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Orthophosphate Impacts on Wastewater

February 28, 2024

Executive Summary

- Orthophosphate is cycled back to the wastewater treatment plant facility as soluble Phosphorus. Every 3 lb. of phosphate is equivalent to 1 lb. of phosphorus.
- The proposed 2.4 ppm from the water system will increase current phosphorus influent loading to the Water Resource Recovery Facility (WRRF) by approximately 15.4% (1,800 lb./day).
- GLWA anticipates an increase of approximately 57% (15,246 lb.) in ferric chloride. This will likely double the truck delivery, bringing the facility to two trucks per day.
  - *However, the performance of ferric chloride on soluble phosphorus is limited, the proposed increase may not be sufficient, and the effluent loading may still increase in the receiving water body.*
- GLWA has committed to a goal under the Boundary Waters Treaty International Joint Commission to reduce loading (the total amount of phosphorus discharged) by 40% from the 2008 total.

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lb. = pound

Background

Phosphorus is a chemical element necessary for life!

- Living cells use Phosphorus to metabolize food into energy for growth.
- Used in fertilizers, soft drinks, other industrial processes.
- Formerly found in detergents.
  - Michigan banned phosphates from dish detergents in 2010.
  - Due to concern over the adverse effects that arise from excess phosphorus loads to lakes, rivers, and streams.
- Used in drinking water treatment for controlling corrosion in pipes.
  - It reacts to form a coating on the inside of the pipes and prevents the leaching effects of lead and copper pipes, thus preventing lead from entering the water.

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Background

In wastewater, phosphorus mostly comes from organic wastes.

- When potable water goes down the drain (running the sink, showering, flushing), any phosphorus that was left over from the corrosion control goes down the drain too.
- The GLWA - WRRF receives approximately 6 tons of phosphorus every day, at an average concentration of about 2.5 mg/l.
- Two kinds of phosphorus: “particulate” (caught up in solid particles that will settle or be filtered out), and “soluble” (dissolved in the water).
- Excess phosphorus in lakes and rivers contributes to harmful algae blooms, like the one that shut down the city of Toledo’s water intake in 2014.

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mg/l= milligrams per liter

Regulations

- To control these blooms, the Environmental Protection Agency (EPA) and Michigan Department of Environment, Great Lakes, and Energy (EGLE) limit how much phosphorus can be in wastewater discharges through the National Pollutant Discharge Elimination System (NPDES) permit.
- GLWA's discharge limit is currently 0.7 mg/l phosphorus, and the average for the six months from April-September is limited to 0.6 mg/l phosphorus.
- EGLE has signaled future interest in lowering the April-September limit.

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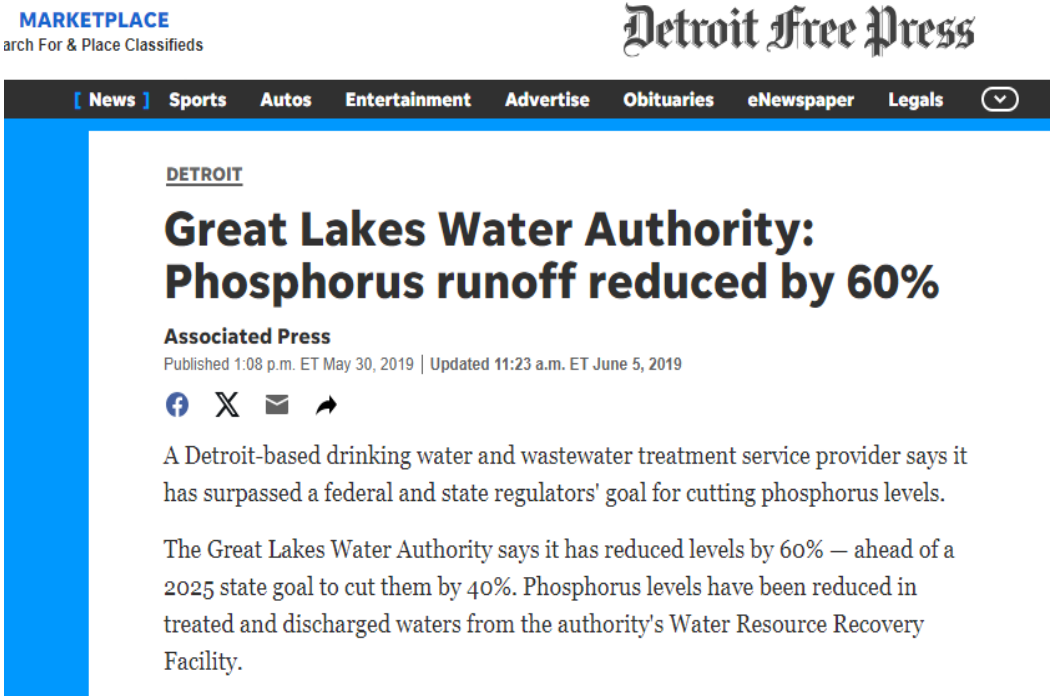
mg/l= milligrams per liter

Too Much of a Good Thing



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DETROIT

Great Lakes Water Authority: Phosphorus runoff reduced by 60%

Associated Press

Published 1:08 p.m. ET May 30, 2019 | **Updated 11:23 a.m. ET June 5, 2019**

A Detroit-based drinking water and wastewater treatment service provider says it has surpassed a federal and state regulators' goal for cutting phosphorus levels.

The Great Lakes Water Authority says it has reduced levels by 60% — ahead of a 2025 state goal to cut them by 40%. Phosphorus levels have been reduced in treated and discharged waters from the authority's Water Resource Recovery Facility.

- There is also a goal under the Boundary Waters Treaty International Joint Commission to reduce loading (the total amount of phosphorus discharged) by 40% from the 2008 total.
- GLWA achieved and surpassed the goal well in advance of the requirement.
- GLWA's goal is to limit the phosphorus discharge to 469 tons a year.

Methods for Phosphorus Treatment

At the GLWA WRRF:

- Ferric chloride solution is added to the wastewater as it enters the plant – this reacts with soluble phosphorus to turn it into particulate phosphorus.
- Particulate phosphorus settles out of the wastewater in the primary treatment system.
- Microorganisms in the secondary treatment system use some of the remaining soluble phosphate to help them remove organic chemicals – their “food” – from the wastewater.

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Corrosion Control – Striking a Balance

- Increasing the corrosion control dose will send more soluble phosphate to the WRRF without sending more organic chemicals.
- Without additional “food”, the microorganisms will not use additional phosphate, so using more ferric chloride is likely to be the most viable means for removing this additional phosphate.

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Baseline Assumptions

- Sanitary flow reaching the WRRF totals approximately 300 MGD.
  - “drought conditions” WRRF flow in November 2022 averaged 350 MGD, but not all of that is sanitary flow.
- Almost all added ortho-phosphate will pass through the system
  - Potable water analyzed at WRRF during February 2023 was 0.35 mg/l as phosphorus / 1.1 mg/l=l as phosphate; 1.2 mg/l as phosphate was originally added.
- Removal of 250 pounds of soluble phosphorus requires 2.3 dry tons of ferric chloride.
  - Actual WRRF performance from 2021-2022
- October 2023 ferric chloride cost: $997/dry tons

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mg/l= milligrams per liter
MGD = million gallons per day

Three Scenarios Analyzed

1. "Maintain Ferric Usage" - same amount of soluble phosphorus is removed in primary, all excess passes through to secondary and is removed at the same ratio as existing plant performance
2. "Maintain Performance" - same fraction of soluble phosphorus is removed in primary as existing plant performance, some excess load is passed to secondary and removed at same ratio as existing plant performance
3. "Maintain Effluent Quality" - all excess soluble phosphorus is removed in primary via ferric addition.

For scenarios 1 and 2, “existing plant performance” was calculated on a daily basis using actual lab data from that date.

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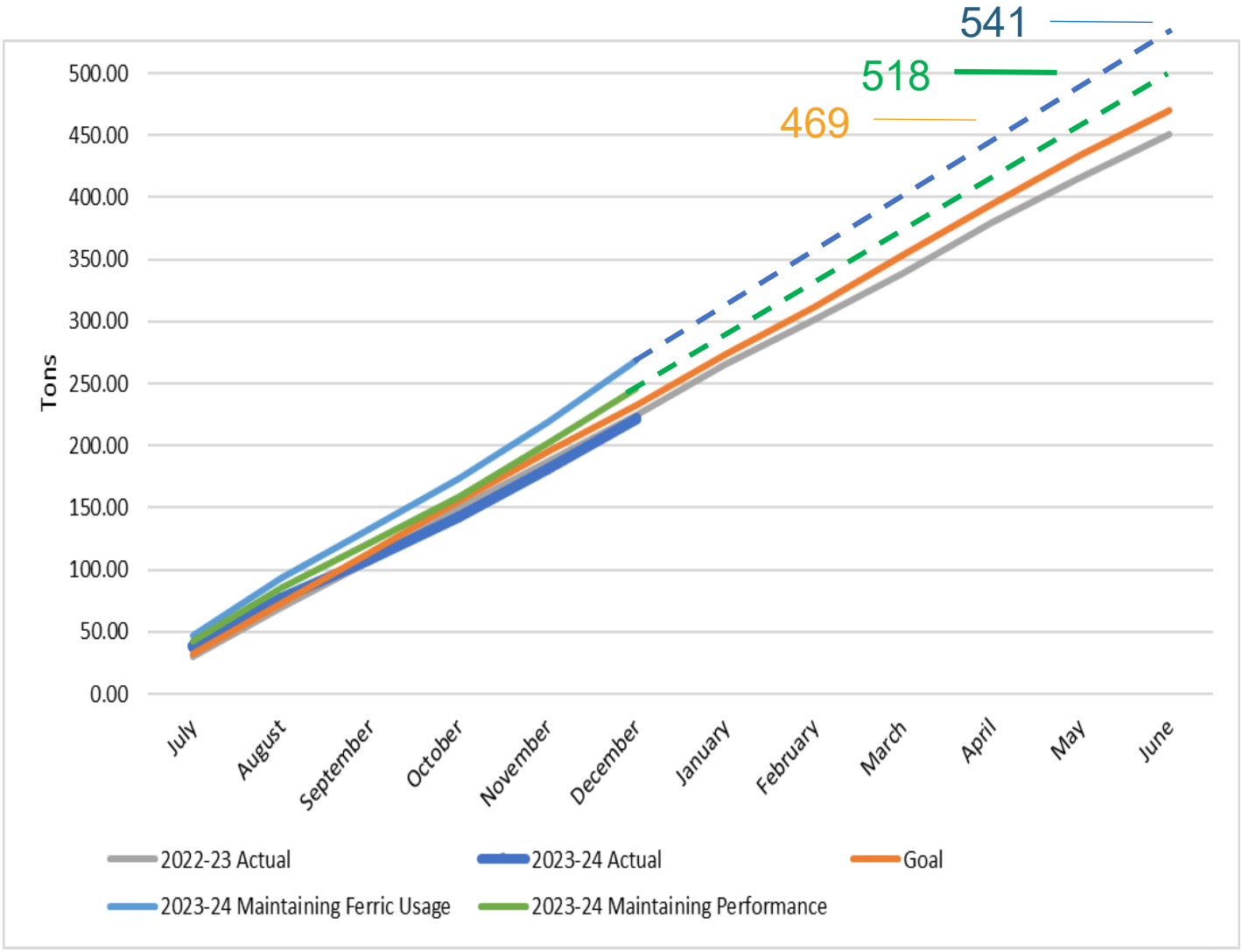
Phosphorus Loading YTD



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NPDES Permit Discharge Requirements

Hypothetical C2E (049B) TP concentration (mg/L) - maintaining performance

	Actual (1.2 ppm)	1.5 ppm	2 ppm	2.5 ppm	3 ppm	4 ppm
Jan-21	0.5	0.5	0.6	0.6	0.6	0.6
Feb-21	0.5	0.5	0.5	0.5	0.5	0.6
Mar-21	0.4	0.4	0.4	0.4	0.5	0.5
Apr-21	0.4	0.4	0.4	0.5	0.5	0.5
May-21	0.6	0.6	0.6	0.6	0.7	0.7
Jun-21	0.4	0.4	0.4	0.5	0.5	0.5
Jul-21	0.2	0.2	0.2	0.2	0.2	0.2
Aug-21	0.2	0.2	0.2	0.3	0.3	0.3
Sep-21	0.3	0.3	0.3	0.3	0.3	0.4
Oct-21	0.3	0.3	0.3	0.3	0.4	0.4
Nov-21	0.4	0.4	0.4	0.4	0.4	0.4
Dec-21	0.2	0.2	0.3	0.3	0.3	0.3
Jan-22	0.4	0.4	0.4	0.4	0.4	0.4
Feb-22	0.4	0.4	0.4	0.4	0.4	0.4
Mar-22	0.3	0.3	0.3	0.3	0.3	0.3
Apr-22	0.3	0.3	0.3	0.3	0.3	0.3
May-22	0.2	0.3	0.3	0.3	0.3	0.3
Jun-22	0.4	0.4	0.4	0.4	0.4	0.5
Jul-22	0.4	0.4	0.4	0.4	0.4	0.5
Aug-22	0.4	0.4	0.5	0.5	0.5	0.5
Sep-22	0.6	0.6	0.6	0.6	0.6	0.7
Oct-22	0.7	0.8	0.8	0.8	0.8	0.9
Nov-22	0.6	0.6	0.6	0.7	0.7	0.7
Dec-22	0.5	0.5	0.6	0.6	0.6	0.6
Jan-23	0.5	0.5	0.5	0.5	0.6	0.6
Feb-23	0.4	0.4	0.4	0.4	0.5	0.5
Mar-23	0.3	0.3	0.3	0.3	0.3	0.4
Apr-23	0.4	0.4	0.4	0.4	0.4	0.4
May-23	0.5	0.5	0.5	0.5	0.6	0.6
Jun-23	0.5	0.5	0.5	0.5	0.6	0.6
Jul-23	0.4	0.4	0.4	0.4	0.4	0.4
Aug-23	0.4	0.4	0.4	0.4	0.4	0.5
Sep-23	0.5	0.5	0.5	0.5	0.6	0.6
Oct-23	0.5	0.5	0.5	0.5	0.6	0.6
2021 Summer	0.4	0.4	0.4	0.4	0.4	0.4
2022 Summer	0.4	0.4	0.4	0.4	0.4	0.5
2023 Summer	0.4	0.4	0.4	0.5	0.5	0.5

Yellow = Increased reported concentration

Red = New violation

Current permit requirements: monthly average may not exceed 0.7 mg/l

Summer (April-September) average may not exceed 0.6 mg/l

Permit to be issued 2024 will lower summer average limit.

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(ppm) parts per million
(mg/L) milligrams per liter
(TP) total phosphorus

At Potable Phosphate Dose…

At current plant performance and ferric cost, at potable phosphate dose…						
Orthophosphate loading from GLWA Water Plants	1.2 ppm (baseline)	1.5 ppm	2 ppm	2.5 ppm	3 ppm	4 ppm
Influent SP load from potable water (lb/day)	876	1072	1430	1787	2144	2859
Maintaining Ferric Usage						
Avg 049B TP	0.41 mg/l	0.42 mg/l	0.45 mg/l	0.47 mg/l	0.49 mg/l	0.54 mg/l
Increased discharge		3.3%	9.3%	15.4%	21.4%	33.4%
Maintaining Current Removal Performance						
Avg 049B TP	0.41 mg/l	0.42 mg/l	0.43 mg/l	0.45 mg/l	0.47 mg/l	0.50 mg/l
Increased discharge		2.3%	6.4%	10.5%	14.6%	22.8%
Additional Ferric Chloride (lb/day)		1,063	3,009	4,915	6,820	10,832
Increase in Delivery		4%	12%	19%	27%	42%
Maintaining Current Effluent Standards						
Excess SP (lb/day)		196	554	911	1268	1983
Additional Ferric Chloride (lb/day)		3,310	9,328	15,246	21,264	33,300
Increase in Delivery		13%	36%	60%	83%	130%

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