that EGLE eliminate this offending condition from the permit; or (b) at a minimum, that the agency restart the permit development process and comply with the law. Cf. MCL 24.306(1)(a) & (1)(c) (providing that a court could set aside EGLE's decision if it is "in violation of . . . a statute" or "made upon unlawful procedure resulting in material prejudice to a party").

IV. EGLE's Mandated Vegetated Buffer Strips Are Unconstitutionally Arbitrary Under Takings Clause Precedent.

EGLE's mandate to install vegetated buffer strips also unconstitutionally deprives farms of their property by preventing the beneficial use of wide swaths of farmland. This Tribunal should strike that condition for that reason alone.

A. *This Tribunal Has Jurisdiction to Consider Whether the 2020 CAFO General Permit Arbitrarily Deprives Petitioners of Their Private Property Rights.*

Farm Petitioners anticipate that EGLE will ask this Tribunal to ignore constitutional defects in the General Permit since it is not a judicial body. While this Tribunal undoubtedly lacks the authority as a quasi-judicial agency to hold statutes unconstitutional, it is not prevented from restraining unconstitutionally arbitrary executive action. For example, in *Wikman, v City of Novi*, the Supreme Court noted that an administrative agency does not "possess the power to hold statutes unconstitutional" but it may entertain "assertion[s], in constitutional terms, that" an executive action is "arbitrary and without foundation." 413 Mich at 647. Many other cases have applied the same distinction. See *Johnson v City of Livonia*, 177 Mich App 200, 207; 441 NW2d 41 (1989); *Meadowbrook Village Associates v City of Auburn Hills*, 226 Mich App 594, 597; 574 NW2d 924 (1997).

The former question (i.e., challenging a statute) is a problem for the separation of powers: the executive cannot exercise a quintessential judicial function by declaring the superiority of the Constitution over a statute in a particular instance and enjoining its application. *Marbury v Madison*, 5 US 137; 2 L. Ed. 60 (1803); see Mich Const 1963, art iii, § 2. (Indeed, this Tribunal has no injunctive powers, which are judicial. *Wikman*, 413 Mich at 647–648.) The latter problem is merely a question of executive self-restraint. But the Michigan Supreme Court in *Wikman* expressly blessed such executive self-restraint by noting that an administrative tribunal is not precluded from determining "an assertion, in constitutional terms" that an agency action "was arbitrary and without foundation." *Id.*; see also *Hillsdale Co Sr Servs, Inc v Hillsdale Co*, 494 Mich 46, 60, n 15; 832 NW2d 728 (2013). Importantly also, this Tribunal's decisions are reviewed for whether "the decision or order is . . . (a) In violation of the constitution . . . ." MCL 24.306(1)(a); Mich Const 1963, art vi, § 28. So, it makes sense that this Tribunal could identify constitutional concerns and, acting as the executive branch, hold the executive to the universal measuring stick of the constitution—the fundamental law and guide for all executive action. Accordingly, this Tribunal can (and should) entertain constitutional challenges to executive action.

B. *The Combined Vegetated Buffer and Setback Mandate Arbitrarily Deprives Petitioners of Their Property Contrary to Takings Clause Doctrine.*

When permits impose property-use restrictions as part of their issuance, courts review the validity of those restrictions under the "unconstitutional conditions" doctrine. Generally, that provides a three-part test.

First, the imposed condition must have an "essential nexus" to the harm the government seeks to mitigate. *Nollan*, 483 US at 837; see also *Lambert v City & Cty of SF*, 529 US 1045, 1046; 120 S.Ct. 1549; 146 L.Ed.2d 360 (2000) (Scalia, Kennedy, and Thomas, dissenting from the denial of certiorari) ("a burden imposed as a condition of permit approval must be related to the public harm that would justify denying the permit."). This ensures that the government is seeking to mitigate harm created by a property use, and not simply using permitting requirements as pretext to discourage development or acquire something it would otherwise have to pay for. *Nollan*, 483 US at 837.

Second, the mitigation must be "roughly proportional" to what is needed to eliminate the harm or externality which justifies the mitigation. *Dolan*, 512 US at 391; *Lambert*, 529 US at 1046. This is because when the "city demand[s] more" than what is required, that excess demand is not really mitigation at all, but a demand for a public benefit at private expense. See *id.* at 393.

Finally, the assessment of rough proportionality must be based on a site-specific "individualized determination" that the mitigation is related "both in nature and extent to the impact of the proposed development." *Dolan*, 512 US at 391. This site-specific approach ensures that governments cannot circumvent the requirements of *Dolan* with "conclusory statement[s]" about the public interest. *Id*. at 395. Each property is unique, and therefore the harm caused by a given property use will necessarily vary based on site-specific factors. By requiring that the government "make some effort to quantify its findings," *Dolan* ensures that the government does not by mere *ipse dixit* establish that a particular property use is harming one's neighbors, and demand mitigation based on imaginary harms. *Id*.; see also *Yates v City of Milwaukee*, 77 US 497, 505; 19 LEd984; 10 Wall 497 (1870) ("[T]he mere declaration by the city council. . . that a certain structure was an encroachment or obstruction did not make it so, nor could such declaration make it a nuisance unless it in fact had that character.").

The vegetated buffer requirement imposed by EGLE in the 2020 CAFO General Permit fails this test. This condition applies directly to farms who use Bray P1 soil testing. (Ex. R-45, Section I.B.3.h.) But farms who use the MPRA are under a similar mandate. (Vol. I, 154:13–22.) Sylvia Heaton conceded that the buffer stripe effectively eliminates usable acreage. (Vol. V, 1254:22–1255:1.) And both Christine Alexander and Bruce Washburn testified that most ordinary crops cannot be grown in these areas. (Vol. I, 132:6–134:14; Vol. III, 585:9–586:4.) That is EPA's interpretation as well. (Vol. X, 2569:8–10.) Nor could a road could be built in these buffer areas. (Vol. III, 586:17–20.) Instead, as the permit itself states, these buffers must be populated exclusively with "dense perennial vegetation" that cannot be harvested. (Ex. R-45, Section II.A) (defining "vegetated buffer" and "perennial.")

Yet EGLE has not performed any proportionality analysis. Nor is there any site-specific review performed processing a Certificate of Coverage, (Vol. II, 317:18–22), or as a matter of imposing this condition—it is simply a mandate of the General Permit. (Ex. R-45, Section I.B.3.h.) Accordingly, this property exaction required simply to be permitted as a CAFO—a permit which nearly every CAFO *must* obtain, Mich Admin Code, R 323.2196(1)(b)—is an unconstitutional exaction contrary to *Nollan/Dolan*.

Not only so, but this potentially gives rise to a *Loretto* taking as well. Mandatory physical occupations of private property for the public benefit constitute a *per se* taking requiring compensation. *Loretto*, 458 US at 438. Thus, in *Loretto v Teleprompter Manhattan CATV Corp*, the U.S. Supreme Court held that a state law requiring landlords to allow cable boxes to remain attached to their buildings constituted a *per se* taking. *Id*.

The buffer requirement at issue here is much more extensive. In many cases, EGLE is mandating significant swaths of each farm field to be converted into economically useless land occupied by "permanent" "dense perennial vegetation." (Ex. R-45, Section II.A) (defining "vegetative buffer"). For fields within a TMDL, this is expanded to a 50-foot buffer "along the perimeter" of *every* field—in other words, on all sides. (Ex. R-95, TMDL Guidance.) That amounts to a tremendous land-grab by the State, all of which is uncompensated. Those mandated physical occupations are unconstitutional under *Loretto*, and should be stricken from the general permit.

V. The Revised Conditions of the 2020 CAFO General Permit Are Not Necessary to Assure Compliance With State or Federal Regulations.

Finally, EGLE's new general permit conditions are not justified by its statutory power to set those permit conditions that are necessary "to assure compliance with" state and federal standards. MCL 324.3106. This provision does not give EGLE a free-hand to mandate whatever it believes *might* be beneficial; rather, the agency must justify permit conditions by showing they are required to comply with existing state or federal regulations. EGLE has not done so for the conditions at issue.

A. *EGLE May Only Require Such NPDES Permit Conditions as Are Necessary to "Assure Compliance With" Federal or State Standards for CAFOs.*

Michigan law recognizes that the authority of administrative agencies is limited by the scope of the enabling statute. Agencies have no common-law powers; they are creatures of statute. *York v City of Detroit*, 438 Mich 744, 767; 475 NW2d 346 (1991) (citing *McKibbin*, 369 Mich at 82. Thus, the "powers 'specifically conferred' on an agency 'cannot be extended by inference.'" *Herrick Dist Library v Library of Michigan*, 293 Mich App 571, 582–83; 810 NW2d 110 (2011). And an agency may exercise "no other or greater power . . . than that specified." *Id*. Instead, "the power and authority to be exercised by [agencies] must be conferred by clear and unmistakable language, since a doubtful power does not exist." *Consumers Power Co v Public Service Comm'n*, 460 Mich 148, 155; 596 NW2d 126 (1999), quoting *Mason Co Civil Research Council v Mason Co*, 343 Mich 313, 326–27; 72 NW2d 292 (1955); see also *In Re Reliability Plans of Electric Utilities for 2017–2021*, 325 Mich App 207, 222; 926 NW2d 584 (2018).

Permitting by an agency is an exercise of an agency's statutory licensing authority where a licensing or permitting scheme has been created by the Legislature. See MCL 24.205(a) (defining a "license" to include "the whole or part of an agency permit"). An agency may not condition a license or permit on stipulations that are not required by law. *Delta Co v Dep't of Natural Resources*, 118 Mich App at 458 (requiring conditions in agency licenses to be promulgated rules); *Mallchok*, 72 Mich App at 344 (requiring that "[a]bsent rules or regulations constituting grounds for denial, the MLCC shall grant plaintiff a license."). Generally, therefore, the conditions that an agency may place on a permit must be those that are necessary to achieve compliance with the underlying law. For example, MCL 324.1307(5) provides that, for most NREPA permits, "[a]pproval of an application for a permit may be granted *with conditions* or modifications *necessary to achieve compliance with the part or parts of this act under which the permit is issued* . . . .” (Emphasis added).

Following that principle, regulatory standards, such as effluent limitations in a water permit or nutrient management plans for CAFOs, are often incorporated into a permit. *Sierra Club Mackinac Chapter v Dep’t of Environmental Quality*, 277 Mich App 531, 553; 747 NW2d 321 (2008) (noting effluent limitations must be incorporated into a permit); *S Florida Water Mgt Dist v Miccosukee Tribe of Indians*, 541 US 95, 102; 124 S Ct 1537 (2004) (“Generally speaking, the NPDES requires dischargers to obtain permits that place limits on the type and quantity of pollutants that can be released into the Nation’s waters.”). That incorporation of legal requirements into a permit is “a classic example of administrative power” and an “exercise[e] [of] discretion as to the execution of the law.” *Detroit Edison Co v Michigan Air Pollution Control Comm’n*, 167 Mich App 651, 662–63; 423 NW2d 306 (1988). Those conditions of a permit reflect the conditions under which a regulated activity will comply with the underlying law.

Part 31 operates within this understanding. MCL 324.3106 specifies MEGLE’s authority for permits issued under that Part, stating: “The department shall issue permits *that will assure compliance with state standards* to regulate municipal, industrial, and commercial discharges or storage of any substance that may affect the quality of the waters of the state.” (Emphasis added.) Moreover, that section additionally grants that EGLE “*may* set permit restrictions *that will assure compliance with applicable federal law and regulations*.” *Id*. (emphasis added.) In other words, the object of a Part 31 permit is to: (1) “assure compliance with state standards”; and (2) “assure compliance with applicable federal law and regulations.” *Id*. EGLE has statutory authority to set permit conditions necessary to achieve those goals. But, being a creature of limited authority, EGLE may not require anything other than—or more than—what is required to achieve compliance with the underlying law. *Herrick Dist Library*, 293 Mich App at 582–83.

Importantly, when assessing the scope of the delegation under Part 31, it should be kept in mind that the rules governing CAFOs are not typical effluent limitations. Whereas most effluent limitations are set as numerical standards setting the amount of pollution that is acceptable as a calculation of volumetric concentration, CAFOs are governed by qualitative and behavioral standards. Setting conditions that "that will assure compliance with" a numerical standard simply requires incorporating the numerical limits into the permit. Not so with CAFOs. Instead, compliance with a *qualitative* standard is compliance with the effluent limitations. *Waterkeeper Alliance, Inc v United States EPA*, 399 F3d 486, 510 (CA2, 2005) (citing 40 CFR 412.4(c)(2)). So, the permit must include qualitative standards that are consistent with the federal and state regulatory qualitative standards for CAFOs and necessary to "assure compliance with" those standards. MCL 324.3106. EGLE does not have authority to impose qualitative standards beyond what is necessary to achieve compliance with existing standards merely because it believes that doing so will be beneficial.

For EGLE to claim such authority would present a constitutional problem under the non-delegation doctrine by effectively assuming lawmaking authority without adequate guiding principles. "Strictly speaking, there is *no* acceptable delegation of legislative power." *In re Certified Questions from United States District Court*, 506 Mich 332, 358; 958 NW2d 1 (2020). But "conferring authority or discretion as to [the law's] execution" is permissible depending on "whether the *degree* of generality contained in the authorization for exercise of executive . . . powers . . . is so unacceptably high as to amount to a delegation of legislative powers." *Id*. 358–359. Michigan's non-delegation doctrine thus demands that legislative delegations to administrative agencies be accompanied by reasonably precise standards to guide and constrain the agency in its implementation of the delegation. See, e.g., *BCBSM v Milliken*, 422 Mich 1, 51–55; 367 NW2d 1 (1985); *Oshtemo Charter Twp v Kalamazoo Cnty Rd Comm'n*, 302 Mich App 574, 592; 841 NW2d 135 (2013), *lv den*, 495 Mich 977; 843 NW2d 761 (2014). Standards "should be 'as reasonably precise as the subject matter requires or permits'" and will be upheld where "the Legislature provided clear, detailed standards to guide agency action and to facilitate judicial review." *State Conservation Dep't v Seaman*, 396 Mich 299, 310; 240 NW2d 206 (1976); *People v Turmon*, 417 Mich 638, 644, 647; 340 NW2d 620 (1983). "The scope of the delegation is also relevant when assessing the sufficiency of the standards." *In Re Certified Questions*, 506 Mich at 360. Generally, the broader the subject, the more precise the required standard. *Id*. at 361–362.

Courts must interpret statutes in a constitutional manner if possible. *People v Thue*, 336 Mich App 35, 48; 969 NW2d 346 (2021) ("when possible" a court "must interpret statutes to avoid constitutional issues"). Consequently, EGLE's ability to write permit conditions under Part 31 must not be interpreted as so open-ended as to allow the agency to legislate. Instead, it must be tied to substantive standards adopted as law through appropriate processes.

B. *The New Conditions of The General Permit Relating Are Not Necessary to Assure Compliance With Federal or State Standards.*

Applied here, the conditions of the 2020 CAFO General Permit go well beyond what is necessary "to assure compliance with" existing state and federal CAFO rules or water quality standards. MCL 324.3106. EGLE's new requirements go far beyond what the state and federal CAFO rules require. And EGLE has not made any showing that these conditions are necessary to satisfy the narrative water quality standard for nutrients. See Mich Admin Code, R 323.1060(2). Each condition is addressed in turn.

i. **Presumptive Winter Ban on Land Application**

EGLE's presumptive winter ban on the land application of manure is neither required by state or federal law nor necessary to assure compliance with those laws. Instead, both research and practical experience has concluded (and Kevin Elder, Laura Campbell, and David Trainor all testified) that such a ban will have unintended consequences *adverse* to the environment. The ban is thus an arbitrary and unjustified change with massive consequences for farms.

There is no federal or state calendar-based restriction on the land-application of manure. (Vol. V, 1136:10–11 & Vol. X, 2558:4–14.) EPA did not require this change. (Vol. V, 1138:14–21.) Nor does EGLE have any data supporting this change. (Vol. III, 561:22–564:3.) Rather, EGLE's purported justification for this requirement is instead just a general sense that it will decrease discharges and thereby minimize phosphorus. (Vol. I, 79:7–11; Vol. III, 641:10–16; see also Vol. II, 458:14–459:12 & Ex. R-65.) Michigan has historically followed 2005 Technical Standard, which required incorporation within 24 hours and same evaluation of application to frozen ground regardless of the time of year. (Vol. X, 2558:15–2560:2.) Incorporation is "the single most important practice to prevent runoff" and "[i]f manure is required to be incorporated, there is no environmental advantage to further restricting soil phosphorus rates" beyond their normal levels. (2565:7–13.) Indeed, Kevin Elder observed based on his years of experience in regulatory enforcement that phosphorus losses are relatively equivalent throughout different seasons other than the concern of applying onto frozen ground without incorporation. (Vol. XI, 2928:16–20.) In fact, he noted that "phosphorus will be more biologically available as the soil warms up because the warmer temperatures will release phosphorus into the soil." (2928:20–23.) In other words, there is nothing special in winter beyond the need to incorporate applications—which the 2005 Technical Standard already requires. Though EGLE relies on anecdotal examples of winter discharges, those merely demonstrate application that does not comply with the existing

Technical Standard. (Vol. X, 2565:16–2566:10.) They do not justify a need for a complete ban on land-application. (*Id.*)

EGLE's presumptive winter ban is thus inherently arbitrary. (Vol. XI, 2890:3–5.) Winter spreading restrictions under a calendar-based approach will eliminate eligible days even when the fields are not frozen or snow-covered. (Vol. IX, 2219:21–24.) "A calendar-based application restriction or ban does not follow the science of actual risk of manure runoff in frozen conditions, nor does it acknowledge the suite of more effective practices to minimize the risk of runoff if manure must be applied in frozen conditions." (Vol. X, 2554:7–12.) Instead, such a ban encourages making land-application decisions "based on calendar dates and not on soil or weather conditions," (2561:10–25; 2942:8–10)—the standard under federal regulations. 40 CFR 412.4(c). Thus, "[b]lanket timeframe exclusions for the land application of manure are impractical, counterproductive, unrelated to sound agronomic practice and overall bad policy." (Vol. XI, 2933:14–17.) And "[t]here are usually times each year within the restricted period where it is actually more suitable to land apply manure than at other allowed times depending on the weather." (2933:18–21.)

"Weather conditions vary widely, both from location to location in Michigan, and also from year to year," (Vol. X, 2562:20–2.) As examples, in East Lansing, soil temperatures in 2021 were below freezing for 33 days during the months of January through March, with the last day being February 26. (2563:1–4; Ex P-35.) The prior year, soil temperatures were below freezing for only three days, all of which were in late February. (2563:4–6; Ex P-36.) And, in 2018, soil temperatures dropped below freeing for only 7 days—all in early January. (2563:9–11; Ex. P-38.) In other words, the majority of the winter days from 2018 to 2021 "would be appropriate or manure application with incorporation of CAFO manure" in that area, but "application is now arbitrarily limited" based on the calendar and an exceptionally low Soil Test P level that most farm fields will not meet. (2563:12–16.) More particularly:

> Michigan weather does not always abide by the calendar, and the weather experienced in Southern Michigan does not mirror the weather in areas like Cadillac. Having a single restriction covering the entire state does not make sense . . . farms will lose days that they can be working in the field or growing crops based on a calendar restriction that is supposed to cover everyone uniformly across the state.

(Vol. XII, 3254:23–3255:6.) Thus, EGLE's time restrictions "make no sense from the perspective of their timing" and also "from the perspective of selecting fields appropriate for application." (Vol. X, 2564:24–2565:2.)

Not only is the ban unjustified, but it will also have several unintended consequences. *First*, a ban will likely shift manure applications to riskier times of the year. (2206:9–16) (opining that the ban means "putting more stress on the windows when you can apply (or manifest)"); (2890:11–15) ("By cutting off times that the weather is good for spreading, it simply pushes the farms to make bad management decisions . . . ."). In other words, "large amounts of manure" will need to be "land applied in small windows in high precipitation seasons." (Vol. IX, 2204:24–2205:2.) The vast majority of CAFOs need to spread manure before they plant. (Vol. III, 651:12–15.) For most crops, land application cannot occur when a crop is growing. (Vol. IV, 780:19–22; 1961:20–25.) Most planting must occur between April 1 and late May. (Vol. III, 573:21–574:11.) March is thus a valuable time for famers to spread manure because "manure needs to be applied as close to when the nutrients will be used as possible" to grow crops. (Vol. VIII, 1960:6–8; 2889:21–25; Vol. XI, 2892:2–12.) Further, the weather in March is often "warm and dry." (Vol. VIII, 1960:11–15.) By contrast, "the weather conditions in April do not always allow for spreading because manure cannot be spread when it is raining or when the fields are saturated." (1960:9–11.) And "[d]uring much of the spring, it is rainy or the ground is saturated." (Vol. XI, 2890:1–2; 2891:20–24) "[M]anure cannot be applied during rainfall events or when the land is flooded or saturated with water at the time of application." (Vol. VIII, 1961:5–7.) "So, overall, there are very few days in April where manure can be spread." (1961:9–10.) Accordingly, the ban reduces the window of eligible time for manure to be spread, (Vol. III, 658:5–9), placing a ban on March pushes more land application into April and May, (Vol. VIII, 1960:21–25 & 1961:10–12)—months that are both wetter and riskier for nutrient runoff. (Vol. III, 574:12–16; Vol. VII, 1682:12–16; Vol. VIII, 1963:11–21; Ex. P-92, p. 2.)

For those reasons, Kevin Elder opined that calendar-based restrictions "make water quality impacts worse right before and after the dates, depending on weather events." (Vol. XI, 2940:12–14.) He explained that:

> The calendar-date restrictions encourage farmers to engage in applications right before the deadline or right after the deadline, and then manure is not being applied under ideal condition. Thus, time-related conditions tend to discourage good manure management. Instead, you want to apply the manure based on weather conditions. [2934:1–8.]

He also noted that this "can lead to more total manure being applied in shorter periods of time and, if bad weather conditions occur shortly after applications, then it will cause a larger runoff event of more nutrients tha[n] if they are applied during better soil conditions regardless of a prohibited dat[e] timeframe." (2940:3–8.)

Researchers have noted similar concerns. Dr. Steven Safferman of MSU has explained that significant restrictions on winter application can lead to "[o]vertaxing long-term storage systems can lead to overflows, spills, or the need to make emergency applications during spring thaw months, which are most sensitive to manure application." (Ex. P-92, pp. 1–2.) Additionally, Dr. Safferman noted that "this sensitivity to manure releases can correspond with environmental sensitivities as well," as "the most correlated anthropogenic factor" for HABs is "total phosphorus influent" during *the spring*. (Ex. P-92, pp. 2.) Indeed, even EGLE in its response to comments acknowledged that "there is potential for soluble reactive phosphorus to increase and be transported off the landscape into surface water after a complete January, February, March ban on CAFO waste applications." (Ex. R-112, p. 28.) Practical experience has borne this out: in Ohio, the Grand Lakes/St. Mary's Soil Water Conservation District banned winter application, and "since then," it has "had significant problems." (Vol. XI, 2933:23–25.)

Though EGLE claimed to address this concern by moving from a "total ban" to a presumptive ban, it has not done so. EGLE's presumptive ban is still a practical ban in most instances. (Vol. IX, 2204:6–10.) Thus, the proposed condition will pressure farmers to land apply during conditions presenting a greater risk of runoff, (Vol. VIII, 1963:11–21), and/or shift application to times that are not aligned with the agronomic needs crops receive from the nutrients provided by manure. (Vol. IX, 2207:9–14.) In either event, it presents a more significant environmental risk than allowing land-application based on field and weather conditions like in the 2015 CAFO General Permit.

Second, a presumptive ban will shift the fertilization of crops prior to planting to commercial nutrients. (Vol. XI, 2934:15–17.) Despite EGLE's bans, farms can still apply nutrients through any other means. (Vol. III, 670:3–5.) In most cases, they must do so prior to planting. (651:12–15.) Thus, a strict calendar-date prohibition tends to incentivize applying commercial fertilizers during the banned time. (Vol. XI, 2949:23–25.) For the reasons already discussed, that shift is bad for water quality, increasing dissolved reactive phosphorus loadings. See Statement of Facts, pp. 38–40, *supra*.

Third, because a winter ban encourages spring application that causes compaction (and associated water quality concerns)."[T]ypically, you cannot get land application equipment (such as tractors and spreading equipment)" on wet soils because it is muddy and "causes a compaction problem." (2891:11–14.) Compaction is a "robber of yield" for farmers. (2891:16–19.) And “[o]nce compacted, it may take a long time—sometimes many years—for the soil to be restored to a better condition.” (2934:24–25.) Significantly, compaction also increases runoff and lessens the ability of the soil to quickly adsorb or attach nutrients and water. (2935:11–14.) That lower adsorption and greater runoff directly correlate to increased nutrient loading. (See, e.g., Vol. IX, 2184:11–13.) Relatedly, studies have shown less sediment loss from fields where manure had been applied during winter than bare soil due to the stabilizing effect on soil aggregates. (Vol. X, 2552:9–14; Ex P-94.)

Finally, EGLE’s presumptive ban will create added stress on Michigan roads. Indeed, the Michigan Townships Association, Michigan County Roads Association, and Michigan Association of Counties all commented that “if manure hauling and application is severely limited or prohibited” in winter, “much larger volumes of manure would need to be hauled in April when those restrictions lift.” (2554:21–2555:14; Ex. P-32.) This “will increase damage to roads, bridges, shoulders, and culverts,” (2555:6–7), and “as few as 10 passes with a fully loaded manure spreader in spring conditions . . . can permanently damage hard surface roads.” (2555:9–12.) In its response to comments, EGLE “recognize[d]” that “the restrictions of and potential conflicts with weight loads.” (Ex. R-112, p. 32; see also Vol. II, 350:215–353:1.) In other words, not only will this ban be bad for water quality but it is also bad for Michigan’s roads.

But even if EGLE’s proposed presumptive ban were justified (and it is not), it is still arbitrarily overly broad. For starters, EGLE’s rationale of preventing snow or frozen ground driven discharges most often does not apply in March. Most CAFOs are located in the southern half of lower peninsula. (Vol. I, 183:7–13.) Yet weather data indicates that the ground is not often frozen in March in that region. (Vol. X, 2563:1–4; Ex P-35; 2563:4–6; Ex P-36; 2563:9–11; Ex. P-38; 2563:12–16.) Even EGLE’s meteorologist Jim Haywood opined that “it is not rare for an early, dry Spring to occur in March that could provide an adequate ground that for soil work and surface application [of manure].” (Vol. VII, 1669:21–22.) For example, conditions in March 2021 would have been favorable for land application. (1676:11–16.) Overall, he believed there is about a 50% chance of conditions being favorable for land application in March. (Vol. VI, 1580:4–5; Vol. VII, 1677:8–20.) Moreover, weather cannot be accurately predicted more than 8 days in advance; it's an “educated guess” beyond that. (Vol. II, 1681:18–19.) Given those odds, EGLE's presumption of unfavorable land application conditions during each day of March for the next five years is simply an untenable gamble with the future of Michigan farming. And restricting application in March “makes it very difficult to get nutrients applied prior to planting crops that need those nutrients at the best time for nutrient uptake.” (Vol. XI, 2934:11–15.)

Additionally, EGLE's proposed presumptive ban arbitrarily places a unique burden on poultry farms even though poultry litter is the least likely form of manure to result in a winter discharge. (Vol. XII, 3255:10–11.) As Rick Sietsema explained, poultry litter is only “about 35 percent moisture” and about half is “bedding material” like “wood shavings bedding like you might have for a pet rabbit or guinea pig.” (Vol. IX, 2114:5–10.) Thus, “when that manure comes out and we store it,” it is “very dry” and “it's a solid.” (Vol. VIII, 2080:5–11 & Vol. IX, 2114:10–11.) Due to those characteristics, poultry litter is hauled in dump trucks and cannot be run through a draghose, pipeline, or tanker. (Vol. VIII, 2078:21 –2079:2.) Poultry litter must be “stacked” in fields “in the middle of February or early March” so that it can be applied “later in the spring.” (2078:1–20; 2114:11–15; & Vol. XII, 3255:11–16.) Due to farm needs and weight restrictions (i.e., frost laws), it is not feasible to land apply poultry litter after the frost laws come into place and it typically must be spread on a field early or mid-April ahead of planting a crop. (Vol. VIII, 2080:21–24; Vol. IX, 2115:13–16 & 2117:9–13.) Thus, the proposed ban is incompatible with needs of poultry litter pre-stacking. (Vol. VIII, 2079:12–23.) Additionally, because litter absorbs rain water "like a sponge," (Vol. IX, 2118:17–25), a ban is not needed for poultry litter.

Thad Cleary agreed that poultry manure is "drier" and thus "not as susceptible to leaching through soil" as other forms of manure. (Vol. IV, 820:22–25.) And Bruce Washburn noted that he could only recall *one* instance where poultry stacking led to an EGLE violation notice—and, even then, there was no discharge to surface water in that instance. (Vol. II, 507:25–508:13.) In other words, stacking poultry litter throughout the winter prior to its application immediately before planting is an important farm practice. And it is not susceptible to winter discharges. Nonetheless, EGLE has arbitrarily restricted the land-application of poultry litter during winter months despite no demonstration that doing so is necessary to assure compliance with state or federal regulations.

For those reasons, EGLE's presumptive winter ban is not necessary to assure compliance with any federal or state laws or regulations. (Vol. X, 2560:17–25 & 2561:1–9.) "If manure application occurs under proper conditions" like those existing under the 2015 General Permit, "then there should be minimal water quality impacts." (Vol. XI, 2940:12–20.) Further, EGLE's ban will have harmful, unintended consequences. (2940:12–20.) This Tribunal should strike this condition.

ii. **<u>Manifesting Ban from January through March</u>**

EGLE's complete ban on manifesting from January to March is similarly unwarranted and presents the same unintended consequences. Approximately 40–50% of manure is manifested. (577:2–6.) EGLE thus has proposed a manifesting ban to prevent non-CAFO farms from land-applying manure during those same months. (Vol. III, 679:12–20.) EGLE's justification for this ban is thus equally flawed for the same reasons discussed in the previous subsection. And the same unintended consequences apply. Indeed, a manifesting ban will increase the regulatory burden on manure, driving more non-CAFOs to apply commercial fertilizer. (Vol. XI, 2934:15–17; 2949:23–25; see also Vol. VIII, 2077:16–18.) That shift will drive greater dissolved reactive phosphorus loadings, (Vol. VII, 1880:6–9; Vol. XI, 2927:10–18), increase erosion, (Vol. IX, 2181:7–11; 2221:25–2222:9; Vol. X, 2517:7–15), and require three-to-five times as much storage for some farmers (costing as much as $30M). (Vol. VIII, 2082:10–14.) Thus, for the same reasons noted above, it is neither necessary to assure compliance with federal or state law or regulations nor prudent. (Vol. X, 2560:17–2561:25; 2850:9–20; Vol. XI, 2939:20–2940:20; 2942:6–23.)

iii. **Requirement to Publicly Notice Necessary or Beneficial Increases of Nitrogen**

EGLE's new 15-day public noticing is likewise not necessary to assure compliance with federal or state regulations. And it will frustrate farming without an associated environmental benefit. (Vol. IX, 2216:21–23 & 2580:24–25.) First, this mandate is beyond what is needed to "assure compliance with" federal or state standards and, indeed, contrary to those standards. Federal and state standards require publicly noticing a permit. 40 CFR 122.23(h)(1); Mich Admin Code, R 323.2117(1). There is no such requirement for publicly noticing the day-to-day activities of CAFOs. Moreover, this paperwork requirement is contrary to federal and state standards for land-application activities, which expressly must balance crop needs and the risk of transporting nitrogen or phosphorus to surface waters. 40 CFR 412.4(c)(1)–(c)(2); Mich Admin Code, R 323.2196(5)(a)(*viii*). Prohibiting the application of nitrogen for an 18-day period while it is publicly noticed and on administrative hold from EGLE is not based on a field-specific assessment of *either* crop needs *or* the likelihood of transporting nitrogen. Public notice has nothing to do with either. Instead, the notice requirement subordinates crop needs to the demand for input by uninterested third parties. Accordingly, this requirement is not necessary to "assure compliance with" federal or state law.

Prior permits have always allowed farmers flexibility to meet crop needs by that if "relevant data shows additional N s needed or will be beneficial to the crop," then its application is permitted. (See, e.g., Ex. R-96, Section I.B.3.c.1.e.) EGLE's new permit forbids this flexibility. (Ex. 45, Section I.B.3.c.3.) EGLE sought to justify the requirement by stating that U.S. EPA mandated the insertion of this language. (Vol. V, 1147:20; 1148:16–23.) That is not accurate. For each of the prior permits (2005, 2010, and 2015), U.S. EPA certified compliance with federal regulations even though no such language existed. (Vol. X, 2579:10–22.) Bruce Washburn explained that he believed this change originated from Sylvia Heaton based on "a recommendation from EPA." (Vol. II, 499:9–20.) More particularly, Sylvia Heaton testified that U.S. EPA suggested these changes to nitrogen application based on *her* questioning in an over-the-phone conversation and EPA's suggestion was never even placed in writing. (Vol. VI, 1147:20; 1148:16–23; & 1151:15–19.) Christine Alexander further testified that U.S. EPA recommendations are not binding and that a permit may be issued without incorporating mere suggestions. (Vol. I, 66:24–25 & 219:8–10.) Therefore, there is neither any express or implicit federal requirement to include this condition in the general permit.

Not only is this condition not needed to comply with state and federal law but its inclusion will also frustrate farming. Christine Alexander initially claimed that EGLE's technical staff (i.e., Bruce Washburn and Thad Cleary) evaluated this concern and decided that the amount of nitrogen need can always be known ahead of time. (210:12–21.) But Alexander later backed off this view, explaining that "we understand that crops in the field as they're growing may need additional nitrogen *kind of on an as-needed basis*." (272:3–5) (emphasis added).

The farmers, CNMP providers, and other agricultural experts explained in detail why plant needs render this requirement impractical without any associated environmental benefit. As Laura

Campbell explained, “Crops showing nitrogen deficiency stress from situations such as unexpected precipitation or temperatures, compacted roots, or other causes, must have nitrogen as soon as possible to prevent crop yield loss,” thus “[f]ifteen days is too long to wait to meet these crop needs.” (Vol. X, 2581:1–5.) The testifying farmers echoed that because “the crops are actively growing, so requiring a 15-day delay does not work in practical reality.” (Vol. XI, 2898:14–17.) Thus, this requirement will cause farmers to lose “growth potential,” (Vol. VIII, 1972:17–20; Vol. XI, 2900:9–12; 2900:14–17), and possibly significantly damage the crops, which could be a “million-dollar crop loss” due to the timing of application. (Vol. IX, 2138:21–23.)

CNMP provider Allison Brink similarly noted that the public noticing requirement for additional needed or beneficial nitrogen is “[c]ompletely in contradiction to agronomic science. If the test results show the crop would benefit from additional N, that does not mean the crop will receive that benefit in 18 days; it means *the crop needs nitrogen now*.” (Vol. IX, 2215:23–2216:1) (emphasis added). Brink noted this is even bad for the environment. As she explained, “[o]ur greatest offensive move to reducing nutrients in the environment is to grow great crops that utilize the nutrients. If farms lose yield, those nutrients don’t get used.” (2216:12–15.) Likewise, CNMP Provider James DeYoung echoed that the public noticing requirement misses the mark because “[s]oil levels results would have changed” after 15 days and the “window of application would be closed since this is a highly time dependent field activity.” (Vol. XII, 3247:11–13.) Thus, it is “not realistic in an agronomic sense, it is burdensome oversight which provides no additional benefit, and it doesn’t follow MSU (or anyone else’s) guidance.” (3247:14–16.)

Ultimately, this condition is neither necessary to comply with federal or state law nor beneficial to the environment or farming. It should be stricken.

iv. **Jurisdictional Reach of Manifesting ("Operational Control")**

EGLE's permit also failed to address a significant issue regarding manifesting. Although Part 31 does not give EGLE authority to place non-CAFO farms (smaller farms) under the restrictions of the general permit, EGLE has increasingly sought to do so. (Vol. X, 2669:22–2670:3.) EGLE's attempts to exercise that jurisdiction is contrary to law and should be constrained by definition within the general permit.

By federal rule, the land application area for CAFOs is limited to "all *land under the control of the CAFO owner or operator*, including where the CAFO owns, rents, or leases the land to which manure from the production area is applied." 40 CFR 122.23(e)(3) (emphasis added); (Ex. P-104, CAFO Permit Writers Manual, p. 67.) Rule 2196 also recognizes that when the act of "land application . . . is not under the operational control of the CAFO owner or operator that generates the production area waste or CAFO production wastewater (generator)," then a manifest must be used and "kept with the CAFO owner or operator's CNMP" but those fields themselves are not within the farm's CNMP. Mich Admin Code, R 323.2196(5)(e). In other words, a farm cannot be held responsible for application to "land" that is *not* "under the control of the CAFO owner or operator" or to "land application" that is "not under [their] operational control . . . ." 40 CFR 122.23(e)(3); Mich Admin Code, R 323.2196(5)(e).

Nonetheless, in practice, EGLE has sought to hold farms responsible for actions of distinct entities based on loose attempts to connect the ownership of the two entities. (Vol. II, 297:3–8; 540:1–541:29; Vol. X, 2661:7–23.) There is no basis for EGLE doing so. Therefore, as EGLE itself has recognized, a definition of "operational control" is needed. (Ex. P-29; 686:8–14.) That definition must comport with the plain meaning of the phrase and must be consistent with Rule 2196 and the federal rule since EGLE is bound by its rules. *Grass Lake Improvement Bd*, 316 Mich App at 366–367. Further, that definition should acknowledge, as Bruce Washburn has, that "the law allows" CAFOs to manifest "to someone else to use as they see fit" and are thereafter "no longer responsible" for the waste. (Vol. III, 685:19–24.)

"Control" is defined when used as a noun as having the "[a]uthority or ability to manage or direct." *American Heritage Dictionary, 4th Ed* (2000), p. 400. And "operational" is used adjectivally to modify "control" according to its meaning as "of or relating to an operation." *Id.*, p. 1233. Accordingly, put together, "operational control" should be defined as follows:

> **Operational Control.** Land application is within the operational control of a permitted CAFO only if both of the following conditions are met: (a) the land to which the CAFO waste is applied is under the authority of the CAFO owner or operator via ownership of the land, lease of the property, or other property right; and (b) the permitted CAFO maintains the authority to manage or direct the particular means of applying the manure to the field at issue.

This specification will eliminate ambiguity in EGLE's enforcement of the permit and is necessary to constrain EGLE's exercise of jurisdiction within its statutory bounds.

v. <u>Setback and Buffer Mandates</u>

EGLE's mandate that farmers implement <u>*both*</u> compliance alternative practices for limiting runoff (i.e., setbacks <u>*and*</u> buffers)—rather than one or the other—is likewise unfounded and contrary to U.S. EPA's determinations and the science. (Ex. R-45, Section I.B.3.h.) The federal rules for CAFOs have always provided a compliance alternative, requiring farmers to utilize 100-foot setbacks from surface waters and certain features in land-applying manure but allowing farmers to substitute a 35-foot vegetated buffer if preferred. 40 CFR 412.4(c)(5). In setting this standard, EPA explained that setback and buffer requirements are "[r]elatively equivalent" and that "both approaches . . . are expected to achieve comparable pollutant reductions" per 68 FR 7212. (2817:13–18.) Moreover, EPA's decided not to require both in its CAFO rules "*because that would unnecessarily require CAFOs to take that portion of the cropland out of production*." (Vol. X, 2568:3–25 & 2817:21–25), quoting 68 FR 7211 (emphasis added).

Contrary to this longstanding standard, EGLE now proposes to require both in order to achieve the same ends as the untested MPRA. (Vol. V, 1256:12–1257:4.) But EGLE has failed to demonstrate how requiring both is necessary to assure compliance with federal or state regulations. It clearly is not with respect to the CAFO regulations, which explicitly permit a "compliance alternative" that gives farms flexibility. 40 CFR 412.4(c)(5)(*i*) & (c)(5)(*ii*). That rule has not changed since the last permit. (Vol. III, 707:12–21.)

Nor does the science support EGLE's position. Both buffers and setbacks achieve same purpose per EPA: "to slow runoff, and minimize the potential for pollutants, nutrients, or pathogens to reach surface waters." (Vol. X, 2576:3–5; see also Vol. XI, 2930:7–11.) Each is independently effective at achieving that end. (Vol. IX, 2210:14–2211:2.) A vegetated buffer by itself is sufficient to control runoff and the transport of nutrients carried by runoff. (Vol. X, 2818:8–19.) Further, research has shown that the use of a buffer "must be evaluated on a site-specific basis in accordance with USEPA's compliance alternative." (2820:16–19.) Therefore, it is not necessary to have both a setback and a buffer. (Vol. XI, 2932:7; 2941:4–12.)

Simply put, the buffer and setback requirements are duplicative. (Vol. IX, 2210:17.) EGLE's mandating both is thus an overly restrictive gauze-over-the-band-aid approach. (2210:17–2211:2.) And these requirements are not necessary to comply with either state or federal law. (Vol. X, 2577:3–21.) Nor are they sound environmental policy. (2577:22–2578:9; Ex. P-104.)

Not only that, but EGLE's mandate may have unintended consequences adverse to the environment and to water quality. For example, buffers can negatively impact phosphorus by releases of nutrients from dead vegetation. (2573:22–26; Ex P-100.) In climates similar to Michigan's, some studies have found vegetated buffers to "ac[t] as a source area [for phosphorus], especially during the spring melt because all this phosphorus has been bound up during the dormant period is then released because of the spring melt runoff. (2865:1–4.) Thus, some studies indicate that "simply the unmaintained presence of vegetation that dies in the winter or the increased microbial activity in the soils of vegetated buffers increases phosphorus loss to waterways compared to fields without vegetated buffers." (2574:4–12; Ex. P-101; Ex. P-102; Vol. IX, 2210:1–2.) Additionally, Kevin Elder opined that requiring setbacks and buffers together (along with EGLE's other restrictions) will likely "support a shift to use of more soluble commercial fertilizer" that is "more likely to result in runoff than the responsible use of manure." (Vol. XI, 2942:14–20.)

Moreover, even if it were necessary to have a buffer on top of an already effective setback, EGLE's mandated 35-foot feet length is unnecessary. Though this is the standard length when used as a "compliance alternative," 40 CFR 412.4(c)(5)(*i*), no federal mandate exists for this length if EGLE is to require both. Moreover, studies have shown that 90% of sediment has been caught by buffers of 10 feet in width, (Vol. X, 2570:15–17), and buffers remove 95% of particulate pollutants in the first 15 feet. (Vol. XI, 2930:12–16; Ex P-52.) In other words, the 20 additional feet provides less than a 5% effectiveness. (2931:19–23.) Thus, even *if* this Tribunal found that buffers are somehow needed on top of exiting setbacks, that buffer can be reduced to 10–15 feet in length while providing much of the same protection.

For those reasons, this Tribunal should strike this requirement. Or, alternatively, it should limit any buffer requirement to no more than 15-feet in length.

vi. **<u>Soil Test Phosphorus Limit Reduction</u>**

EGLE's reduced soil-test phosphorus limitations are similarly not necessary to achieve compliance with state or federal laws. (Vol. X, 2545:21–2549:16.) Nor are they scientifically supported. (2543:7–2544:11; 2687:9–11; Vol. XI, 2925:17–18.) Rather, EGLE arbitrarily mandated a reduction of this number by 10 to 20% across the board. (145:11–20; 2543:22–2544:3.) It did so to effectively achieve the same results as it intended through the mandated use of the untested and unsupported MPRA index. (Vol. II, 401:17–25; Vol. V, 1256:12–1257:4.) EGLE's new standard has no correlation to an actual reduction in phosphorus movement offsite.

The longstanding requirement for Soil Test P levels has been to limit one-year application rates above 75 ppm and altogether prohibit applications above 150 ppm. (Vol. X, 2535:3–9.) These levels have existed since the first Soil Test P standards set, (2536:2–9; Ex. P-88), and they are based on research regarding Soil Test Phosphorus levels that notes a difference between agronomic and environmental levels, with the latter based on PAC. (2536:20–24.) "Unlike nitrogen which can be quickly lost from a field through leaching into groundwater or volatilizing in the air, phosphorus can be in the soil for a long period of time as it cycles between plant-available and non-available forms." (2537:12–16.) "Because of the lengthy cycle of phosphorus between plant-available and non-available forms . . . the concentration of plant-available phosphorus (the phosphorus tested by the Bray P1 method) rises more slowly than the total rate of application." (2537:21–2538:1.) With the historic, 150-ppm Soil Test P number, Michigan restricts phosphorus application via manure "starting at 75 ppm, the average between the low and high rates at which phosphorus may be observed and therefore only be applied at the rate plants can make use of it that year and then prohibits applications entirely at 150 ppm, which is twice that rate." (2538:12–20; Ex. R-90.) Barring application above 150-ppm levels represents the level where, on average, "there is a lack of attachment sites for phosphorus to attach to the soil" and thus, "at that point, more of the phosphorus is more likely to move in solution and less will absorb into the soil." (Vol. XI, 2924:11–16.) In other words, it is "the level that soils, on average begin to reach a point where, at the 8-inch soil sample, it begins to lose the ability to hold onto phosphorus and there may be more phosphorus that stays in solution for longer periods of time." (2924:19–2925:1.) But "before that level, the relationship between biologically available phosphorus in the soil and the likely runoff is non-linear." (2925:5–7.) Accordingly, "the 150-ppm standard selected by regulators in the past was based on the break in the curve where losses of nutrients from the soil increased." (2925:15–17; Ex. R-129, Fig. 34-12.)

There is no demonstrated benefit to reducing phosphorus levels below 150 ppm. (2939:10–12.) The issue from an environmental or water quality standpoint is setting Soil Test P at levels that reflect Phosphorus Adsorption Capacity ("PAC") or "the rate at which soil can hold nutrients while minimizing the potential to run off." (Vol. X, 2686:19–21.) That PAC-level is appropriately set between 150 ppm and 200 ppm. (2536:20–24; 2924:11–2925:7; Ex. P-88, Figs. 34-12 & 34-13.) Christine Alexander's notes during the permit's development acknowledged "75/150 ppm ***is based on actual P loss from soil***." (Ex. P-129; 158:2–4) (emphasis added). That level has nearly universal acceptance. (Vol. IV, 901:6–7; Vol. IX, 2196:24–2197:9.) It is the USDA's adopted level and the level Michigan maintains for the GAAMPS, for MAEAP, for land-applied biosolids, and for every CAFO permit from 2002 to the present. (Vol. I, 156:18–157:4; Vol. IV, 901:8–20; 901:25–902:2; 909:17–22; Vol. X, 2539:10–2541:11; Exs. P-19 & P-129.) And it is also the level at which most Great Lakes states with numeric value limits place that level. (Exs. P-141, P-142, & P-143.) Indeed, Minnesota, Illinois, Wisconsin, and Indiana place the discontinuation point between 150 ppm and 200 ppm. (Vol. X, 2544:16–2545:16.)[2] EGLE's 120-ppm to 135-ppm value, if adopted, would be the most restrictive numerical standard among the Great Lakes States.

[2] EGLE's witnesses uniformly acknowledged that they did not consider these other states' numbers in setting this reduction nor conduct any 50-state survey. (160:13–22; 346:20–23; & 1119:10–1120:8.) Candidly, Bruce Washburn testified that EGLE did not do so because those states "have similar or higher levels." (719:8–13.)

(2545:17–20.) Thus, there is a clear rationale for the 150-ppm level of the prior CAFO general permits.

There is no similar rationale for EGLE's proposed reduction. Although EGLE seeks to blame the CNMP providers for this reduction, that is baseless. EGLE provided a regulatory mandate to accept the MPRA or else provide something comparable. (Vol. IX, 2191:20–24.) There was no "negotiation"—this was a regulator making a demand. (2246:25–2247:3.) Even Christine Alexander testified that the CNMP providers' suggestion was received only because "they knew that the Department was looking for a decrease in phosphorous concentrations in soils." (266:24–25.) Allison Brink and James DeYoung similarly both testified that they provided this suggestion only as a means of avoiding the mandated MPRA because EGLE was demanding a change and would implement an unworkable alternative. (2246:1–7; 2705:1–8; 2796:19–25; 2756:10–15; 3336:3–9.) In any event, EGLE eventually not only reduced the Soil Test Phosphorus limits but also mandated _both_ a 35-foot vegetated buffer and 100-foot setback in order to effectively achieve the end result of the MPRA, (Vol. II, 401:17–25; Vol. VI, 1256:12–1257:4)—completely undermining any notion that this was a "compromise" figure.

EGLE also presented a lot of testimony to the effect that somehow the correct number for Soil Test Phosphorus would be the "agronomic" number. (Vol. II, 345:11–14; Vol. IV, 769:16–770:3; Vol. V, 1200:12.) That number is unrelated to any environmental concerns. (Vol. XI, 2945:24–2946:5.) It is a _bare minimum_ amount of the fertilizer that must be used to provide crop needs, intending to maximize the economical benefit of fertilizer. (Vol. X, 2686:17–19) (explaining that agronomic rates measure "how little fertilizer a farmer can apply to achieve the maximum yield for the least cost"). That has zero correlation to any concerns about runoff or movement of phosphorus through tiling. (Vol. XI, 2944:20–2941:2.) Even Thad Clearly agreed that the "agronomic" numbers from the Tri-State Fertilizer recommendations are "not to environmentally manage" the phosphorus but rather reflect "crop production" needs. (Vol. IV, 889:14–17.) The relationship of Soil Test P below to the offsite movement of phosphorus from either of those routes below 150 ppm is non-linear. (Vol. XI, 2925:5–7; Ex. R-129, Figs. 34-12 & 34-13). And "[t]he additional application of manure on fields below those levels is not excessively contributing to dissolved reactive phosphorus in runoff." (2948:8–19.) In other words, there is no proven environmental benefit to reducing this level to 135 ppm; it is simply an arbitrary standard with significant detrimental impacts on farms. (Vol. X, 2543:22–2544:3 & 2925:17–18.)

EGLE's further mandated reduction of Soil Test P to 120-ppm for fields within TMDLs is equally arbitrary. CAFO BMPs "are all designed to prevent [a] discharge rather than discharge a specific concentration or amount of pollutants." (Vol. X, 2679:22–24.) Therefore, reducing Soil Test P to 120 ppm in TMDLs makes no sense. The level must be set where it will impact a discharge offsite; that level has been scientifically established at 150-ppm. Moreover, because Bray P1 thresholds are in themselves self-limiting, further reductions do not accomplish anything. (Vol. IX, 2219:14–17.)

At bottom, EGLE's reduction in Soil Test Phosphorus levels is a regulatory mandate without scientific support or any proven correlation to water quality. (2196:12–20; Vol. X, 2543:22–2544:11; 2687:9–14; Vol. XI, 2925:15–18; 2939:10–12 & 2939:16–19.) That cannot stand. This Tribunal should strike that change and keep the scientifically proven and generally accepted 150-ppm Soil Test Phosphorus level from the prior 2015 CAFO General Permit.

vii. **"Additional Pollutant Control Measures" Required in TMDLs.**

Lastly, EGLE's requirement for farms to install treatment systems or otherwise implement "additional pollutant control measures" in TMDL watersheds impose greater operational difficulties on farms with no demonstrated accompanying environmental benefit. EGLE's alternative to installing an undefined "treatment system" is principally lengthier vegetated buffers and lengthier setbacks. No science supports EGLE's position that simply going bigger is better.

Rather, Sylvia Heaton could not justify requiring a 50-foot vegetated buffer "along the perimeter" of *all* farm fields in a TMDL. She noted she generically believed "a larger area [is] better" and "a wider area [is] better to help with infiltration . . . ." (Vol. VII, 1189:5–9.) She could not "point to" anything to support that particular length, but she believed "it came from somewhere." (1189:10–13.) More particularly, Heaton admitted she was unaware of any research that an extra 15 feet "makes a measurable difference in terms of nutrient removal or sediment removal." (1189:18–22.) And the research says the opposite of her belief: 95% of a buffer strips' effectiveness comes from the *first* 15 feet. (Vol. XI, 2930:12–16; Ex P-52.) In other words, not only is a 35-foot mandate itself superfluous but mandating a 50-foot buffer based on EGLE's bigger-must-be-better rationale is simply arbitrary and unfounded.

Likewise, the TMDL guidance requires some tiled fields in TMDLS to limit application of manure to 1/8 inch. (Ex. R-95.) But "[r]educing liquid application rates to 1/8 inch is not feasible for many manure spreaders . . . potentially excluding nearly 40 percent of Michigan fields from manure application if they are in E. coli TMDL watersheds." (Vol. X, 2586:3–8; Ex. P-106.) Moreover, this and other TMDL restrictions (such as the 120-ppm soil test phosphorus reduction discussed above) oddly apply to *both* nitrogen and phosphorus TMDLs. But "restricting application based on soil phosphorus rates in a nitrogen TMDL watershed makes no scientific sense." (2585:10–12.)

Laura Campbell explained that these TMDL restrictions in combination make it "[v]irtually impossible to apply sufficient manure to empty storage structures or apply sufficient nutrients for crop needs." (2523:19–23.) And they "do not represent scientifically researched or tested conservation practices." (2589:9–10.) Accordingly, she concluded that "[t]he application restrictions required in EGLE's 2020 General Permit in watersheds with phosphorus or nitrogen TMDL are arbitrary and are not based on any research or scientific study to evaluate the effectiveness of reducing phosphorus application." (2585:2–6.) In other words, these added restrictions for fields within a TMDL are not necessary to achieve compliance with water-quality standards or any other state or federal requirement for CAFOs. EGLE's added TMDL requirements should be stricken.

EGLE's TMDL provisions are also contrary to Part 31 as applied to MAEAP-verified farms. The Michigan Agriculture Environmental Assurance Program ("MAEAP") is a "voluntary program" that includes an educational program, implementation of a conservation plan, and an on-site evaluation by EGLE all with the intent of promoting good environmental stewardship by farms. See MCL 324.8701 *et seq*. Nothing in EGLE's general permit conditions for TMDLs accounts for a farm's MAEAP verification. Yet MCL 324.3109d(1)(c) expressly provides that:

> If a MAEAP-verified farm is in compliance with all MAEAP standards applicable to the farming operation, *the farm is considered to be implementing conservation and management practices needed to meet total maximum daily load implementation for impaired waters pursuant to 33 USC 1313*. [Emphasis added.]

In other words, EGLE cannot rely on a generic observation that *something* additional must be done for farms within a TMDL because MAEAP-verified farms are already going above and beyond to reduce such impacts and are "considered" as "implementing conservation and management practices needed to meet" the TMDL. *Id*. At a minimum, therefore, the general permit must carveout MAEAP-verified farms from these additional TMDL requirements.

CONCLUSION AND RELIEF REQUESTED

For the above-stated reasons, Petitioners ask that this Tribunal to determine that the newly adopted conditions of the 2020 CAFO General Permit constitute "rules" under MCL 24.207 and therefore their incorporation into the General Permit without prior promulgation under the APA is forbidden. Alternatively, this Tribunal should adopt a Proposal for Decision recommending that EGLE issue the 2020 CAFO General Permit with the following revisions:

(a) Revising Section I.B.3.c.1.a, I.B.3.c.2.a., and I.B.3.c.2.b to provide that the maximum allowable Bray P1 soil test level should be 150 ppm for all fields and that one-year application rates shall apply to fields over 75 ppm;

(b) Striking the last three sentences of Section I.B.3.c.3;

(c) Striking Section I.B.3.e.;

(d) Striking Section I.B.3.f.3 (including Subsections I.B.3.f.3(a)–I.B.3.f.3(f));

(e) Striking Section I.B.3.f.4;

(f) Revising Section I.B.3.h to permit the use of *__either__* setbacks *__or__* vegetated buffer strips; or, alternatively, limit vegetated buffers to no more than 10 feet;

(g) Striking the second sentence of Section I.B.3.g;

(h) Conforming Subsections I.C.8.a.– I.C.8.h. to Mich Admin Code, R 323.2196(5)(e)(*i*)–(5)(e)(*viii*);

(i) Striking Section I.C.9.b (including Subsections I.C.9.b.1–I.C.9.b.3.b); and

(j) Adopting the definition of "operational control" provided in Section I.B.iv of this Brief.

Respectfully submitted,

CLARK HILL PLC

/s/ *Zachary C. Larsen*
Michael J. Pattwell (P72419)
Zachary C. Larsen (P72189)
215 S. Washington Square, Ste. 200
Lansing, MI 48933
(517) 318-3100
MPattwell@clarkhill.com
ZLarsen@clarkhill.com

Dated: June 8, 2022

EXHIBIT 31

Michigan Administrative Law § 8:11

Michigan Administrative Law | June 2023 Update
President and Dean Don LeDuc[a0]

Chapter 8. Method and Court of Judicial Review of Agency Action

II. STATUTORY REVIEW

§ 8:11. Declaratory judgments under Michigan Administrative Procedures Act

References | Correlation Table

Section 63 Declaratory Rulings—While most of the Administrative Procedures Act and all of the Revised Judicature Act review provisions deal exclusively with adjudicative and quasi-judicial action by state administrative agencies, another review mechanism is provided by the APA to review an administrative rule promulgated by an agency, as well as to consider the applicability of underlying statutes, agency rules, and prior agency orders to an actual state of facts involving a person. Section 63[1] of the APA provides:

> On request of an interested person, an agency may issue a declaratory ruling as to the applicability to an actual state of facts of a statute administered by the agency or a rule or order of the agency. An agency shall prescribe by rule the form for such a request and procedure for its submission, consideration and disposition. A declaratory ruling is binding on the agency and the person requesting it unless it is altered or set aside by any court. An agency may not retroactively change a declaratory ruling, but nothing in this subsection prevents an agency from prospectively changing a declaratory ruling. A declaratory ruling is subject to judicial review in the same manner as an agency final decision or order in a contested case.[2]

The authority granted clearly includes the power to determine the applicability of a statute to an actual state of facts.[3]

However, an agency has no power to determine the validity of a statute. Nor does an agency have the authority to issue a declaratory ruling regarding the applicability of a statute that it does not administer, according to Booth v. Consumers Power Co. (on remand).[4] While this statement is undoubtedly true in many situations, agencies are often called on to interpret the effect of statutes they do not administer within the context of statutes that they do administer. Too rigid an application of the holding in Booth would undermine the purpose served in allowing declaratory rulings.

Section 64 Declaratory Judgments—Where a court finds that a rule or its threatened application interferes with or impairs a person's legal rights or threatens to do so, and no exclusive review procedures or remedies are provided by the underlying statute, Section 64[5] of the APA provides for direct judicial review of the validity or applicability of that rule:

> Unless an exclusive procedure or remedy is provided by a statute governing the agency, the validity or applicability of a rule may be determined in an action for declaratory judgment when the court finds that the rule or its threatened application interferes with or impairs, or imminently threatens to interfere with or impair, the legal rights or privileges of the plaintiff. The action shall be filed in the circuit court of the county where the plaintiff resides or has his principal place of business in this state or in the circuit court for Ingham county. The agency shall be made a party to the action. An action for declaratory judgment may not be commenced under this section unless the plaintiff has

> first requested the agency for a declaratory ruling and the agency has denied the request or failed to act upon it expeditiously. This section shall not be construed to prohibit the determination of the validity or applicability of the rule in any other action or proceeding in which its invalidity or inapplicability is asserted.

Such review is in the nature of a declaratory judgment.

One purpose of Section 64 is to remove uncertainty as to an agency's interpretation of its own rules. The section vests subject matter jurisdiction in the circuit court and specifies that venue is proper either in the plaintiff's county of residence or principal place of business or in Ingham County.

Exhaustion of Remedies under Sections 63 and 64—Exhaustion of administrative remedies is generally not required when purely declaratory relief is requested in a situation where the facts are uncontested.[6] However, Section 64 of the APA requires as a condition precedent to seeking a declaratory judgment regarding the validity or applicability of a rule that an interested person must first request the agency to issue a declaratory ruling under Section 63 on the applicability of the challenged rule to the particular fact situation.[7] If the request for a declaratory ruling is subsequently denied, or if the agency fails to act expeditiously on the request, Section 64 can then be invoked.

The declaratory ruling and declaratory judgment provisions of APA Sections 63 and 64 are widely misunderstood. Section 63 gives agencies the permissive authority to issue declaratory rulings regarding the applicability of a statute or a rule administered by an agency. Section 64 explicitly requires exhaustion of the Section 63 declaratory ruling provision only for actions challenging the validity or applicability of a rule. This eliminates the exhaustion requirement regarding issues involving the validity or applicability of a statute, likely because issues regarding the meaning of statutes are more appropriately left to the courts and the validity of statutes is an issue reserved for the judicial branch. The language of Section 64 imposes the exhaustion requirement only when the action is brought "under this section," meaning Section 64, which applies only to the validity or applicability of rules. Neither section applies to determinations of the validity of statutes.

When a declaratory judgment is sought regarding the applicability of a statute, Section 63 gives the agency permissive power to issue a declaratory ruling, but that step is not required before seeking a declaratory judgment outside Section 64, because Section 64 applies only to rules, not statutes. This clear distinction is frequently missed by the courts, which impose the exhaustion requirement to declaratory judgment actions challenging an agency's construction of a statute, as exemplified by Huron Valley Schools v. Secretary of State.[8]

The misconstruction of these provisions converts the permissive power granted to agencies into a judicially imposed mandatory requirement that a plaintiff resort to the administrative remedy first. Thus, the courts have unknowingly converted this into a primary jurisdiction policy situation, a policy that applies when an agency and a court have concurrent original subject matter jurisdiction.[9] Other than a concern that this policy introduces additional time burdens into situations that may be volatile, this actually may be a good result, because the policy gives the agency the first shot at interpreting an underlying statute it administers, which encourages uniformity in interpretation, reliance on administrative expertise, and conservation of judicial resources. But it would be preferred that this result be reached on purpose, rather than by accident though still another Court of Appeals per curiam opinion, and one that ignores the primary jurisdiction doctrine entirely.

Other Declaratory Ruling and Declaratory Judgment Considerations—Only agency rules are reviewable in a declaratory judgement action under Section 64. For the purposes of both Sections 63 and 64, a rule is narrowly defined by Section 7 of the APA[10] and includes only agency statements formally promulgated pursuant to the agency rulemaking procedures.[11]

When agency statements are not formally promulgated rules, circuit courts generally lack jurisdiction under Section 64 to review them.[12] The Supreme Court held, however, in Detroit Base Coalition for Human Rights of Handicapped v. Department of Social Services[13] that interpretive statements which modify existing rules are, in effect, rules and are reviewable as such under Section 64.

The term "declaratory ruling" has been narrowly interpreted by the courts to include only rulings issued responding to a specific request for a declaratory ruling. Other agency statements will not satisfy the condition precedent—seeking a declaratory ruling—to invoking Section 64 review. Section 64 judicial review is available only when a declaratory ruling is not issued. Once issued, the declaratory ruling is subject to review as a contested case under Sections 103 through 106 of the APA, not under Section 64.[14]

The Supreme Court in Ludington Service Corp. v. Acting Commissioner of Insurance[15] applied the scope of review provisions in APA Section 106 during the review of an agency's declaratory ruling. Interestingly, this case began as a declaratory judgment action based on the failure of the agency to make the declaratory ruling in a timely manner, but was converted to a review of a declaratory ruling made after the declaratory judgment action was filed in the circuit court. This case also involved a possibly erroneous use of the declaratory judgment provision in Section 64, because it did not involve the applicability or validity of a rule.[16]

The Court of Appeals in Sierra Club Mackinac Chapter v. Department of Environmental Quality,[17] rejected an agency argument that jurisdiction to review its declaratory ruling regarding the state administration of a federal statute reposed in the federal courts. The court correctly held that the review should proceed in the same manner as review of a contested case, although it paraphrased the scope of review provision inaccurately at one point[18] and subsequently limited the scope too narrowly at another.[19]

Courts continue to be unequal to the task of deciphering the relationship between Sections 63 and 64 and the exhaustion of remedies issue they provide, as demonstrated by Michigan Farm Bureau v. Department of Environment, Great Lakes, and Energy.[20] By substituting various characterizations of agency action as if the actions constitute rules, the courts engage in unnecessary and often complicated analysis. The key remains that the definition of rule is intended to limit or describe what a rule is; if an agency action does not meet that definition because APA Chapter 3's rulemaking requirements have not been followed, that action cannot result in a rule. Whatever that action is, it is not a rule and it is not governed by Sections 63 or 64. Any issues in a particular controversy regarding that action must be resolved through other administrative and judicial proceedings. Given the continued inability of the courts and the bar to correctly apply these two provisions, it is time for the Legislature to step in with a clarifying amendment, perhaps to APA Section 7's list of what is not a rule or by making the beginning words of Section 7 read: Sec. 7. "Rule" means *a properly processed and published* agency regulation, statement, standard, and so forth (emphasis added).

Footnotes

a0 Western Michigan University Thomas M. Cooley Law School

1 Administrative Procedures Act, § 63; MCLA 24.263.

2 This passage was cited as the appropriate standard of judicial review in Priority Health v. Commissioner of Office of Financial and Ins. Services, 489 Mich. 67, 73, 803 N.W.2d 132, 135 (2011), after noting that the arbitrary and capricious standard does not apply to the statutory interpretation aspect of review. Priority Health at 489 Mich. at 72, n.9, 803 N.W.2d at 135, n.9.

3 See Farm Bureau Mut. Ins. Co. of Michigan v. Commission of Ins., 204 Mich. App. 361, 514 N.W.2d 547 (1994).

4 Booth v. Consumers Power Co., 226 Mich. App. 368, 573 N.W.2d 333 (1997) (on remand).

5 Administrative Procedures Act, § 64, M.C.L.A. § 24.264.

6 Judges of 74th Judicial Dist. v. Bay County, 385 Mich. 710, 190 N.W.2d 219 (1971); BCS Life Ins. Co. v. Commissioner of Ins., 152 Mich. App. 360, 393 N.W.2d 636 (1986).

See §§ 10:25 to 10:42 for full discussion of the doctrine of exhaustion of administrative remedies.

7 See Pletz v. Secretary of State, 125 Mich. App. 335, 336 N.W.2d 789 (1983).

8 Huron Valley Schools v. Secretary of State, 266 Mich. App. 638, 645-47, 702 N.W.2d 862, 866-67 (2005).

9 See §§ 10:43 to 10:60.

10 Administrative Procedures Act, § 7, M.C.L.A. § 24.207.

11 Bentley v. Department of Corrections, 169 Mich. App. 264, 425 N.W.2d 778 (1988).

See also Michigan Farm Bureau v. Bureau of Workmen's Compensation, Dept. of Labor, 408 Mich. 141, 289 N.W.2d 699 (1980).

See also §§ 4:4 to 4:6 for discussion of the definition and nature of rules.

12 Michigan State Chamber of Commerce v. Secretary of State, 122 Mich. App. 611, 332 N.W.2d 547 (1983).

13 Detroit Base Coalition for Human Rights of Handicapped v. Department of Social Services, 431 Mich. 172, 428 N.W.2d 335 (1988). This troublesome opinion should not be relied upon without serious parsing and reviewing its discussion throughout Chapter 4 of this text.

14 See generally Health Cent. v. Commissioner of Ins., 152 Mich. App. 336, 393 N.W.2d 625 (1986), but note that there does not seem to be an issue of the validity or applicability of a rule in this case, the only basis for imposing the Section 63 exhaustion requirement.

15 Ludington Service Corp. v. Acting Com'r of Ins., 444 Mich. 481, 511 N.W.2d 661(1994), opinion amended on other grounds on denial of reh'g, 444 Mich. 1240, 518 N.W.2d 478 (1994).

16 See Michigan Ass'n of Intermediate Special Educ. Administrators v. Department of Social Services, 207 Mich. App. 491, 526 N.W.2d 36 (1994) for a less convoluted example of the use of the APA petition for review provisions to review a declaratory ruling.

17 Sierra Club Mackinac Chapter v. Department of Environmental Quality, 277 Mich. App. 531, 747 N.W.2d 321 (2008).

18 Sierra Club Mackinac Chapter, 277 Mich. App. at 545, 747 N.W.2d at 329-30.

19 Sierra Club Mackinac Chapter, 277 Mich. App. at 549, 747 N.W.2d at 331-32.

20 Michigan Farm Bureau v. Department of Environment, Great Lakes, and Energy, 2022 WL 4281573 (Mich. Ct. App. 2022) (wrongly requiring Section 63 exhaustion in a review of an agency action that did not involve a rule).

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EXHIBIT 32

STATE OF MICHIGAN

MICHIGAN ADMINISTRATION HEARING SYSTEM

In the matter of:	Docket No.: 20-009773
Petition of Michigan Farm Bureau; Michigan Milk Producers Association; Michigan Allied Poultry Industries; Foremost Farms USA; Michigan Pork Producers Association; Dairy Farmers of America; Select Milk Producers, Inc.; and 126 Identified Livestock Farms /	Permit No.: MIG010000 Part: Part 31, Water Resources Protection Agency: Department of Environment, Great Lakes and Energy Case Type: Water Resources Division

HEARING - VOLUME NO. I

BEFORE DANIEL PULTER, ADMINISTRATIVE LAW JUDGE

Via Microsoft Teams Meeting

Monday, December 6, 2021, 9:00 a.m.

APPEARANCES:

For the Petitioners:
MR. ZACHARY CHAD LARSEN (P72189)
MR. MICHAEL JOHN PATTWELL (P72419)
Clark Hill, PLC
212 East Cesar E. Chavez Avenue
Lansing, Michigan 48906
(517) 318-3053

For the Respondent:
MS. ELIZABETH ANNE MORRISSEAU (P81899)
MS. JENNIFER A. ROSA (P58226)
Assistant Attorneys General
Department of Attorney General
525 West Ottawa Street
G. Mennen Building, 6th Floor
Lansing, Michigan 48933
(517) 373-7540

I am still kind of befuddled by your decision not to raise the unlawful rulemaking argument before the contested case hearing because it seems like an incredible waste of time that we go through an entire contested case hearing. And if I were to make that kind of a recommendation to the director that it would be unlawful rulemaking and the director decides that I'm correct, it just seems like an incredible waste of time and I'm perplexed why you didn't raise that issue before the case proceeded to hearing. If that is really your concern in this case, I just don't understand your decision to hold that back.

MR. LARSEN: Your Honor, respectfully, it is one concern and it is a concern as to which because of the Department's characterization of certain factual issues we though it would still be helpful for this Court to -- or for this Tribunal to have the underlying facts.

JUDGE PULTER: I understand. I understand. And one of the things that the parties are going to have to address in their briefing as well -- and I'll just tell them right now -- I'm required to make a proposal for decision based on evidence, but the director is not. The director can issue policy making decisions and those policy decisions can be put within an NPDES permit unless you can show me authority that says she cannot. So to me, you know, in this contested case we're going to have to take a look at what's