Total Organic Carbon

Presented by Cheryl Porter, *Chief Operating Officer – Water and Field Services*

April 2024

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Key Take Aways

1. A treatment technique violation requires a Tier-2 public notification (30 days from the time the community water supply receives the violation). In this case, GLWA had 30 days to notify the member partners and they had 30 days from GLWA's public notification to notify their customers.
2. Total Organic Carbon (TOC) have **no known health effects** based on current literature.
3. TOC in GLWA drinking water is generally from natural organic matter (NOM).
4. The TOC requirement is ≤ 2.0 mg/L for locational running annual average (LRAA).
5. Water Works Park individual TOC levels appear to be returning to previous levels, but still higher than they were in 2021 (~1.5 mg/L).
6. GLWA Water and Field Services' Teams are actively working on ensuring that we continue to provide drinking water of unquestionable quality to the people of southeast Michigan.

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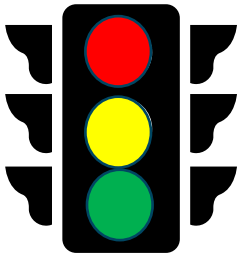
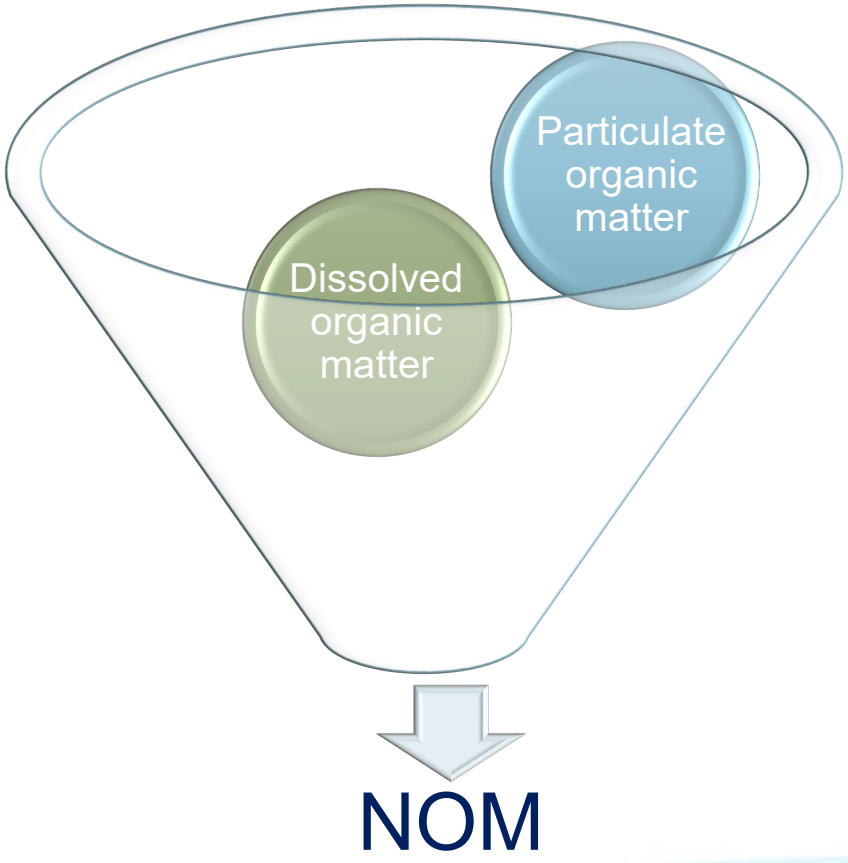


What is TOC?

TOC = Total Organic Carbon

Total organic carbon is a measure of the concentration of dissolved and suspended organic carbon contained in a water and comes from natural decaying vegetation and man-made sources.



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TOC (continued)

- TOC has no known reported health effects.
- TOC is regulated to reduce the potential for **disinfectant byproduct (DBP)** formation and is monitored to ensure that appropriate source water treatment techniques are used.
- Source water contains TOC, and it is decreased by water treatment to meet the regulatory requirements to protect public health from disinfectant byproduct formation.

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Disinfectant Byproducts (DBPs)

What are Disinfectant Byproducts?

- DBPs can be formed by the reaction of disinfectants such as chlorine with the organic precursors (TOC) present in the source water.
  - These include regulated compounds some of which are considered Volatile Organic Compound (VOC).
- These organic precursors are usually natural organic matter (NOM).
- NOM is a complex mixture of organic matter and is found in all groundwater and surface waters and comes from decaying vegetation.

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Monitoring at GLWA

- GLWA is required to monitor TOC from their five water plant taps and the source water (Detroit River and Lake Huron) to determine the removal efficiency of the treatment process.

- Compliance is **calculated** quarterly based on **locational running annual average** (LRAA) of the quarterly averages of monthly averages using source and treated TOC paired samples.

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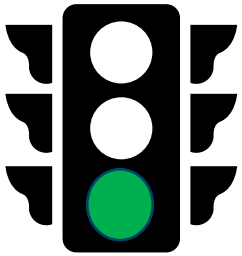

US EPA Stage 1/Stage 2 Disinfectant Byproduct Rule

Source water TOC (mg/L)	Source water alkalinity (mg/L as $CaCO_3$)		
	0 to 60	>60 to 120	>120
>2.0 – 4.0	35.0%	25.0%	15.0%
>4.0 – 8.0	45.0%	35.0%	25.0%
>8.0	50.0%	40.0%	30.0%

Required Removal of TOC by Enhanced Coagulation for Plants Using Conventional Treatment Removal Percentages

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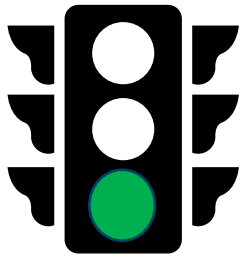

US EPA Stage 1/Stage 2 Disinfectant Byproduct Rule

Enhanced coagulation and enhanced softening plants meeting at least one of the six alternative compliance criteria are not required to meet the removal percentages

- The system's source water TOC is less than 2.0 mg/L
- The system's treated water TOC is less than 2.0 mg/L
- The system's source water TOC is less than 4.0 mg/L, the source water alkalinity is more than 60 mg/L as $CaCO_3$, and the system is achieving TTHM less than 40 µg/L and HAA5 less than 30 µg/L.
- The system's TTHM is less than 40 µg/L, and HAA5 is less than 30 µg/L, and only chlorine is used for primary disinfection and maintaining a distribution system residual.
- The system's source water SUVA prior to any treatment is less than or equal to 2.0 L(mg/m)
- The system's treated water SUVA is less than or equal to 2.0 L(mg/m)

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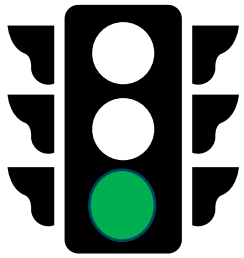

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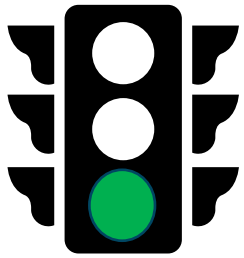

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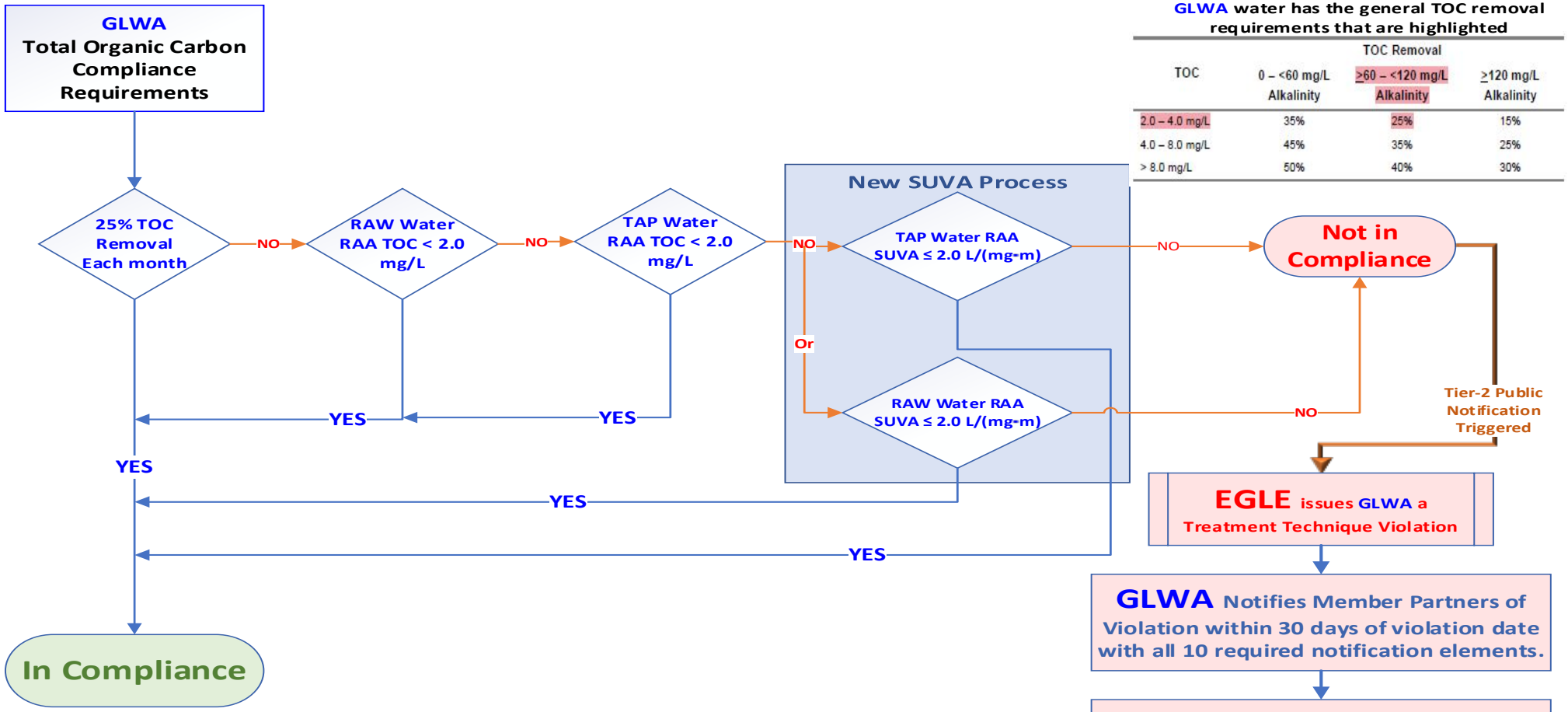

GLWA water has the general TOC removal requirements that are highlighted

TOC	TOC Removal		
	0 – <60 mg/L Alkalinity	≥60 – <120 mg/L Alkalinity	≥120 mg/L Alkalinity
2.0 – 4.0 mg/L	35%	25%	15%
4.0 – 8.0 mg/L	45%	35%	25%
> 8.0 mg/L	50%	40%	30%

- **Monthly averages** = average of all samples taken within the month.
- **Quarterly averages** are calculated by averaging each calendar's monthly averages.
- **Running annual average (RAA)** are calculated by averaging the last four (4) quarterly averages.

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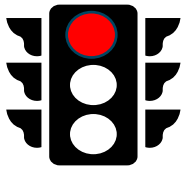
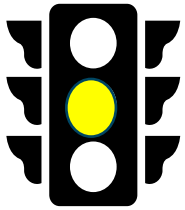
EGLE Public Notification Rule

The Michigan EGLE Public Notification (PN) rule has several tiers.



- Tier-1 PN: as soon as practical but no later than 24 hours after learning of the violation
  - *E. coli* or fecal coliform present or present failure to test after a positive total coliform sample detected. **Maximum Contaminant Level (MCL) exceedance** for nitrate, nitrite; failure to take confirmation samples. Chlorine dioxide, turbidity, waterborne disease outbreak, etc., or other violations determined by the Michigan Department of Environment, Great Lakes, and Energy (EGLE).



- Tier-2 PN: as soon as practical or within 30 days of being notified. Repeat notice every 3 months until violation or situation is resolved.
  - All MCL violations and **treatment technique violations** (except if a Tier-1 notice is required). Failure to comply with variance and exemption conditions, etc.
- Tier-3 PN: 12 months and repeat annually until resolved.
  - Monitoring or testing procedure violation, etc., unless elevated to Tier-2 by EGLE.

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Violation

- GLWA was informed by EGLE that its TOC compliance monitoring sample, was higher than the acceptable standards required by the regulations for third quarter of 2023 ending September 2023.
- Water Works Park is the only plant impacted.
  - Detroit, Grosse Pointe Park, Hamtramck, Harper Woods and Highland Park
- Received email notice March 15, 2024 of another Tier-2 public notification for quarter ending December 2023.
- Another Tier-2 public notification is anticipated for the quarter ending March 2024.

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Violation

- GLWA's Water Works Park Plant's treated water TOC was greater than 2.0 mg/L *(2.04 mg/L)* for the locational running annual average at the end of the 3rd calendar quarter of 2023.

- The tier-2 violation began October 1, 2023, (following the quarter in which the required removal was not met) and continues until required removal percentages or alternative compliance criteria are met.

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GLWA and Member Partner DBPs

- DBPs are health concerns after long exposure and are routinely tested to ensure that they do not exceed their MCL:
  - Four - Trihalomethanes (THMs) – (MCL = 80 µg/L), and
  - Five - Haloacetic acids (HAA5s) – (MCL = 60 µg/L)
- GLWA Member Partners test for THMs and HAA5s in their respective distribution systems.
- GLWA tests for volatile organic compounds (VOCs) in the water plants and some THMs are a subset of VOCs.
- **No known DBP MCL exceedances by the GLWA nor their member partner communities.**

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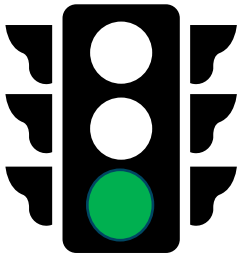
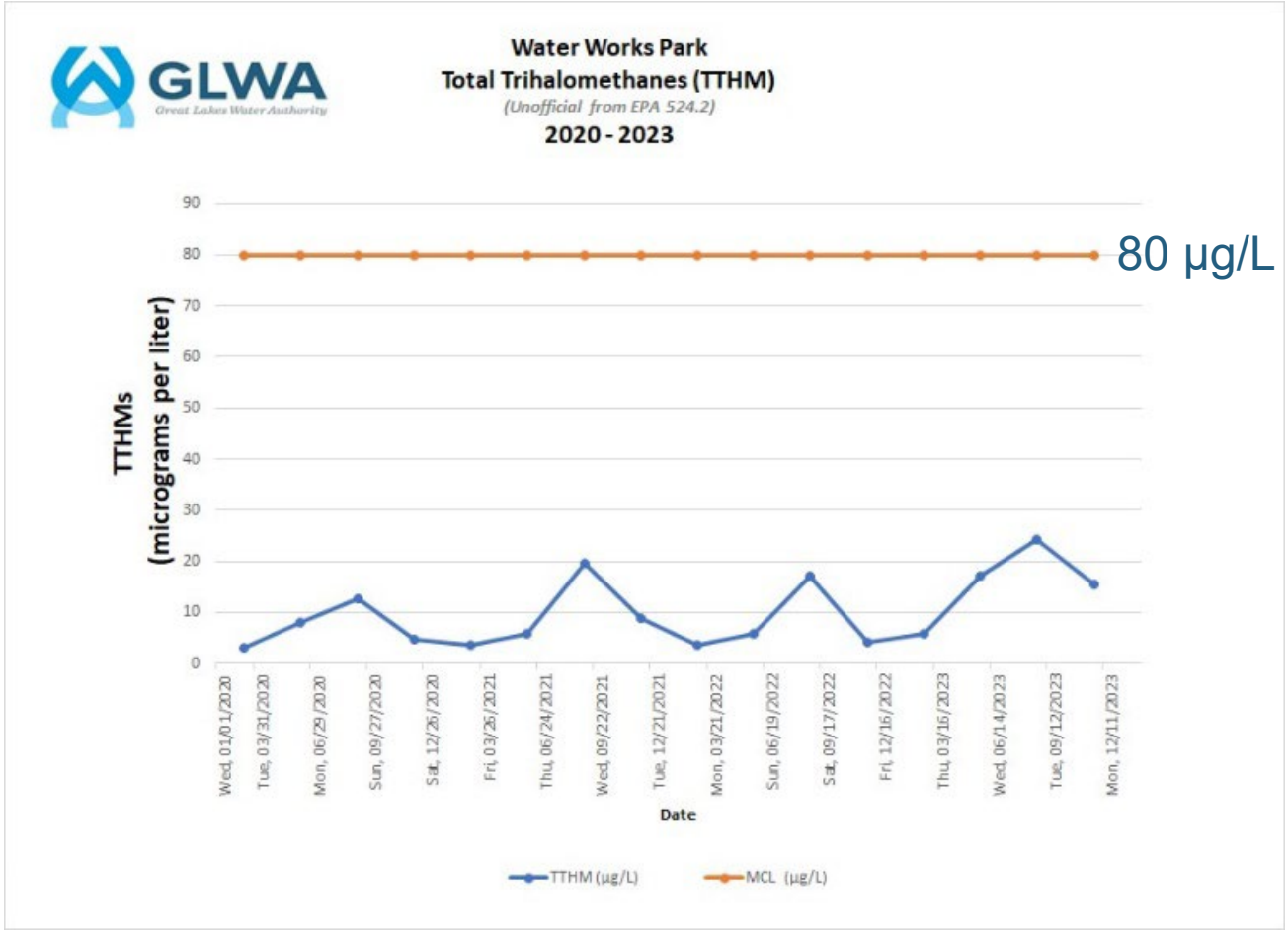
GLWA and Member Partner DBPs (cont.)



Water Works Park Measured Plant TTHMs



TTHMs Are Well Below their Maximum Contaminant Level

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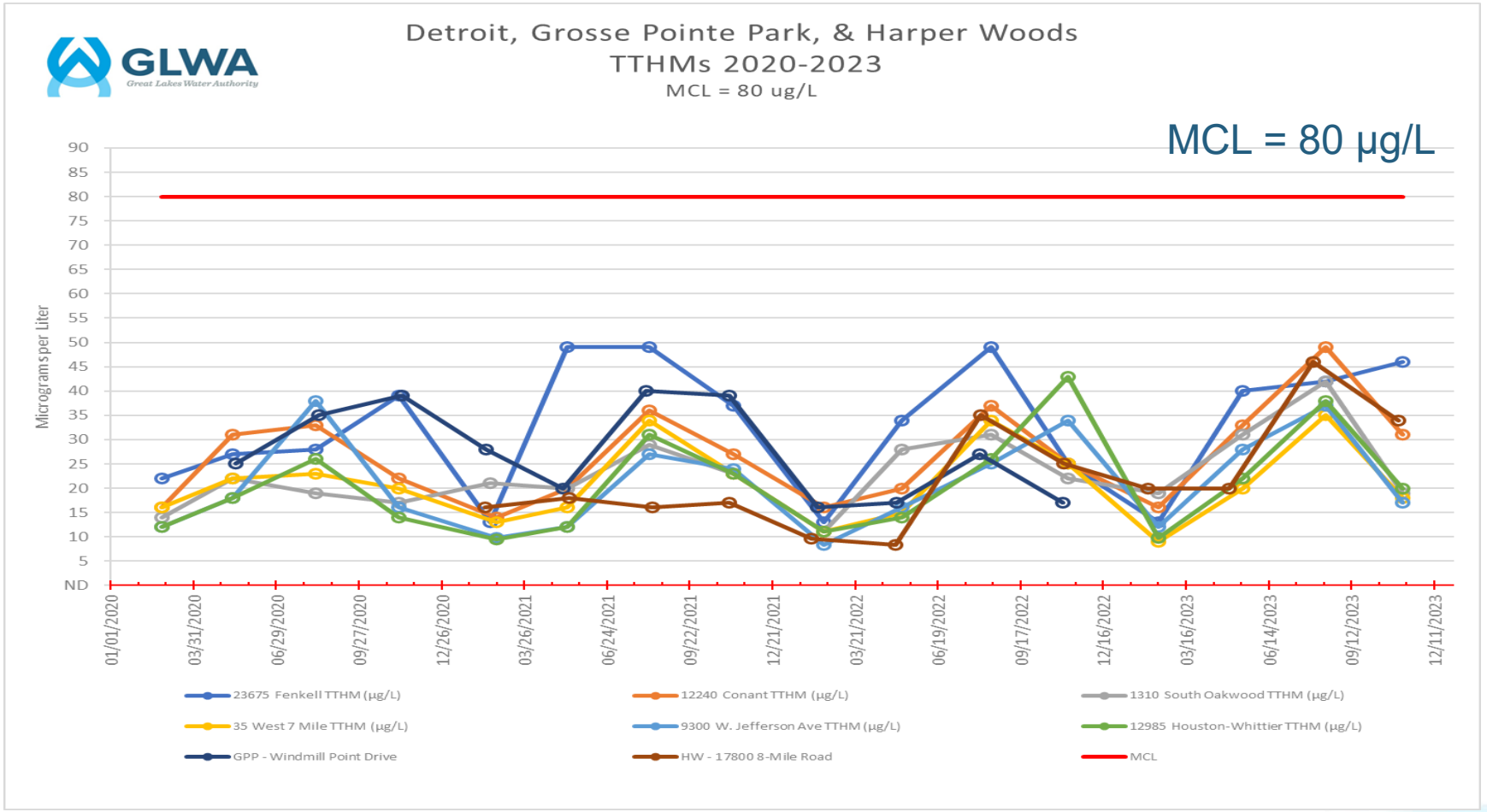
GLWA and Member Partner DBPs (cont.)

Distribution System TTHMs



TTHMs Are Well Below their Maximum Contaminant Level

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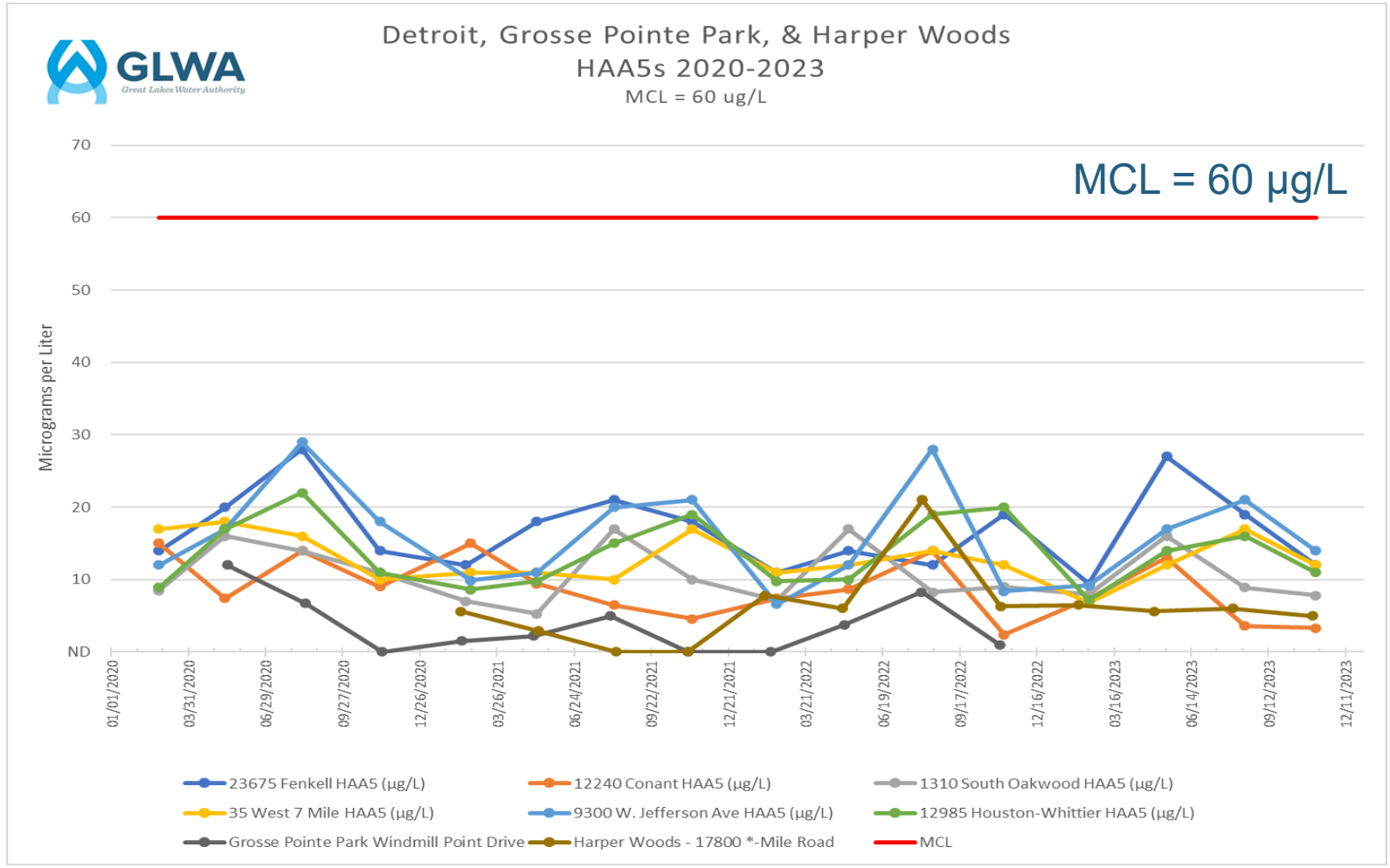
GLWA and Member Partner DBPs (cont.)



HAA5s Are Well Below their Maximum Contaminant Level

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Steps Taken

- GLWA Notified the member partners public within 30 days of the violation.
- Member partners notified their customers within 30 days of receiving notice from GLWA.
- Water Quality started testing the TOC weekly. The TOC results are trending lower compared to previous readings (TOC for 4th Quarter 2023 is 1.8 mg/L and TOC for LRAA 4th Quarter 2023 is 2.0+ mg/L).
- Flushed and replaced Water Works Park TOC sample line.
- Established a sample increase in dissolved organic carbon (DOC) testing.
- Water Quality lab is performing the UV-254 testing for specific ultraviolet absorbance (SUVA).

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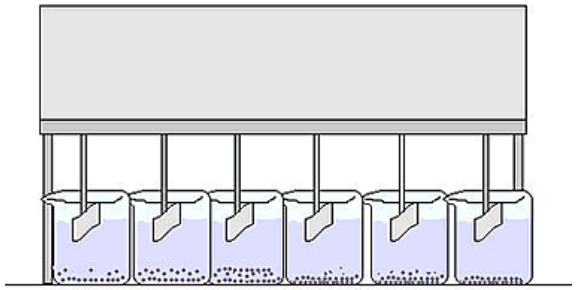
Several Ways for GLWA to Meet Compliance

A. Source water TOC ≥ 2.0 mg/L, source water TOC ≤ 4.0 mg/L, source water alkalinity between 60 mg/L and 120 mg/L, and 25% removal of TOC from source water as compared to treated water.

B. Jar testing to set an alternative TOC percent removal for determining compliance (must be completed monthly).

GLWA's Research and Innovation team is working on this as a possible means of meeting compliance.



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Several Ways for GLWA to Meet Compliance (continued)

C. Alternative compliance (enhanced coagulation):

1. Source water LRAA TOC < 2.0 mg/L *(GLWA historic method)*
2. Treated water LRAA TOC < 2.0 mg/L *(GLWA historic method)*
3. Specific Ultraviolet Absorption Source water LRAA SUVA ≤ 2.0 L/(mg-m)
4. Specific Ultraviolet Absorption Treated water LRAA SUVA ≤ 2.0 L/(mg-m)
5. Source water LRAA TOC < 4.0 mg/L,
   a. *Source water Alkalinity > 60 mg/L and*
   b. *TTHM < 40 µg/L & HAA5 < 30 µg/L for distribution compliance samples.*
6. *Free chlorine as only disinfectant and TTHM < 40 µg/L & HAA5 < 30 µg/L for distribution compliance samples.*

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Specific Ultraviolet Absorbance (SUVA) Results

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Supply: **GLWA - WATER WORKS PARK PLANT**

WSSN: 02838 Month/Year: ***Dec. 2023, Jan and Feb 2024***

Month	Treated DOC (mg/L)	Treated UV254 m^{-1}	Treated SUVA L/(mg•m)	Source DOC (mg/L)	Source UV254 m^{-1}	Source SUVA L/(mg•m)
Dec-23	2.1	0.7	0.39	2.4	1.5	0.63
Jan-24	1.9	2.3	1.23	2.4	1.4	0.96
Feb-24	**2.3**	**0.8**	**0.33**	**2.4**	**1.5**	0.45

If Treated Water LRAA < 2.0, then system in compliance — Treated LRAA: 0.39, 1.23, 0.33

If Source Water LRAA < 2.0, then system in compliance — Source LRAA: 0.63, 0.96, 0.45

The first compliance calculation must be made after the first Monitoring Period, then quarterly, then annually

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EGLE's Approval on SUVA

GRETCHEN WHITMER
GOVERNOR

STATE OF MICHIGAN
DEPARTMENT OF
ENVIRONMENT, GREAT LAKES, AND ENERGY
MARQUETTE DISTRICT OFFICE

EGLE

PHILLIP D. ROOS
DIRECTOR

March 6, 2024

VIA EMAIL

Patrick Williford, Water Quality Manager
Great Lakes Water Authority
10100 East Jefferson Avenue
Detroit, Michigan 48214

PWS ID: **02838**
County: Wayne

Dear Patrick Williford:

SUBJECT: Laboratory Method Approval: UVA (Standard Methods 5910)

Representatives from the Department of Environment, Great Lakes, and Energy (EGLE), Drinking Water and Environmental Health Division recently met with you at the Water Works Park treatment facility on February 21, 2024, to review onsite laboratory practices and methodologies for analysis of Ultraviolet Absorbance (UVA), under Standard Method 5910. Our review included sample preparation, analysis, instrument calibration, quality control, and written standard operating procedures review. Staff also verified sample collection conforms to locations listed in Rule 610c (1)(b)(v) and (vi). Based on our review, and per Rule 2701 of the Safe Drinking Water Act, 1976 PA 399, as amended EGLE has approved your procedures for UVA analysis.

This approval, along with the use of an outside certified laboratory for dissolved organic carbon (DOC) analysis allows EGLE to accept specific ultraviolet absorption (SUVA) results

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Next Steps – not required

1. Water Quality continues to sample Water Works Park for TOC, DOC, and UV-254 monthly until the TOC compliance and will institute this new sampling protocol for all GLWA water plants though not required.

2. Research and Innovation is determining the best aluminum sulfate and coagulant aid ratios and dosages for each water plant for efficient TOC removal.

3. Provide team training regarding the additional laboratory techniques on TOC using UV-254 absorbance monitoring.

4. Securing external experts to review and confirm any additional changes to ensure compliance.

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Key Take Aways

1. A treatment technique violation requires a Tier-2 public notification (30 days from the time the community water supply receives the violation). In this case GLWA had 30 days to notify the member partners and they had 30 days from GLWA's PN to notify their customers.
   - ✓ Teir-2 public notifications must continue until LRAA is ≤ 2.0 mg/L for LRAA.
2. TOCs have **no known health effects** based on current literature.
3. TOC in GLWA drinking water is generally from NOM.
4. The TOC requirement is ≤ 2.0 mg/L for LRAA.
   - ✓ LRAA is the averages of the last four calendar quarterly averages.
   - ✓ SUVA is an approved alternate compliance method that can be performed along with the TOC compliance monitoring that is indicative of the potential of forming disinfectant byproducts.
   - ✓ SUVA is a viable means to demonstrate GLWA's treatment process remains in compliance with the stage-2 disinfectant-disinfectant byproduct rule.
5. Water Works Park individual TOC levels appear to be returning to previous levels, but still higher than they were in 2021 *(~1.5 mg/L).*
6. **No known DBP MCL exceedances by the GLWA nor their member partner communities.**

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Questions?

Appendix

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TTHM and HAA5

NAME OF CONTAMINANT	MCL/MLG	HEALTH EFFECTS OF CONTAMINANT	MONITORING REQUIREMENTS / COMMENTS
Total Trihalomethanes (TTHMs)	0.080		
• **Chloroform** • **Bromadichloromethane (BDCM)** • **Bromoform** • **Dibromochloromethane (DBCM)**	/0.07 /0 /0 /0.06	Cancer risk; potential reproductive system effects: liver/kidney/nervous system problems	Compliance Monitoring: Locational Running Annual Average (LRAA) of quarterly samples (yearly for very small surface water and small ground water systems) take at locations determined by initial Distribution System Evaluation (IDSE). Compliance sites are locations in the distribution system where TTHMs are high, HAA5s are high, and at average detention time sites. The number of sites is based on the type of source water and population served.
Haloacetic Acids (HAA5)	0.060		
• **Monochloroacetic Acid (MCAA)** • **Dichloroacetic Acid (DCAA)** • **Trichloroacetic Acid (TCAA)** • **Bromoacetic Acid** • **Dibromoacetic Acid**	/0.07 /0 /0.02 /- /-	Cancer risk	

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EGLE Public Notification Rule (continued)

Ten Elements of a Public Notification

Unless otherwise specified in the regulations,* each notice must contain:

1. Description of the violation or situation, including the contaminant(s) of concern, and (as applicable) the contaminant level(s).
2. When the violation or situation occurred (i.e., date the sample was collected or was supposed to be collected).
3. Any potential adverse health effects from drinking the water and standard language regarding the violation or situation. (For MCL, MRDL, treatment technique violations, or violations of the conditions of a variance or exemption, use health effects language from Appendix B of the PN Rule. For monitoring and testing procedure violations, use the standard monitoring language below.)
4. The population at risk, including subpopulations that may be particularly vulnerable if exposed to the contaminant in their drinking water.
5. Whether alternate water supplies should be used.
6. Actions consumers should take, including when they should seek medical help, if known.
7. What the PWS is doing to correct the violation or situation.
8. When the PWS expects to return to compliance or resolve the situation.
9. The name, business address, and phone number or those of a designee of the PWS as a source of additional information concerning the notice.
10. A statement (see standard distribution language below) encouraging notice recipients to distribute the notice to others, where applicable.

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References

1. Total organic carbon: Although TOCs can cause taste and odor issues in drinking water, they do not have any serious health impacts on their own. They are known as precursors to DBP formation potential. The references below highlight the point that TOCs are a concern when they react with high levels of chlorine residuals to form DBPs.

- ***Bull, R. J., and Kopfler, F. C. (1991). Health effects of disinfectants and disinfection by-products. American Water Works Association Research Foundation, Denver, Colo.***

- ***Nikolaou, A.D. and Lekkas, T.D., The role of natural organic matter during formation of chlorination byproducts: a review, Acta Hydrochim. Hydrobiol., 2001, vol. 29, pp. 63–77.***

- ***Nikolaou, A.D., Golfinopoulos, S.K., Lekkas, T.D., and Kostopoulou, M.N., DBP levels in chlorinated drinking water: effect of humic substances, Environ. Monit. Assess., 2004, vol. 93, pp. 301–319.***

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References

2. DBPs consists of compounds that can be carcinogenic with known health impacts (not all the regulated DBPs are carcinogenic). Some regulated DBPs are reported to have high volatility such as the THMs (Chloroform, Bromoform, dibromochloromethane, and bromodichloromethane) others have low volatility such as all the regulated HAA5. The references below support the statement that DBPs consists of volatile organic compounds.

- ***Nicholson, B.; Maguire, B. P.; Bursill, D. B. Henry's Law constants for the trihalomethanes: effects of water composition and temperature. Environ. Sci. Technol. 1984, 18, 518–521***

- ***Nallanthigal Sridhara Chary, Amadeo R. Fernandez-Alba, Determination of volatile organic compounds in drinking and environmental waters, TrAC Trends in Analytical Chemistry, Volume 32, 2012, Pages 60-75, ISSN 0165-9936, https://doi.org/10.1016/j.trac.2011.08.011.***

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Definitions

- **Carbon** is a chemical element with symbol C and atomic number 6. Classified as a nonmetal, Carbon is a solid at room temperature.
- **Carbon compounds** are defined as chemical substances containing carbon.
- **Organic Compounds** don't just contain carbon. They contain carbon bonded to hydrogen.
- **Inorganic Compounds** do not contain carbon and hydrogen example carbon dioxide contains carbon but is an inorganic compound.
- **Natural Organic Matter (NOM) -** It is a complex mixture of organic matter and is found in all groundwater and surface waters. It can enter water naturally in the form of plant or animal-based substances containing carbon.
- **Synthetic Organic Chemicals (SOCs) -** are man-made synthetic carbon material. They are used as pesticides, defoliants, fuel additives and as ingredients for other organic compounds. polyvinyl chloride (PVC), polystyrene (PS), nylon, Teflon etc. are examples of SOCs.
- **Total Organic Carbon (TOC)** in source waters comes from decaying NOM as well as SOCs such as detergents, pesticides, fertilizers, chemical spills, etc.

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Definitions

- **TOC,** which is a part of NOM and SOCs, can be classified into **dissolved organic carbon** (DOC) which is soluble in water and **Particulate Organic Carbon** which is insoluble in water.
- **Volatile Organic Compounds (VOCs)** - are a group of chemicals that can vaporize into air.
  - The sources of VOCs are both natural and anthropogenic. Natural sources comprise emissions from plants, forest fires occurring from natural causes and anaerobic moors processes.
  - Anthropogenic sources of VOC include fuel production, distribution, and combustion, with the largest source being emissions from motor vehicles and biomass burning.
- **Total trihalomethanes and Haloacetic acids (DBPs) are a class of VOCs.**

GLWA is testing for TOC, SOCs (no detection) and VOCs.

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