Morrison Lake
Phosphorus Mitigation (2020-2022)

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PLM Lake & Land Management Corp

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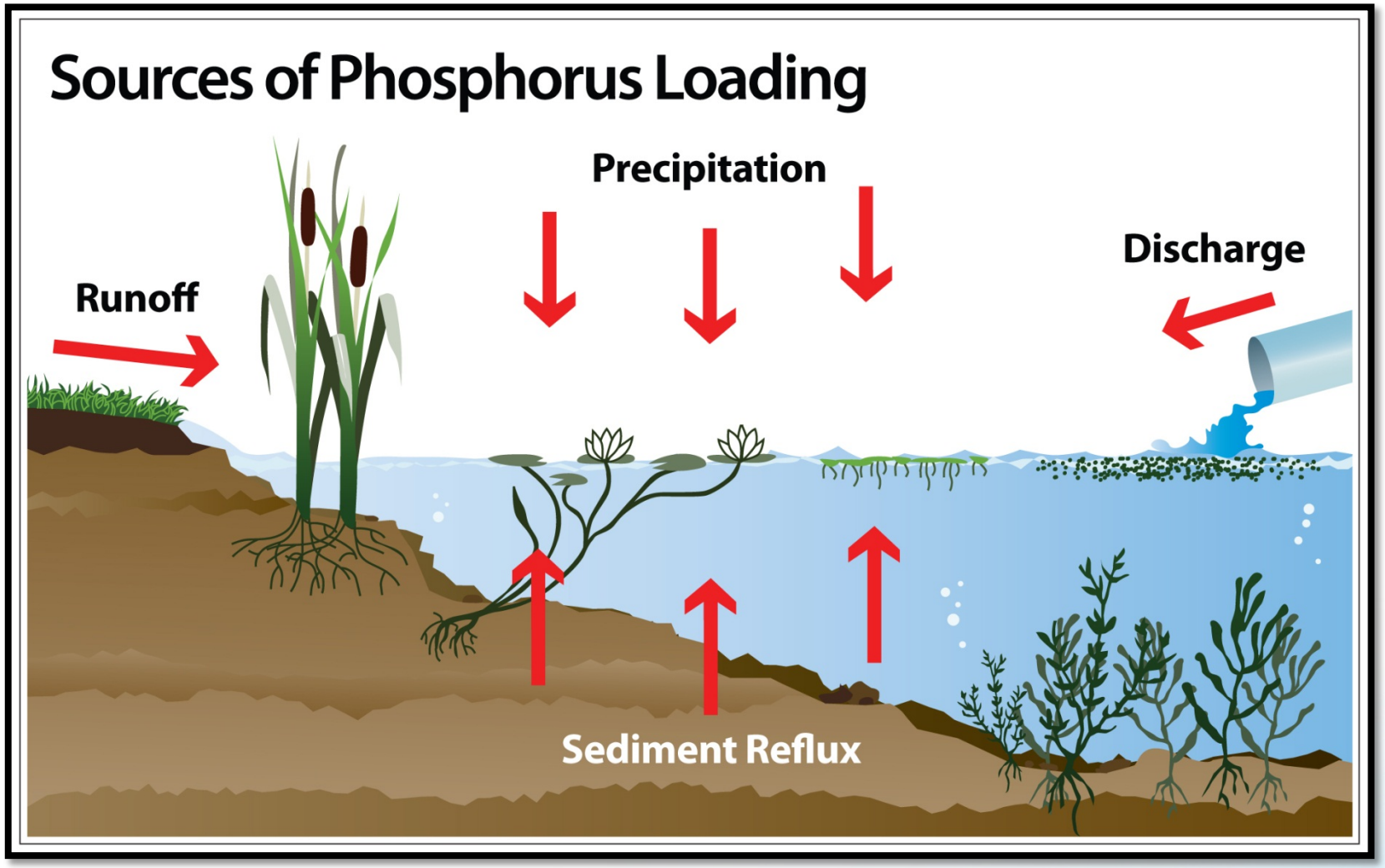


- We must protect our water resources, education, green belts, watersheds..
- Lake and pond bottoms are a sink for sediments and ultimately phosphorus
- Sediments are a significant annual source of available P to lake water column
- Sedimentation is a significant part of "**Eutrophication**"…

Phosphorus (P)=Eutrophication… Your Lake…?

Phosphorus pollution is the primary component governing eutrophication in freshwater resources and is highly correlative to algae productivity (Carpenter et. al, 1998)

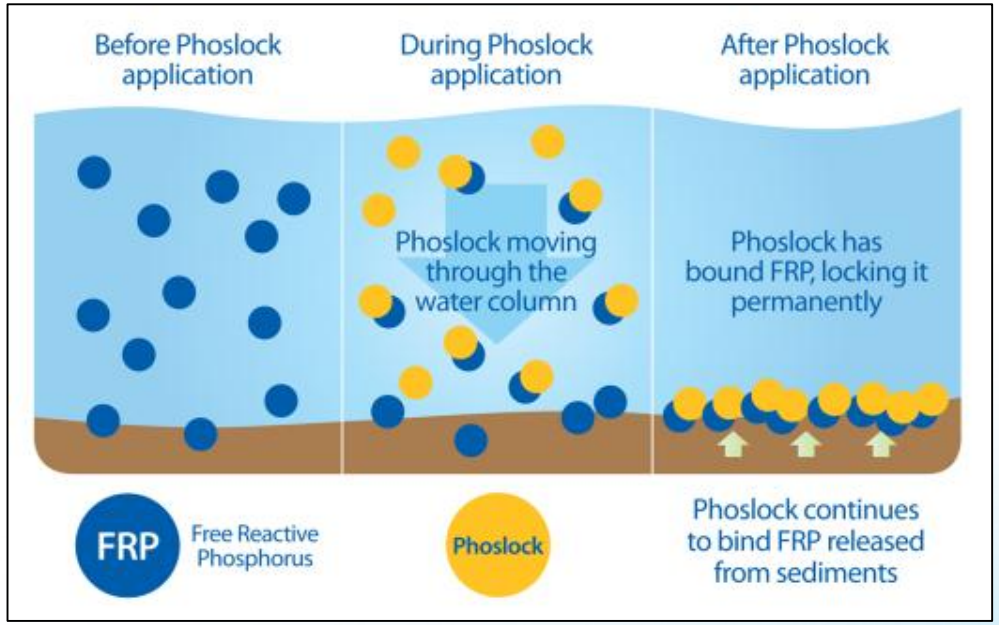
Trophic Status	Total Phosphorus (ug/L)	Chlorophyll a (ug/L)
Oligotrophic	**< 12**	**< 2.7**
Mesotrophic	**12-24**	**2.7-20**
Eutrophic	**25-96**	**21-56**
Hypereutrophic	**> 96**	**> 56**

Phoslock®

Phosphorus Locking Technology

A natural technology that inactivates bio-available phosphorus & restores water quality

- 95% Bentonite Clay
- 5% Lanthanum
  - "Element #57"
- 100 lbs. of Phoslock will bind 1 lb. of FRP
- 1 lb. of Phosphorus can support 500 lbs. of algae growth



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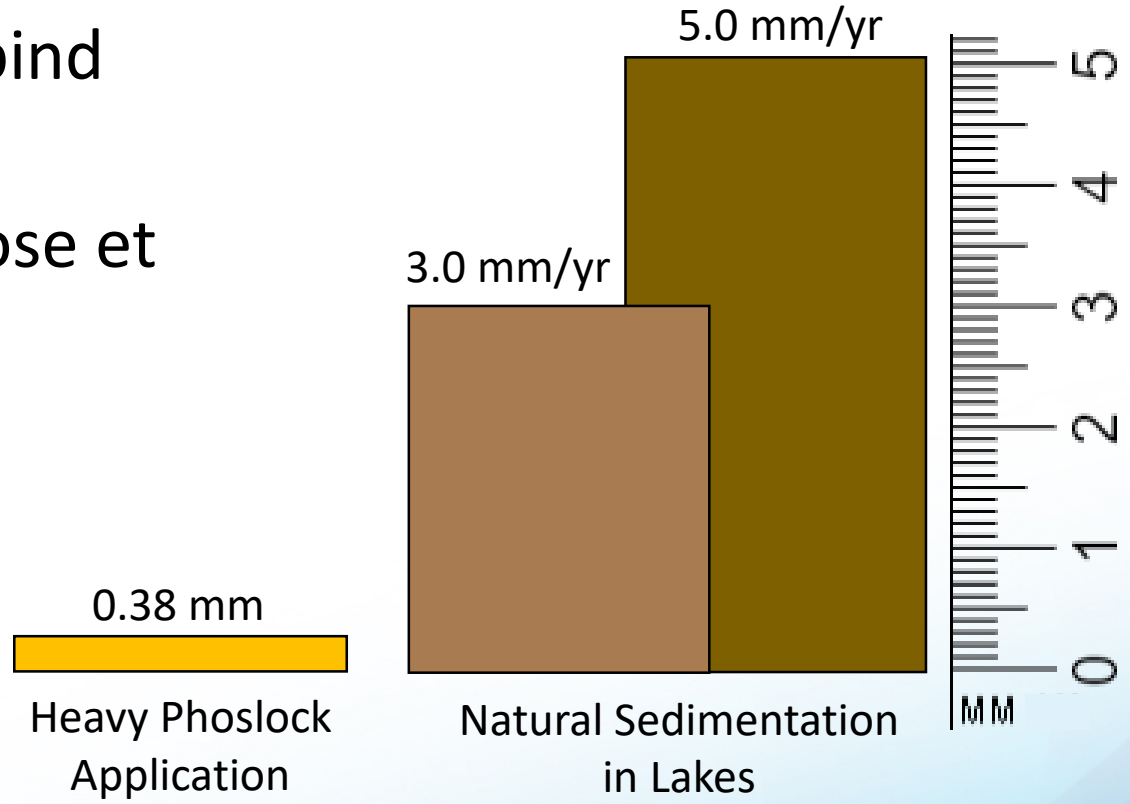
Phoslock in Sediments

- Permeable layer that continues to bind phosphate
- Increases sediment stability (Egemose et al 2010)
- Usually <u>fractions of a millimeter</u> added to sediment per application.

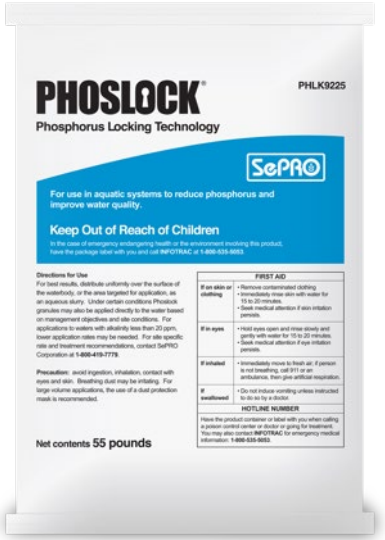


Morrison Lake 2020 Example
Phoslock layer thickness - 0.012 millimeters
U.S. Dollar Bill = 0.109 mm
0.012 mm / 0.109 mm = 11% of the thickness of a dollar bill

Phoslock®

Phosphorus Locking Technology

NSF/ANSI 60



- The phosphorus pollution solution
- Restores water quality by removing phosphorus
- Phosphorus is highly correlative to algae production (*EPA)
- Effective on a wide range of water chemistries
- Does not change water quality, pH, or create floc (like alum)
- Only technology that binds permanently and exclusively to phosphorus
  - Resulting mineral (LaPO4) is insoluble, not bio-available and non-toxic
- NSF / ANSI 60 certified for drinking water

Prescription

Utilizing information gained in the assessment phase to develop a plan and strategy.

Adaptive Management

We recommend a process of continued monitoring, stakeholder input, and adaptive management to successfully achieve or sustain project goals.

Stakeholder Input

Collaboration to create an understanding of the project, determine feasibility, and outline desired goals.

2.

1.

3.

Assessment

Collection of historical information, water quality data, and lake sediment samples.

Implementation

Efficiently and effectively executing the prescription outlined.

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Accelerating Water Resource Restoration

Case Study - Morrison Lake, MI

Morrison Lake is a 330-acre lake located near Clarksville, Michigan. The lake is impaired for phosphorus pollution and struggles with harmful algal blooms (HABs) and associated cyanotoxins that threaten human health, pets, and wildlife. Total Maximum Daily Load (TMDL) criteria were established for the lake in 2006 by the Michigan Department of Environment, Great Lakes and Energy (EGLE).

For more than 30 years, PLM Lake & Land Management Corp scientists and state-certified applicators have made it their priority to provide the highest quality service.

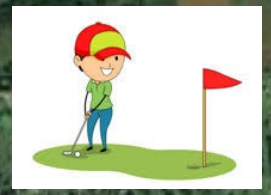
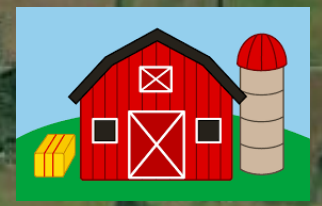
40 YEARS

Morrison Lake – Phosphorus Mitigation

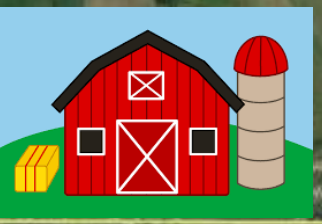
- Phosphorus Loading
  - Leary Drain
  - Stuart Green Drain
  - Deep water zone (>15 feet)
- 2019
  - HAB Advisories
- Low-dose Phoslock Proposed
  - Reduce in-water P (multi-year program)
  - Begin restoration of the lake (monthly)
  - Meet TMDL standards (538 lbs P)
  - Reduce impacts caused by poor water quality (HAB) (Secchi) (Native Plants)





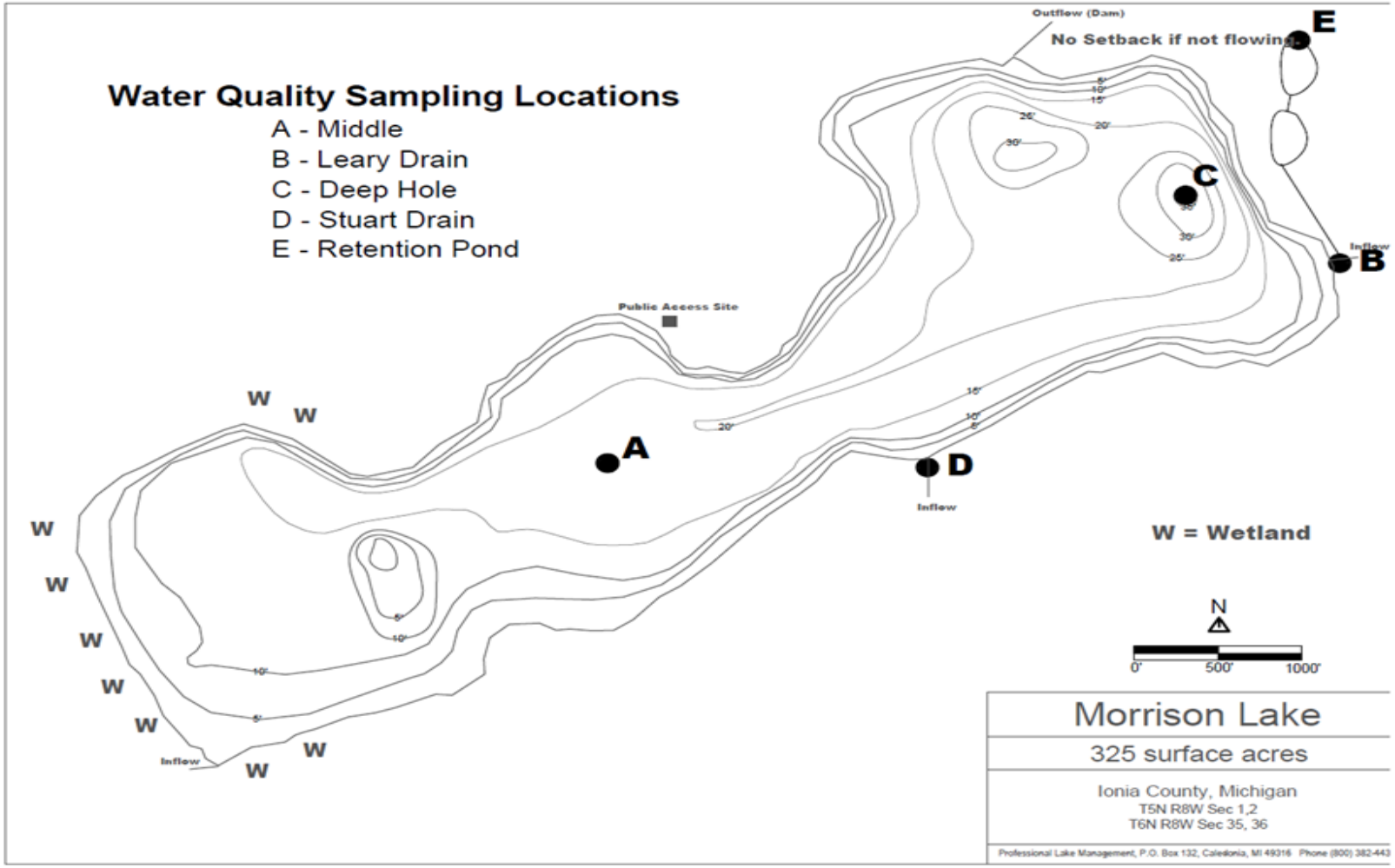








96
Cross St
2021 Google
Google Earth

Morrison Lake Phosphorus Loading



Morrison Lake Drains Data (2006)

Drain	Month	Jan	Feb	mar	Apr	May	jun	Jul	Aug	Sep	Oct	Nov	Dec
	Days	31	28	31	30	31	30	31	31	30	31	30	31
Leary	**Leary Drain**												
Leary	TP	0.073	0.073	0.073	0.054	0.061	0.101	0.146	0.085	0.1	0.075	0.038	0.073
Leary	Mean Flow (MGD)	1.9	3	5.9	4.5	2.1	1.6	0.7	0.4	0.5	1	1.5	2.1
Leary	Acre-feet/day	5.8	9.2	18.1	13.8	6.4	4.9	2.1	1.2	1.5	3.1	4.6	6.4
Leary	CFS	2.9	4.6	9.1	7.0	3.3	2.5	1.1	0.6	0.8	1.5	2.3	3.3
Leary	Daily Load	1.2	1.8	3.6	2.0	1.1	1.3	0.9	0.3	0.4	0.6	0.5	1.3
Leary	Monthly Load	35.9	51.2	111.4	60.8	33.1	40.5	26.4	8.8	12.5	19.4	14.3	39.7
Leary	Total Annual 2006	454.0											
Stuart	**Stuart Green Drain**												
Stuart	TP	0.106	0.106	0.106	0.091	0.087	0.093	0.106	0.106	0.099	0.106	0.162	0.106
Stuart	Mean Flow (MGD)	0.8	1.2	2.4	1.8	0.8	0.6	0.3	0.1	0.2	0.4	0.6	0.8
Stuart	Acre-feet/day	2.5	3.7	7.4	5.5	2.5	1.8	0.9	0.3	0.6	1.2	1.8	2.5
Stuart	CFS	1.2	1.9	3.7	2.8	1.2	0.9	0.5	0.2	0.3	0.6	0.9	1.2
Stuart	Daily Load	0.7	1.1	2.1	1.4	0.6	0.5	0.3	0.1	0.2	0.4	0.8	0.7
Stuart	Monthly Load	21.9	29.7	65.8	41.0	18.0	14.0	8.2	2.7	5.0	11.0	24.3	21.9
Stuart	Total Annual 2006	263.6											
	Total L + S Drains	717.6											

717.6 x 75% = 538 lbs Reduction Goal

Implementation ….

STATE OF MICHIGAN
DEPARTMENT OF
ENVIRONMENT. GREAT LAKES. AND ENERGY
LANSING

EGLE

GRETCHEN WHITMER
GOVERNOR

LIESL EICHLER CLARK
DIRECTOR

May 28, 2020

VIA E-MAIL

Mr. Jason Broekstra
Vice President of Great Lakes Operations
PLM Lake & Land Management Corp.
P.O. Box 132
Caledonia, Michigan 49316

Dear Mr. Broekstra:

The Michigan Department of Environment, Great Lakes, and Energy (EGLE) approves your December 10, 2019, workplan titled, "Morrison Lake Phosphorus Mitigation & HAB Control," per R 323.1097 (Rule 97) of the Part 4 Rules, Water Quality Standards, promulgated pursuant to Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. The approved workplan involves the application of Phoslock to Morrison Lake for phosphorus control. Morrison Lake is located in Ionia County (5N, 7W, Sections 33 and 34) and Barry County (4N, 7W, Sections 3, 4, and 5) Michigan.

The enclosed Certification of Approval is issued pursuant to Rule 97 of Michigan's Water Quality Standards and provides specific reporting and procedural requirements that must be complied with for EGLE authorization. Please carefully review the conditions of the Certification of Approval prior to commencing the project.

If you have any questions, please contact me at 517-449-2181 or BushD6@Michigan.gov.

Sincerely,

Dennis Bush, Supervisor
Water Toxics Unit
Surface Water Assessment Section
Water Resources Division

Enclosure
cc: Mr. Mike Worm, Grand Rapids District Supervisor, EGLE
Ms. Anne Garwood, EGLE
Mr. Eric Calabro, EGLE
Ms. Sylvia Heaton, EGLE
Dr. Sarah Bowman, EGLE
Rule 97 File, EGLE

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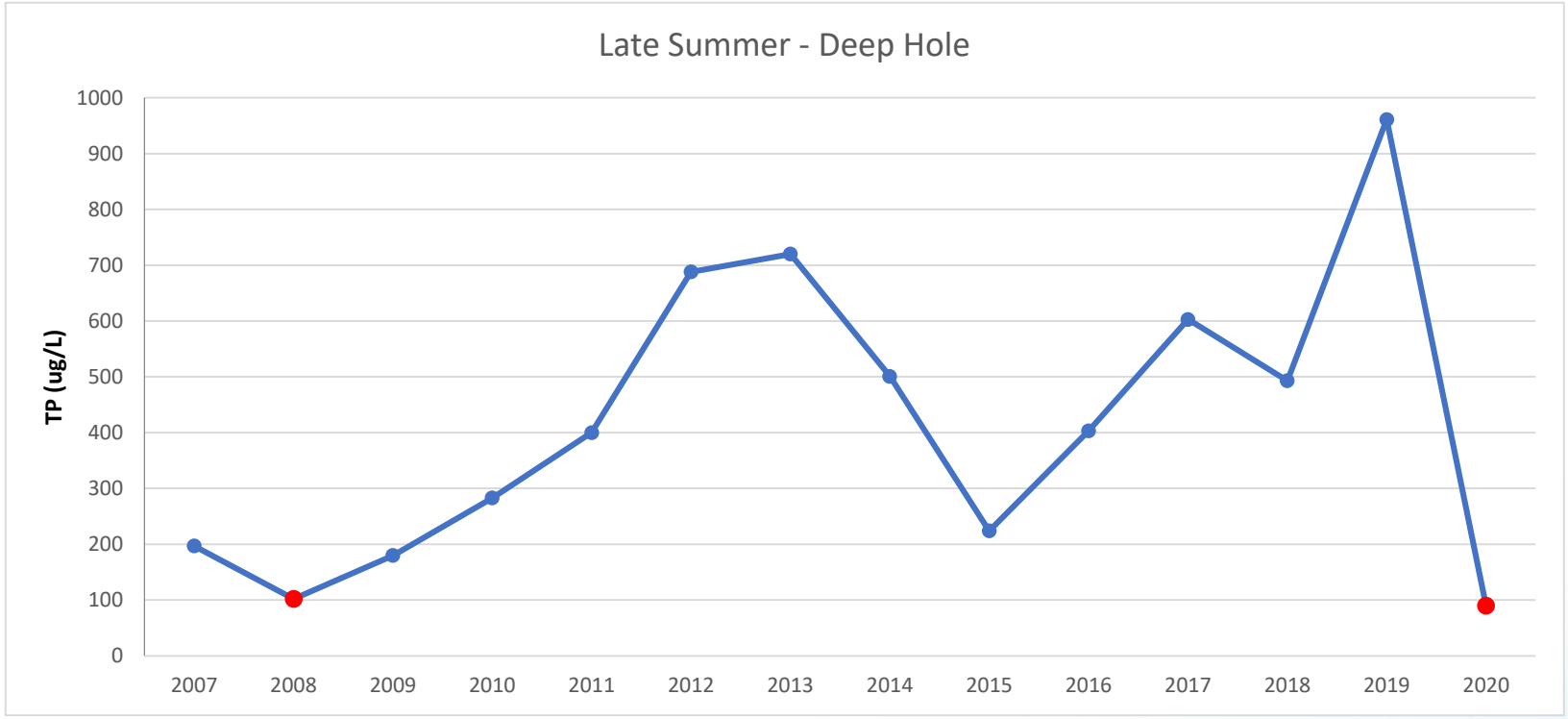
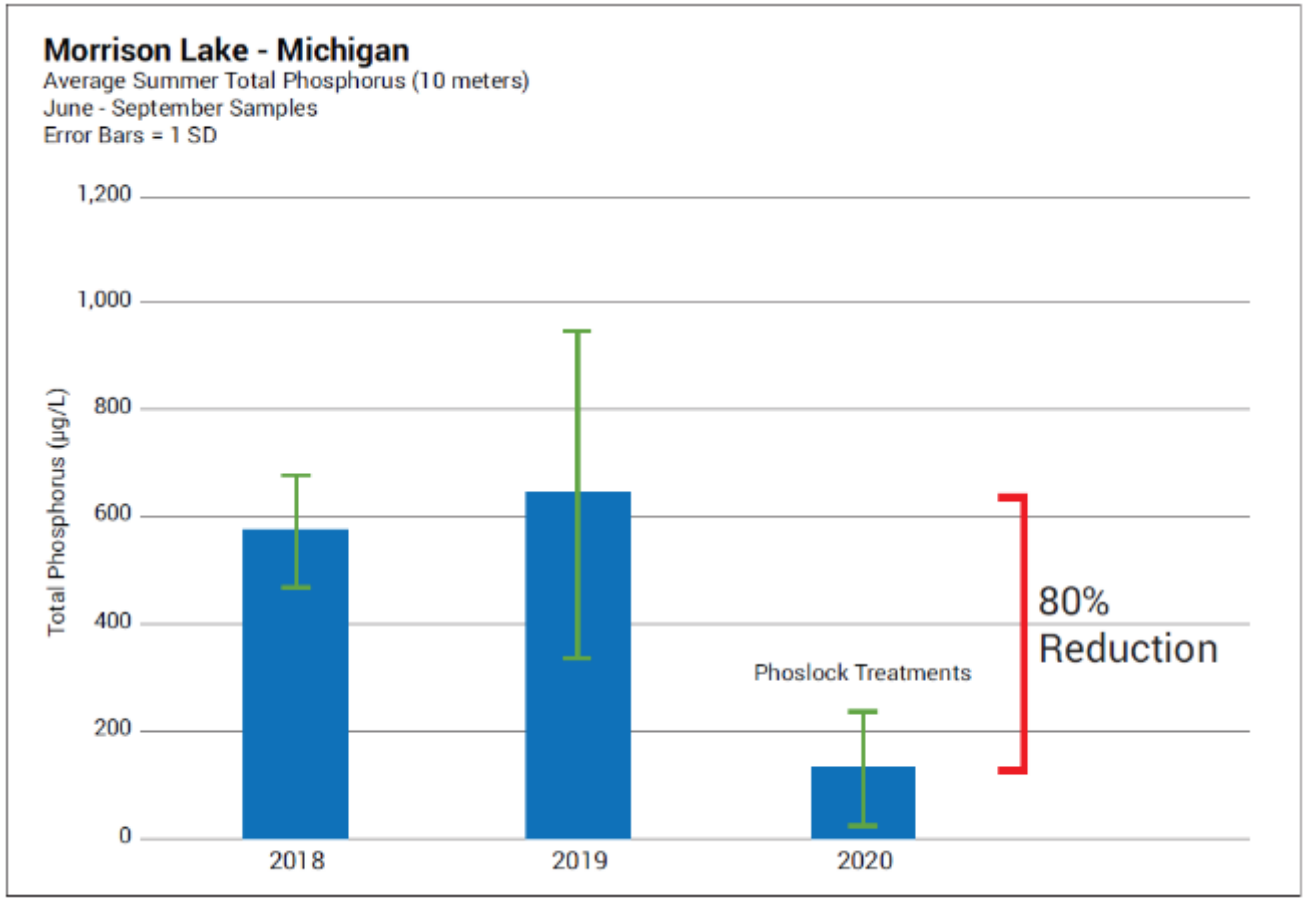
Historical Phosphorous Data Comparison



Date of Treatment	Amount of Phoslock Applied (lbs)
6/02/2020	10,000
6/25/2020	6,000
7/08/2020	3,000
7/23/2020	7,000
8/12/2020	2,000
8/27/2020	2,000

2020 Results



80% Reduction in hypolimnetic P
No late-season HABs ~300 lbs P

2021 – Phoslock, "EutroSORB"
2022 – Phoslock, "EutroSORB"
2023 - TBD

Benefit to Water Resource Management

- Rapid binding of nutrients in flowing water
  - Complement *in situ* Phoslock programs
  - Complement watershed based BMPs
- Proactively manage water resources
  - Offset need for reactive treatments of HAB's
- Ecologically benign
- Recovery/ reuse message
- Critical fit in water resource management programs
  - Stormwater, TMDL & NPDES discharges, ponds, etc.

EutroSORB™
Phosphorus Filtration Technology

EutroSORB – Leary Drain 2021

- Target Area – lower drain (red circle)
- ~May 15th
  - 100 filters
- ~July 1st
  - 84 filters

An example of "In Series" arrangement

Morrison Lake 2021, 2022 and Future!

- Phoslock + EutroSORB
  - ~350 lbs. of phosphorus mitigated
- Monitor, Assess, & Adaptively Manage
- 2022 – Continue Phoslock as planned and expand EutroSORB pending results.
- Restore Morrison Lake's ecological stability… clarity, native plant diversity, fisheries, recreation and property values!

Michigan Lakes

- ~25% of MI Lakes – Eutrophic
- 17% due to Phosphorus
  - Water-Quality Characteristics of Michigan's Inland Lakes, 2001–10

TMDL Lakes

Bear Lake	Phosphorus	2008
Brighton Lake	Phosphorus	2000
Ford Lake and Belleville Lake	Phosphorus	2019
Goose Lake	Phosphorus	2011
Great Bear Lake Proper	Phosphorus	2004
Kent Lake	Phosphorus	2000
Lake Allegan (Kalamazoo River Impoundment)	Phosphorus	2001
Morrison Lake	Phosphorus	2008
Ore Lake	Phosphorus	2000
Strawberry Lake	Phosphorus	2000

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

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).

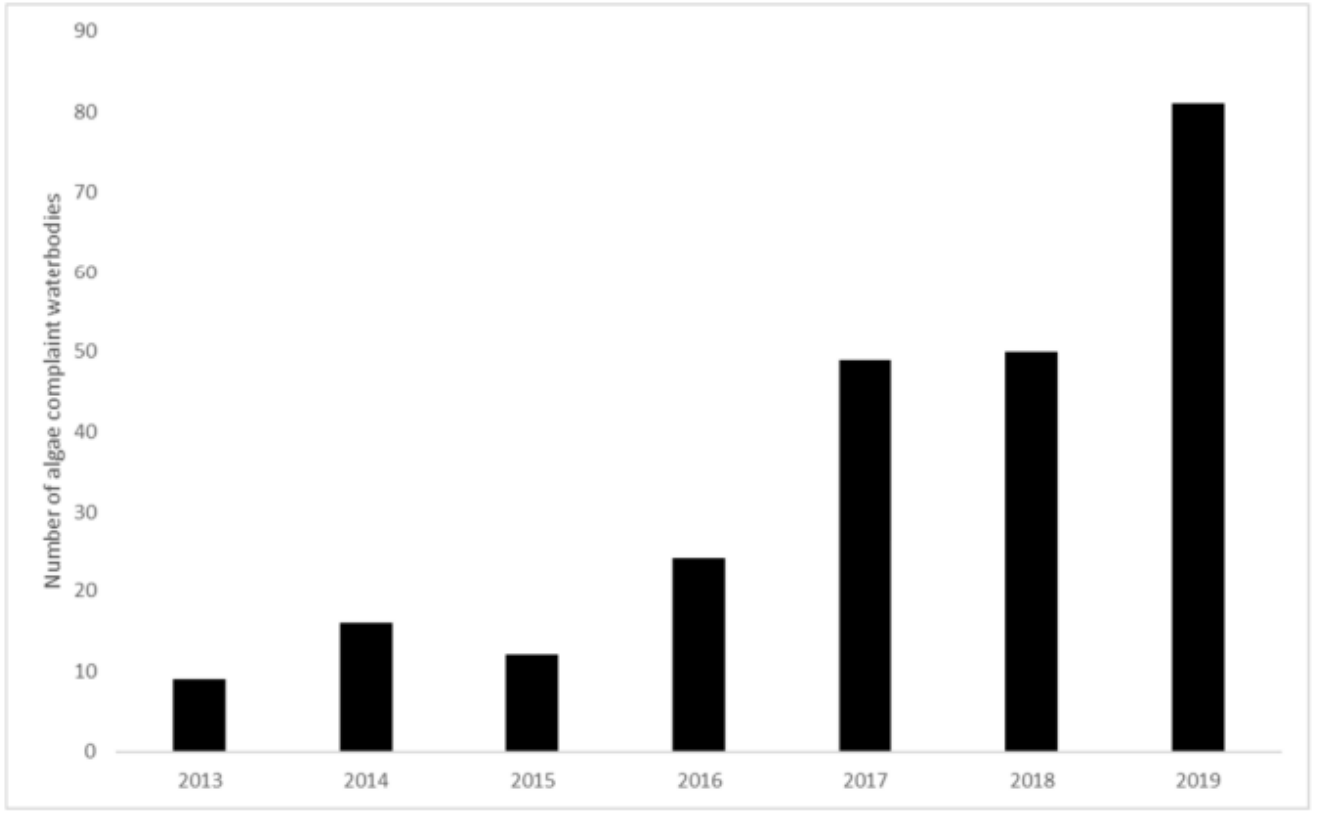


Figure 3. Number of different water bodies with complaints about algae or cyanobacteria from 2013-2019.

Questions Please… Thank You! ☺

- Jason Broekstra, 1-800-382-4434 x 2000 jasonb@plmcorp.net
- Scott Shuler, 1-317-388-3316 scotts@eutrophix.com