# Upper Mississippi River Basin Association

# Water Quality Task Force Meeting

**October 4, 2022**

# Agenda

**with**

**Background**

**and**

**Supporting Materials**

Hampton Inn & Suites
St. Paul, Minnesota

# UPPER MISSISSIPPI RIVER BASIN ASSOCIATION
# WATER QUALITY TASK FORCE MEETING

## October 4, 2022

## Agenda

Connection Information

- Web, video conferencing, click on the following link:
  - https://umrba.my.webex.com/umrba.my/j.php?MTID=m9b4f7cbba893872ddde4e2ee60860334
- Dial-in number: (312) 535-8110
  - Access code: 2552 450 0038
  - Passcode: 1234

| Time | Attachment | Topic | Presenter |
|---|---|---|---|
| 1:00 p.m. | | Welcome and Introductions | *Heather Peters, MODNR* |
| 1:05 | A1-A17 | Approval of the June 7-8, 2022 WQEC-WQTF Draft Meeting Summary | *All* |
| 1:10 | B1-B2 | UMRBA WQ Task Force Updates<br>• How Clean is the River? Report | <br>*Robert Voss, MODNR* and *Lauren Salvato, UMRBA* |
| 1:25 | C1 | UMR Interstate WQ Monitoring<br>• Reaches 8-9 Pilot | <br>*Lauren Salvato, UMRBA* |
| 1:35 | <br>D1-D7<br>D8-D9 | Emerging Contaminants<br>• Contaminants of Emerging Concern: Thoughts and Perspectives<br>• USEPA PFOA-PFOS Draft Aquatic Life Use Criteria | <br>*Dr. Christine Custer, USGS*<br>*All* |
| 2:20 | | Break | |
| 2:45 | <br><br>E1-E2 | Cyanotoxins<br>• State and Federal Updates<br>• USEPA Recommended Recreational Criteria | *All* |
| 3:30 | | CWA<br>• 305(b) and 303(d) Consultation<br>• TMDL Updates | *All* |
| 4:00 | F1-F4 | Illinois River Basin NGWOS | *Jim Duncker, USGS* |
| 4:30 | | Nutrients<br>• State and Federal Updates<br>• Usage of Credits for Dischargers | *All* |
| 4:55 | | Administrative Items | |
| 5:00 p.m. | | Adjourn | |

# ATTACHMENT A

## <u>June 7-8, 2022 WQEC-WQTF Draft Meeting Summary</u>

*(A-1 to A-14)*

# Upper Mississippi River Basin Association
# Water Quality Executive Committee
# and Water Quality Task Force Meeting

**June 7-8, 2022**
**Draft Highlights and Action Items Summary**

**Tuesday, June 7**

**Approval of the WQTF Draft January 25-26, 2022 Meeting Summary**

The UMRBA Water Quality Executive Committee (WQEC) and Water Quality Task Force (WQTF) approved the January 25-26, 2022 draft highlights and action items summary.

**UMRBA WQ Task Force Updates**
*How Clean is the River? Report*

Lauren Salvato shared an update on the How Clean is the River? (HCR) Report. Dr. Kathi Jo Jankowski reached out about an issue that arose during the USGS review process for the Upper Mississippi River Restoration Status and Trends Report water quality results. The reviewer asked if the results included the WRTDS model update that accounted for "non-stationarity" trends (i.e., trends in the distribution of flows over time). In response, Jankowski re-ran the models for total suspended solids (TSS), total nitrogen (TN), and total phosphorus (TP). She noted that the biggest changes in results were for flux rather than concentration. [Note: the HCR results are reported in concentration]. Fortunately, the high-level summaries in the status and trends report are unaffected. Missouri DNR staff ran the updated model with data from the La Grange and Open River sites and following a discussion with the WQTF determined that re-running all the results was not necessary. The report will include a note that an older version of the model was used in the development of the trends.

There are a few remaining items to accomplish before beginning to work with a graphics designer and communication specialist: 1) an updated GIS map of the sites used to calculate trends, 2) appendices for readers that want to do a deep dive into pool-by-pool concentrations, and 3) additional graphics to display that lead increases in concentration are well below drinking water limits.

Kirsten Wallace said the HCR Report release could coincide with the Clean Water Act's (CWA) 50$^{th}$ anniversary in October 2022 to point to the report conclusions and the success of the CWA.

**UMR Interstate WQ Monitoring**
*Reaches 8-9 Pilot*

John Olson said the Reaches 8-9 pilot was conducted to test the feasibility of the UMR Interstate Water Quality Monitoring Plan, a comprehensive CWA-like assessment. The non-regulatory approach to communicate water quality is done with the development of a "condition class" for each beneficial use of the river (aquatic life, recreation, drinking water, and fish consumption). Each condition class is evaluated as “good,” “fair,” or “poor.” During 2020 and 2021, sampling was conducted along roughly 100 miles of shared borders of the river with Iowa, Missouri, and Illinois from L&D 17 (at New Boston, IL) to L&D 21 (at Quincy, IL).

John Olson reviewed the results of the Reaches 8-9 Pilot Condition Assessment. The Aquatic Life condition class is based on Index of Biological Integrity (IBI) scores for fish and aquatic macroinvertebrates. Reach 8 received a “poor” condition class assessment due to only 5 out of 13 sites passing the macroinvertebrate index threshold, whereas Reach 9 received a “good” assessment due to 10 out of 13 samples passing the macroinvertebrate index threshold. The macroinvertebrate index was developed by Wisconsin DNR utilizing data from the major rivers bordering and within the state. The macroinvertebrate results hovered around the threshold and Olson suggester further investigation whether the index is suitable for the Upper Mississippi River.

The Recreation condition class was based on levels of *E. coli* and chlorophyll-α (chl- α). *E. coli* thresholds were based in USEPA recommendations and chl- α was based in user perception of nuisance surveys by the Minnesota PCA. Both Reaches 8 and 9 received “poor” assessments due to “very serious nuisance” threshold exceedances in both reaches and an *E. coli* threshold exceedance in Reach 9.

Olson stated the Drinking Water condition class was based in Safe Drinking Water Act criteria for pesticides, volatile organic compounds (VOCs), metals, nitrate, fluoride, and chloride. Cyanotoxins criteria and per- and polyfluoroalkyl substances (PFAS) health advisory levels were used to determine the condition class. Both Reaches 8 and 9 received “poor” assessments due to excursions of cyanotoxin detection above guidelines, while all other drinking water standards of the condition class received a “good” assessment. However, the assessment applies treated water criteria to raw and untreated water because the loss of participation of public water suppliers (PWS) after the COVID-19 pandemic begun. Olson said the levels of cyanotoxin detection were below the recreational threshold. The Reaches 8-9 pilot planning committee discussed the application of untreated water results to a treated water criteria extensively but ultimately the assessment of “poor” can be used as a cautionary notification, raising a flag for PWS to be aware of threats to drinking water.

The Fish Consumption condition class was based on levels of polychlorinated biphenyls (PCBs) and mercury found in fish fillets of common carp and largemouth bass and fish consumption advisories from states along the Upper Mississippi River. An additional analysis in the Condition Assessment is PFAS fish tissue data. The Missouri Department of Health and Senior Services (DHSS) had grant money to pay for the analysis. This was good opportunity to partner as DHSS was able to utilize the fish obtained in the Reaches 8-9 pilot. Olson said that there was no perfluorooctanic acid (PFOA) detected in fish tissue, and only perfluorooctane sulfonate (PFOS) were detected. The threshold was developed by Minnesota PCA as a site-specific indicator for fish consumption at 0.37 ng/g. The draft U.S. Environmental Protection Agency (USEPA) criteria are expressed in milligrams per kilogram and were developed as a toxicity indicator for fish communities, rather than consumption. Both Reaches 8 and 9 received “fair” assessments for the Fish Consumption condition class, based in a detection of mercury in largemouth bass in Reach 8 and a consumption advisory issued by the state of Missouri for Reach 9 fish.

Overall, all but one reach and condition received a “good” rating. Olson concluded that the time frame of the project could have influenced results. The low water period of early summer could have created a dissolved oxygen (DO) sag in Pool 19, affecting the invertebrate communities. Cyanotoxins and chl- α concentrations were likely impacted by the low water as well.

| Beneficial Use | Reach 8 | Reach 8 Issues: | | Reach 9 | Reach 9 Issues: |
|---|---|---|---|---|---|
| Aquatic Life | Poor | Low biotic integrity of macroinvertebrate community | | Good | |
| Recreation | Poor | Chlorophyll | | Poor | *E. coli* and chlorophyll |
| Drinking Water | Poor | Cyanotoxins (microcystin) | | Poor | Cyanotoxins (microcystin) |
| Fish Consumption | Fair | Levels of mercury in Largemouth Bass | | Fair | One meal / month consumption advisory |

Amy Shields shared that USEPA has extended the public comment period for the published draft national recommended aquatic life criteria for PFOA in freshwater for an additional 30-days, through July 2, 2022. The draft PFOA criteria document contains acute and chronic criteria for freshwaters. The draft criteria document also contains chronic criteria expressed as tissue-based concentrations to protect aquatic life from PFOA bioaccumulation. The chronic freshwater and chronic tissue criteria are intended to be independently applicable and no one criterion takes primacy.

When asked about a hypothesis for the DO sag in Pool 19, Olson stated that the pool has a long residence time, and suspended solids dropping out of the water column likely lead to a rise in chl- α. The Des Moines River does not likely influence the DO as the relative contribution of the river is small. Karen Hagerty added that a large amount of aquatic vegetation in Pool 19 could be a possible factor. Kelly Warner asked if field samplers noticed microcystin pooling at the dams. Daniel Kendall noticed that plankton was visibly pooling at L&D 17 at New Boston. Schneiders asked if 60 µ/L is aesthetically objectionable greenness. Robert Voss replied that without a lot of suspended sediment, the water is very green. Kendall recalled that the fixed sites, 100mL of water were filtered, and the green was noticeable. Nicole Manasco suggested looking at Habitat Rehabilitation and Enhancement Project data collected in backwaters during 2021 to see if the low water year was an outlier in terms of chl- α concentrations.

*Reaches 8-9 Evaluation Report*

Lauren Salvato stated the goals of the Evaluation Report are to reflect on how the Reaches 8-9 pilot was implemented, including successes, lessons learned, and next steps. Now that pilot projects involving all the five UMRB states are wrapped up there is work to accomplish to before implementing the full scale UMR Interstate WQ Monitoring Plan. The outstanding questions and conclusions are as follows:

- UMRBA had different roles in the two pilots. For the Reaches 8-9 pilot, UMRBA staff convened monthly coordination calls and provided project coordination. The Reaches 8-9 planning committee recommends that UMRBA continue to serve as a centralized convening entity.

- Having one laboratory for water chemistry analyses is still a reasonable goal for ensuring consistency in laboratory results. The planning committee suggests using a contracted laboratory rather than a state laboratory given capacity constraints. However, using a contracted laboratory will increase the analytical costs.

- The cost to ship samples was significant for the Reaches 8-9 pilot (approximately $19,000). Analyzing samples with one laboratory means that shipping costs are inevitably high. The planning committee recommends negotiating shipping rates to reduce costs.

- Iowa DNR staff built and maintained a Microsoft Access database to house Reaches 0-3 and 8-9 pilot data. As this did take a significant amount of time (approximately three-fold higher than budgeted), the planning committee recommends housing UMR Interstate WQ Monitoring Plan data in a database that is maintained routinely and is publicly accessible.

- Partnering with USEPA Region 5 to analyze PFAS samples for the pilot was valuable to collect emerging contaminants data for Reaches 8-9. The planning committee and the UMRBA WQTF are interested in scoping an emerging contaminants monitoring plan for the UMR in 2022-2023.

- The Reaches 8-9 pilot relied on contractors to carry out some of the work for the pilot. For example, Missouri DNR contracted with Missouri DOC to conduct all the field sampling for Reach 9. A contractor was utilized to write the Reaches 8-9 Pilot Condition Assessment. State agencies have varying abilities to participate in the pilot, and full-scale monitoring will require hiring additional state agency staff to bring all five UMRB states up to capacity.

- Half of the PWS in Reaches 8-9 participated in the drinking water use assessment, and only one was able to participate after March 2020. There were challenges associated with training PWS operators, ensuring correct sampling protocols, and maintaining participation. The COVID-19 pandemic further strained PWS ability to participate in the Reaches 8-9 pilot. The planning committee recommends reassessing the ability to maintain PWS participation for the entirety of the sampling period. The variety of sizes of the PWS along the UMR should be considered and factored into requests to participate in sampling.

- The Reaches 8-9 planning committee modified the fish sampling transects to incorporate the Upper Mississippi River Restoration program's Long Term Resource Monitoring (LTRM) design. The primary reasons were to increase fish survivability and reduce field sampling crew fatigue. The Reaches 0-3 pilot confirmed that splitting up transect, to the same electrofishing distance as the original design, was able to provide a reliable IBI. The UMR Interstate WQ Monitoring Plan was designed using the USEPA's Environmental Monitoring and Assessment Great Rivers Ecosystem (EMAP-GRE) program. However, further consideration should be given to data compatibility with existing monitoring programs on the river, such as the Upper Mississippi River Restoration LTRM methods, in part to leverage the data and methods.

- The Reaches 0-3 pilot sampled during a high-water year on the UMR and the Reaches 8-9 pilot during a low-water year. Sampling more frequently as envisioned in the UMR Interstate WQ Monitoring Plan would allow for sampling during a range of discharge conditions and increase confidence in the results.

Salvato asked for direction from the WQEC and WQTF. If the two pilot projects have confirmed the value of the UMR Interstate WQ Monitoring Plan, then what next steps need to be taken to implement the plan in its entirety?

Hagerty shared that UMRR LTRM is piloting macroinvertebrate monitoring during summer 2023 and the Third UMRR Ecological Status & Trends report, available in June 2022, could help inform some of the outstanding questions. Kim Laing said Minnesota PCA is looking into developing its own statewide index for its five major rivers. PCA staff tested the Wisconsin Big River Index before the agency determined to develop its own. Laing suggested convening a call of the five states to discuss IBI options further. Schneiders suggested that as long as macroinvertebrate sampling is consistent then the data are still useful, even if the IBI is changed at a future time.

Wallace asked participants to think about how to fund the full implementation of the monitoring plan recalling that it could cost an estimated $5 million over five years. The guiding documents e.g., Provisional Assessment must be finalized in the near term. Concurrently, UMRBA staff can work with the WQEC to think about how to scale up state staff capacity. Dana Vanderbosch suggested breaking up funding the entire monitoring plan into smaller chunks. Shawn Giblin concurred and suggested moving forward with one component and then moving onto a different parameter before setting up the larger effort. The WQTF could determine the tiers or stages to implement. Wallace agreed with the approach to work with the WQTF to develop a scope of work and breaking up components of the overall monitoring plan.

**<u>CWA Program Updates</u>**

*Delisting Waters Discussion*

*Iowa* – Kendall said 50 impaired waters were delisted from the 2020 list of impaired waters. The rationale for the delisting was primarily due to water quality improvements (27 out of 50 water bodies) and total maximum daily load (TMDL) preparation and approval (9 out of 50 waterbodies). Many of the waters were delisted for chl- α and relisted due to turbidity. Kendall hopes this indicates an overall improving trend.

In 2022, there are 57 new impairments in 52 segments. Most of the impairments are for 1) fish consumption advisories: mercury (10/57), 2) pH (10/57), and 3) turbidity/Secchi Disk transparency (13/57). Kendall said that 13 years ago a clean water fund was created in Iowa, which enabled DNR to increase ambient water quality monitoring. However, when more monitoring occurs, there are more issues found. Overall, there is a lot of complexity associated with pollution. In response to a question from Schneiders about the role of environmental stakeholders, Kendall replied that environmental groups want DNR to keep pushing further on standards for parameters such as nitrate and microplastics. There is pressure to do more, but there is a lot of work needed to address the existing pollution problems.

*Minnesota* – Laing said there are 6,167 impaired waters in the 2022 impaired waters summary. The majority are due to mercury in fish tissue, fish bioassessments, benthic macroinvertebrate bioassessments, nutrients, and *E. coli.* Waters in Minnesota are now meeting standards due to implementation of actions, but the pace of progress is slow. Delisted waters since the beginning of the program collectively make up one percent of the total impaired waters. Vanderbosch added that mercury impairments are statewide and mask a lot of the other impairing factors in the southern and western portions of the state that are dominated by agriculture. Regulatory programs are overburdened with requests to conduct additional monitoring but struggle with quantifying corrective actions. The hope is that Minnesota's buffer laws and other corrective actions will have a positive impact on water quality over the next ten-year cycle.

Laing stated that while the buffer law has benefitted water quality, it is difficult to track which management practice is accountable for changes in water quality, and asked participants for advice on tracking nonpoint source (NPS) improvements. Chuck Theiling suggested correlating delistings with cover crops adoption. Voss added that if you do not have widespread adoptions of best management practices (BMPs), then it's a game of statistics to determine NPS reduction. Laing said that professional judgement plays a role because it is hard to know whether BMPs in the watershed were enough and at what point investment in restoration was enough to lead to a delisting.

*Wisconsin* – Ashley Beranek said the average number of delistings is 22 waters. The most recent delistings were related to reductions in phosphorus and excess algal growth. A few waters were delisted for PCBs in fish tissue and TSS delistings occurred where restoration projects are being implemented.

*Missouri* – Voss said over the last three cycles of delistings have varied from 20 to 60 waterbodies. Missouri DNR has a history of new and revised standards that have caused delistings. TMDLs account for a quarter of the delistings. After the nutrient criteria were developed in 2020, a lot of waterbodies were listed. Corrective action occurs on a site-specific basis. There has been a recent push to encourage mining operations to clean up tailings, and delistings could result. Data availability is another challenging aspect. For example, when new data are acquired either by DNR or an outside entity, the water body appears to be improved. With another round of data, the waterbody goes back on the impairment list. This commonly occurs for bacteria listings.

Wieberg added that in the 2020 cycle, Missouri DNR had lakes listed as impaired under the combined criteria, which included eutrophication factors. Staff are trying to figure out how it works with multistage criteria and when to delist the waters.

## **<u>Emerging Contaminants</u>**

*The Effects on Environmental Quality of Raising Plants and Growing Animals*

Dana Kolpin introduced the Food Integrated Science Team (Food IST), a multidisciplinary team of 35 USGS scientists and external collaborators across the public and private sectors, tasked with tracking the effects of growing, raising, and processing agricultural products. The Food IST prioritizes research on gaps in issues of global concern.

Kolpin reviewed select research topics, including one on understanding the effects of neonicotinoid use on environmental and human health. Neonicotinoids are the most heavily used insecticide class globally. They are popular due to their broad spectrum of applicability, their potency, and their systemic activity in the plant. The practice of seed treatment with neonicotinoid has tripled in the last decade. Nearly all corn and one third of soybeans are treated with a neonicotinoid prior to planting. Only two to twenty percent of the coating is taken up by the plant. The remainder of the coating is highly soluble in water and persistent in the environment. While early focus on neonicotinoids was on the concern of colony collapse disorder in bees, there is growing evidence that the insecticide effects a number of aquatic and terrestrial organisms, as well as humans. Researchers determined that stream transport of neonicotinoid was driven by planting and precipitation, the first time an insecticide was recorded in a spring flush pattern via treated seeds.

Thompson et al (2021) conducted study in Eastern Iowa and sampled 40 alluvial wells for the presence of neonicotinoids. Neonicotinoids were detected in 73 percent of samples, including detections of Clothianidin, Imidacloprid, and Thiamethoxam. In a study that conducted a comprehensive analysis of 437 organic chemicals in drinking water, the results included the presence of 51 pesticides and 42 pesticide compounds in tap water. For the first time, an insecticide was recorded as a primary contaminant in groundwater.

Farmers' urine was also analyzed to understand and characterize exposure to contaminants. Neonicotinoids were detected in all samples, including neonicotinoids not used in the U.S. Because neonicotinoids are excreted within days of ingestion, there is evidence that neonicotinoid exposures are beyond exposure from drinking water and could also be related to diet, occupation, or household dust.

The next research topic Kolpin described was environmental exposures and effects on recycled liquid and solid waste to farmland. Land applied reuse materials (LARM) include livestock waste, municipal biosolids, and drill fluids. Food IST is investigating microbial activity, total number of PFAS, gastro related organics (GRO), and pesticides found in LARMs. PFAS found in biosolids are high relative to other LARMs, while GRO are found in high amounts relative to others. Pesticides were also observed in biosolids and animal waste.

Another set of studies involved food, beverage, and feedstock facilities, a unique and understudied contaminant source in the U.S. and worldwide. Federal and state programs require basic monitoring of TSS, biological oxygen demand (BOD), and nutrients. Phase one of the national assessment took place in 2019 and 576 organic chemicals, microbial analysis, and bioassays were monitored. Of the 576 organic chemicals monitored, 186 were detected. Frequently detected organics included twelve pesticides, five VOCs, three pharmaceutical compounds, two PFAS, and one hormone. Ubiquitous bacterial growth and antibiotic resistance was also found at the sample sites. PFAS were detected in relatively high concentrations, leading researchers to hypothesize that food, beverage, and feedstock facilities could be an environmental source.

Phase two of the food, beverage, and feedstock study, included seven facilities. Effluent samples were collected above and below outfalls. Results will be published within the fiscal year. Phase three focused on a food web study to characterize PFAS exposure in macrophytes, invertebrates, insects, fish, crayfish, spiders, and tree swallows. The study included a soybean and oilseed processing facility that was found to be releasing large amounts of PFAS in the phase one study.

Kendall asked about the consequences of reusing biosolids citing that Maine has a moratorium on biosolids. Consequently, the state does not have enough space in the landfill to take biosolids and asked if anything is solved by putting biosolids in landfills. Kolpin said that providing science could lead to reactionary action. Maine's biosolid regulation has led to the shipment of biosolids to Canada, where leachate is collected and returned to wastewater treatment plants. The Food IST hopes the results of these studies enable regulating parties to make policy and regulatory decisions.

In response to a question from Giblin about which benthic organisms were evaluated with the tissue analysis, Kolpin responded organisms in the larval stage e.g., mayflies and caddisflies. Artificial substrate samplers were deployed for 30 days and then scraped off. Kick sampling was conducted as well. Early PFAS results in the minnow species were high, particularly in the territorial species. The highest PFAS concentrations occurred in organisms living near the outfall. Giblin asked whether the relative risk between of bifenthrin versus neonicotinoids exposure is understood. Kolpin believes that bifenthrin is more in bed sediment and may not be as mobile. While bifenthrin may be more toxic, neonicotinoids, by design, wipe out insects immediately. Steve Schaff asked if the neonicotinoid study involving farmers' urine have been replicated in non-agriculture settings to understand whether imported foods being ingested pose a risk to the general population? Kolpin noted this study is the first he is aware of. Neonicotinoids are ubiquitous in farmers' urine, but whether imports are a source of neonicotinoids is unclear.

Vanderbosch asked if consumer choices such as buying organic berries or purchasing bulk organic meat from a local farmer could all be undone if, for example, the cattle are drinking from streams loaded with PFAS. Is Kolpin and collaborators looking at the difference in organically grown food? Kolpin cited a study that just began and involves 11 organic dairy sites. He agreed it was a good research question.

Vanderbosch asked Kolpin for strategies encouraging municipalities to participate in wastewater studies. Minnesota has an ongoing fate and transport study but has had challenges getting participation because of fear of lawsuits. The solution has been to guarantee anonymity to municipalities. Kolpin agreed it is a challenge and while USGS is a non-regulating entity, researchers cannot guarantee anonymity if a Freedom of Information Act request comes in. Livestock groups were more difficult to work with but offering data for free was a helpful enticement. Kendall agreed that sample analysis is costly and can be a good motivator. In response to a question from Giblin about the laboratories used for analysis, Kolpin replied that organics are internally processed within USGS. For PFAS, Kolpin has used RTI and SGS AXYS laboratories. Between personnel and hiring issues, methods developed for PFAS have not been a priority, and that is why the analysis has been contracted. Kolpin mentioned that USGS is hoping to expand analytical capabilities for additional contaminants of emerging concern (CECs) such as microplastics and tire leachate.

*Facilitated Discussion*

Salvato shared that the WQTF has had discussions on how to develop a CEC monitoring plan for the UMRB. UMRBA staff reached out to USGS staff about how to begin scoping the design. The WQTF has been challenged by determining a list of CECs to target given the cost of laboratory analysis. Salvato asked the WQEC and WQTF to confirm this is a priority task for the WQTF to continue work. Wieberg said it is valuable and Vanderbosch confirmed. Missouri does not do a lot of CEC monitoring as many are not regulated in the state. The public is interested in CECs, especially microplastics, and what Missouri is doing. UMRBA can help Missouri fill the gap. Wieberg said Missouri has been directing some monitoring to smaller PWS. The upcoming Unregulated Contaminant Monitoring Rule 5 will target bigger PWS for PFAS. Wieberg mentioned the suit involving the Illinois general suing 3M for PFAS contamination at its Cordova facility. In Missouri PWS downstream PFAS was not detected. Salvato said that PFOS and PFOA are not likely to be an issue but would guess that perfluorobutanoic acid (PFBA) would have more detections at higher concentrations.

**<u>Research</u>**

*Simulating Food-Energy-Water and Ecosystems in the UMRB*

Dr. Kelsie Ferin described the FEWscapes program goal "to advance knowledge and support decision making for the security of food, energy, water and ecosystem (FEWE) in the UMRB." In a changing climate how do FEWE systems help inform maintaining food affordability, increasing food production, clean energy availability, improvements to water quality, and increasing water quantity? Model development plays an important role in this project to answer broad questions about FEWE impacts and simulate policy and climate change scenarios into the future.

The Agro-IBIS model simulates cycles of water, carbon, nitrogen, phosphorus, and energy on independent grid cells. A hydrologic routing model called Terrestrial Hydrology Model with Biogeochemistry (THMB) was used to integrate runoff, as well as nitrogen and phosphorus in drainage water. The models are assessed via experimental studies and streamflow gages. Ferin said scenarios are being developed out to the year 2050. The model can be used to quantify indicators that are policy relevant, develop connections to outcomes and policies, and explore unintended consequences of policy. The FEWscapes program is also looking into how people perceive the performance of conservation practices, the effects of storms and floods, and network opportunities for governing bodies.

Salvato asked about the results of stakeholder input sessions conducted by the FEWscapes team in late 2021 and whether there would be additional meetings. Ferin said that the next round of focus groups will request feedback on example modeling scenarios that were developed as a product of the 2021 outreach. The goal is to continue to involve stakeholder input.

Wieberg said Missouri is struggling with how to conceptualize nutrient reductions and that the FEWscapes models could help answer these questions. Ferin said the FEWscapes research team hopes to model scenarios on what would be feasible for nutrient reduction on the landscape. Global climate data is going to be incorporated into the models during 2023 to account for changing climate conditions into the year 2050. Vanderbosch emphasized that any models that influence the agricultural community to increase conservation practice adoption and help state agencies understand how to encourage those types of practices would be incredibly helpful.

Warner asked for the major takeaways of what THMB and Agro-IBIS can offer that SWAT and SPARROW cannot. Ferin explained that the Agro-IBIS model simulates plant processes at the leaf level with an hourly timestamp. The water budget becomes much more refined due to the fine scale reporting of the model and the accounting of evapotranspiration, photosynthesis, and soil moisture. These measurements can be validated in the field.

**UMRB Sediment Budget**

Manasco shared that US Army Corps of Engineers Rock Island Districts as well as St. Louis and St. Paul Districts applied for funding to have a regional conversation on sediment budget for the UMRB. There is a need for current data as the last cumulative effects report was published in the 1990's. Volumes of sediment are caught behind the dams, sediment is filling backwater areas, and as a result, the Lower Mississippi River is sediment starved. The Missouri River Basin reservoirs are a bigger contributor to the issue, but the UMRB is contributing to the issue as well. Wallace added that a sediment budget could be helpful for understanding how sediment moves during flooding and drought, which can also inform UMRBA's resilience work. The funding is for partnership engagement, but NESP could be a possible funding source for monitoring to complement the update. Theiling said it is good to think about how the floodway is filling and how much sediment is trapped, thereby reducing efficiency over time. Wieberg shared that there are debates over the past four decades in Missouri on how sediment capture is occurring, and new data will help create a better understanding of those processes.

**June 8, 2022**

**<u>Environmental Justice</u>**
*2022-2032 CWA 303(d) Program Vision*

Rosaura Conde explained that the CWA Section 303(d) Program can be utilized to bridge water quality data and goals the actions needed for restoration. The draft 2022-2032 CWA 303(d) program vision has goals for 1) planning and prioritization, 2) data analysis, 3) protection, 4) restoration, and 5) partnerships: integration and engagement. The focus areas include environmental justice, tribal engagement, climate change, and program capacity building. Conde said the program is seeking to adequately consider environmental justice (EJ) in water quality assessment, impaired waters listing, and TMDLs to address disproportionality high impacts placed on underserved communities.

Sara Schwartz discussed EJ initiatives within the 303(d) program, organized into three parts: assessment and listing, TMDL prioritization, and TMDL development and implementation. The foundation of EJ and the 303(d) program is fair treatment and meaningful involvement. The upcoming 2024 Integrated Reporting Memo, intended to support states in development of their integrated reports as well as USEPA regional offices, will feature topics such as public engagement, participatory science, and information sharing and capacity building. Examples include building relationships with trusted local leaders to better understand the needs of communities related to EJ, translating education and outreach materials in multiple languages, hosting a mix of in person and virtual meeting options and providing recordings of the meetings. The memo will also encourage states to utilize data collected by volunteers in their assessment process. Lastly, the memo will encourage states increase their sharing and communicating of the information from the integrated reports with communities with EJ concerns. The outcome is to inform the public of the status of their waters and to engage the public in a meaningful way.

Schwartz described tools that may be of use to the meeting participants. The Watershed Index Online (WSIO) is a library of over 400 watershed indicators across the U.S. The 2021 update includes a suite of indicators related to environmental justice, such as percent minority population, percent linguistically isolated populations (i.e., lack of English proficiency), count of hazardous waste management plans within the watershed, and percent of assessed waters within the watershed. Another tool is the Recovery Potential Screening (RPS) Tool, used to compare watersheds based on priority setting characteristics, and incorporates WSIO indicators. USEPA recently released indicator reference sheets to define use of indicators and are currently developing RPS scenario factsheets. The last tool is the not-yet published Clean Water Act and Environmental Justice module.

In addition to the tools described, Schwartz provided links for a number of other resources:

- USEPA Equity Action Plan https://www.epa.gov/system/files/documents/2022-04/epa_equityactionplan_april2022_508.pdf

- USEPA 2022-2026 Strategic Plan: https://www.epa.gov/system/files/documents/2022-03/fy-2022-2026-epa-strategic-plan.pdf

- Watershed Index Online and Recovery Potential Screening Factsheets: https://www.epa.gov/wsio/indicator-reference-sheets

- USEPA's Collaborative Problem Solving Model: https://www.epa.gov/sites/default/files/2015-02/documents/cps-manual-12-27-06.pdf

- Confronting Disproportionate Impacts and Systemic Racism in Environmental Policy: https://www.eli.org/sites/default/files/docs/elr_pdf/51.10207.pdf

- Best Practices for Meaningful Community Engagement: https://groundworkusa.org/wp-content/uploads/2018/03/GWUSA_Best-Practices-for-Meaningful-Community-Engagement-Tip-Sheet.pdf

- EJSCREEN and EnviroAtlas Webinar June 15: https://usepa.zoomgov.com/webinar/register/WN_YOOvmEutQR21H7Z5QEZxmA

Schneiders asked if there are quality assurances processes in place to enable third-party organizations to provide data for studies. There is a significant training commitment to ensure the data are usable, and all of these processes will vary by state. Conde suggested the use of the WQX to submit data, and to make expectations clear when submitting data. Conde emphasized that accessibility was important not only to have an informed public, but also to give communities an opportunity to decide what happens to water bodies around them. Wieberg asked if objectives have been developed related to how states communicate with different areas of the population and if state agency programs are adequate to USEPA's desired outcome. For example, how should Missouri DNR determine if its programs are doing well or can improve related to the amount of communication? Is communicating using the internet and in multiple languages adequate or should paper distribution be utilized? Wieberg asked for feedback. Conde replied that no one strategy will work across programs and populations but sympathized with Wieberg's challenges. For now, Conde suggested focusing on making data accessible to have a more informed public and to empower communities to have a role what happens in their watershed. Information sharing will be highlighted in the 2024 memo because there is growing body of information and a good opportunity to expand information exchange between states and partners. One such forum for information exchange is the 303(d) program annual meeting that brings together states, tribes and territories from across the nation. The exchange can bring out the best strategies and tools and how they can be replicated across other communities. Conde offered to share communication tools and suggested emailing her if Wieberg is looking for more refined strategies.

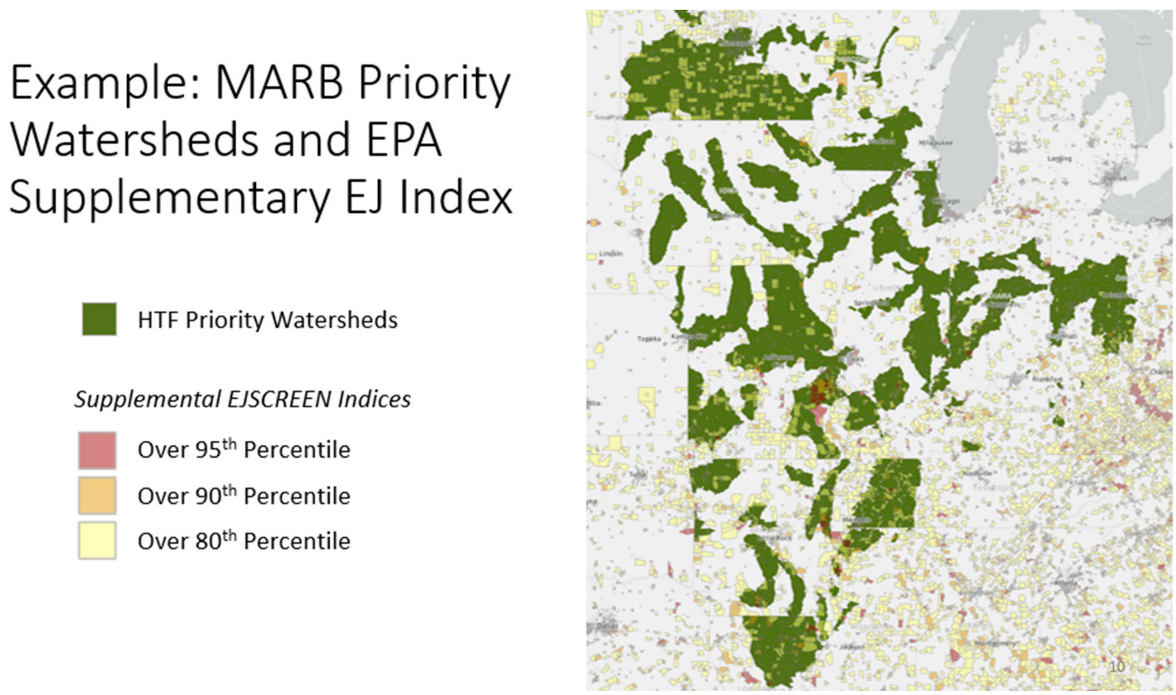
Vanderbosch shared Minnesota's struggle to meaningfully involve communities. Resources are a challenge and meaningful involvement suggests increased interaction. More information and communication are needed to help underserved communities understand how to engage in the regulatory process. Often the concern is related to the placement or expansion of a facility and the local zoning decision is already made by the time the entity applies for a water discharge permit. The tools referenced will be useful. Minnesota is developing web pages and educational pieces on how to effectively to engage in state agencies programs and policies impacting individuals and communities. Minnesota is striving to do more, but work is selective now given the resource constraints. Conde shared appreciation for Vanderbosch's comment and suggested additional dialogue and discussion of opportunities to build out the toolbox.

*Actions to Support Environmental Justice in the Nonpoint Source Program*

Ellie Flaherty reviewed the near-term actions in the 2021 NPS Program Policy Memo: USEPA 1) acknowledges role of the Section 319 program in benefitting communities via watershed projects, 2) encourages states to prioritize actions in FY 22 to advance delivery of NPS benefits to disadvantaged communities, and 3) commits USEPA to take actions to support these goals, including ongoing dialogue with the NPS community. The actions will be implemented beginning in FY 2023.

Flaherty said the two guiding questions for the development of the NPS program analysis tools are 1) how is 319 project funding distributed when compared to underserved populations, and 2) how can this data be used to create future work? The data sources are water quality assessment, 319 funding data, and social indicators and water quality data.  Data layers we utilized from the Climate and Economic Justice Screening Tool, EJScreen, and the National Landcover Dataset.

The data are hosted on the EPA GeoPlatform and will be available in the near term.   Flaherty provided an example of how the tool could be utilized for directing funding and restoration.  Hypoxia Task Force priority watersheds overlain with EJScreen indices reveals overlapping areas. Flaherty noted that the data are imperfect.  Within each state are different circumstances, nuances, and biases in the data.  For example, there maybe be biological, physical, and chemical reasons why funds are not targeted to a waterbody simply based on the number of impairments.




Greg Searle asked if the limitations on the 319 project funds to the approval of nine key element plans applied to all states and tribes.  Mike Scozzafava said the concern has come up during engagement sessions and USEPA is evaluating ways to help communities interested in NPS work to apply with less than a nine key element plan. Searle added that a lot of the healthy watersheds are in the northern part of the state, located in tribal territory.  It would benefit Wisconsin to be able to integrate funding on tribal property or lands.

*Discussion*

*Minnesota* - Vanderbosch said Minnesota PCA has a few staff dedicated to serving as tribal liaisons. Wild rice is a priority to the Ojibwe, Dakota, and Chippewa.  Overall, tribal coordination is robust and routine. Tribal priorities are incorporated into waters outside of tribal areas. Within PCA's regulatory programs, the agency makes sure to prioritize permit issuance and compliance to spend equal amounts of time on permittees and discharges near EJ areas. It becomes logistically challenging to get compliance inspectors to the northern part of Minnesota. Tribal interests are well served but other communities need further support. Vanderbosch asked for resources on the definition of meaningful engagement.

*Missouri* - Wieberg said Missouri DNR staff are incorporating EJ into TMDL development, in part by using the EJ screen tool. There is a struggle with classifying EJ communities as there are many rural areas in the state that area largely Caucasian but still facing many disparities.

On the drinking water side of things, there are less than 10 public water suppliers able to adjust schedules of compliance or adjust water quality variances based on financial disparities. There is a variance approved for affordability factors. Challenges are in both the urban and rural settings. Missouri DNR has an effective permit processing rate and staff have not yet made changes to prioritize EJ efforts from a 303(d) or permitting standpoint.

Missouri does not have any federally recognized tribes in the state but does coordinate with surrounding states with tribal concerns e.g., Oklahoma.

Iowa – Schneiders shared that Iowa DNR's legal coordinator is evaluating the entire agency on how to improve its EJ efforts. The state's biggest activities relate to the Bipartisan Infrastructure Law funding and creating ways of evaluating equitable distribution of funds throughout the state. Iowa DNR will be requesting public comment in late June or July 2022.

Iowa DNR is working on providing translations on its website, state parks and beaches. It will be a lengthy effort and Iowa is engaging USEPA as a partner. Iowa has a credible data law that makes participatory science challenging to integrate into CWA assessments. The law requires certified labs, quality action project plans (QAPPS), and a minimum of seven samples in a given year. Smaller groups do not have the funding resources to meeting the requirements.

*Wisconsin* – Searle said Wisconsin is developing its own version of the EJ screening tool called the Wisconsin Environmental Equity Tool. The Evers administration created an EJ office at the Department of Administration. Wisconsin DNR is bringing in an EJ policy advisory. Statewide, Wisconsin just finalized a diversity hiring guide in hopes to recruit a diverse range of candidates. DNR also has a student diversity internship program.

Marcia Willhite said Wisconsin is in the early stages of how to incorporate EJ and inclusion into program planning. There are many more opportunities to conduct outreach more actively whether it is when DNR is working on triennial standards, putting together a vision for TMDLS and priority areas, or reaching out to entities for increasing data collection for the integrated report. Willhite would like to see more active outreach to tribal communities, rural areas, and urban neighbors that are not typically involved in DNR's programs. The groups may have opinions about water quality e.g., what kinds of contaminants they are concerned about.

**Nutrients**

*USEPA Nutrient Memo*

Tom Wall reviewed portions of the USEPA Nutrient Memorandum published in April 2022 and emphasized the Biden-Harris Administration's support of broader approaches, including advanced watershed planning tools to identify critical resources areas, and promoting state use of the revolving fund of $11.7 billion allocated to CWA State Revolving Funds (SRFs).

The Trump Administration focused on the area of trading and market approaches. The Biden-Harris Administration embraces and supports those strategies but wishes to emphasize a fuller set of tools to make progress on nutrient loading to the Gulf of Mexico. Other highlights of the memo include support for the Gulf of Mexico Program Office's Farmer to Farmer Grant program and the One Water, One Approach. Additionally, the memo cites the importance of alignment with USDA Natural Resource Conservation Service (NRCS) programs which support to support states and tribes, using the CWA framework to make progress, and wastewater treatment plant (WWTP) optimization to reduce nutrient loads.

Willhite said in support of the memo's statement of increased collaboration with the NRCS, one way to do that is to streamline data requests by allowing NRCS state offices to disseminate data to states to update their nutrient reduction strategies with Hydrologic unit code (HUC) 12 NRCS program data. Wisconsin makes the data request to the state NRCS office, but the state NRCS office still has to go through Headquarters to meet the request. Willhite suggested that Headquarters allow state NRCS offices to track practices by watershed and type and revisit the data management structure to better assist states to identify the kind of implementation that has already occurred and better plan what implementation is needed in the future. The current process involves an individual at Headquarters providing the 12 Hypoxia Task Force (HTF) states with NRCS data. Wall appreciated Willhite's suggestion and said that USEPA is planning to look at its guidance and have a discussion with the HTF Coordinating Committee and USDA leadership to figure out a path forward.

Salvato conveyed interest in the memo's mention of alignment of priority areas to address nutrient runoff. The WQEC has previously discussed alignment across state nutrient reduction strategies, Mississippi River Basin Healthy Watersheds Initiative priority watersheds, and National Water Quality Initiative Freshwater Protection grants. Wall said the time is right to make requests to NRCS leadership.

Schneiders emphasized his support of the memo's conclusion about the value and need for building partnerships to advance nutrient reduction progress. One concern Schneiders shared is following the Stoner memo, a lot of conflict occurred over nutrient criteria and that ultimately led to pauses in WWTP upgrades. Despite the challenges, Iowa created partnerships and flexibility that leadership believes has been successful. Presently there are permit appeals, for example in Ohio over Lake Erie TMDL, that may unravel the progress and priority put towards building partnerships. Does USEPA have any thoughts to share? Wall sympathized with Schnieders' concern and believes that offering alternative approaches to meeting nutrient criteria will allow for less contention among industry and others subject to CWA requirements.

Willhite provided background to her comment about the need for emphasizing and promoting partnerships between commodity purchasers and producers. Wisconsin DNR applied for a NRCS climate smart commodities grant to encourage the adoption of practices that both sequester carbon and develop markets for commodities produced in that way. DNR is struggling on how best to promote the adoption of both climate smart and water smart practices. Willhite suggested that the partnerships with commodity purchasers and producers will help provide the economic driver to middle and later adopters of agriculture conservation practices. This was the basis of the grant application. Wall referenced the Cedar Rapids, Iowa project funded by the Soil and Water Outcomes fund. Cargill purchased carbon credits and the City of Cedar Rapids bought water credits. Wall is interested in how to duplicate the Cedar Rapids project in other parts of the Mississippi River Basin watershed. Assistant Administrator Radhika Fox's vision is that urban areas have nutrient reduction needs but you can also work with farmers in the watershed and get equivalent or even more nutrient reduction, carbon capture, and flood resilience benefits.

Wall highlighted the publication of the CWSRF Best Practices Guide for Financial Nonpoint Source Solutions published in December 2021. The document shows how states have conducted successful projects to address NPS. One barrier to the 319 program is the 40 percent statutory match. Case studies from Indiana show how repayment from SRF can be used as a nonfederal match. In Kansas, a farming cooperative bought cover crop inter-seeders using SRF monies. This jump-started cover crop implementation on thousands of acres of lands that had not the practices before. Wieberg shared appreciation for the examples provided in the publication. Missouri has struggled with motivating the SRF side to conduct NPS work when there are many other mandates. Wall offered help from USEPA staff to brainstorm ways to address NPS.

Vanderbosch said that Minnesota has struggled with promoting water quality trading. Cities and municipalities are concerned about having compliance with a permit hinged on the actions or inactions on lands that they do not own. Even with contracts in place, the process to secure payments and manage contracts, there is still hesitancy. Cities would much rather wait years for SRF money to be available to participate in a way that can be controlled. Minnesota has been focusing communication efforts on a changing climate and connection between climate change impacts and aging infrastructure. Even after three years of hosting the ag-urban partnership forum to bring together various aspects of water quality trading and different projects in development, no firm plans have results with any of the National Pollutant Discharge Elimination System permits. It is apparent that local partners are unsure of how to facilitate discussions. Vanderbosch said Minnesota PCA staff will likely reach out to USEPA for additional ideas.

Wieberg said for point source (PS) permittees trading is a way to help meet the permit obligations but there is not significant progress to reduce NPS in watersheds. If a municipality wants to address a water quality problem, it will have to step outside of the regulatory framework and have those conversations. It is not easy to convince citizens or rate payers to invest in caring for a watershed that is not necessarily their responsibility. Overall, Missouri will continue to promote trading, but Wieberg has not viewed trading as a tool to make significant progress. Kevin Kirsch shared a success in Wisconsin has been from the development of nutrient criteria for phosphorus (P). Facilities have low P limits of 75-100 µg/L, and TMDLs may have a higher requirement. The facilities are left to consider the economic requirement for reductions to overcome barriers identified. There is enough of a gradient of risk assessment and variation of what it would cost to upgrade a WWTP. Trading is not a major NPS implementation tool but an alternative tool for PS. Adaptive management is the closest thing Wisconsin has to address NPS in an entire watershed. The best example is the Yahara Wins project led by the Madison Metropolitan Sewer District.

**Administrative Items**

*Future Meetings*

The next WQTF meeting will be convened on October 4, 2022 in St. Paul, MN.

**Participants**

| | |
|---|---|
| John Olson | Contractor, Iowa Department of Natural Resources (Retired) |
| Nicole Vidales | Illinois Environmental Protection Agency |
| Ryan Sparks | Illinois Environmental Protection Agency |
| Adam Schneiders | Iowa Department of Natural Resources |
| Dan Kendall | Iowa Department of Natural Resources |
| Dana Vanderbosch | Minnesota Pollution Control Agency |
| Kim Laing | Minnesota Pollution Control Agency |
| Chris Wieberg | Missouri Department of Natural Resources |
| Erin Petty | Missouri Department of Natural Resources |
| Robert Voss | Missouri Department of Natural Resources |
| Chuck Theiling | U.S. Army Corps of Engineers, Research and Development Center |
| Carl Schoenfeld | U.S. Army Corps of Engineers, Rock Island District |
| Karen Hagerty | U.S. Army Corps of Engineers, Rock Island District |
| Nicole Manasco | U.S. Army Corps of Engineers, Rock Island District |
| Ellie Flaherty | U.S. Environmental Protection Agency |
| Katie Flahive | U.S. Environmental Protection Agency |
| Rosaura Conde | U.S. Environmental Protection Agency |
| Sara Schwartz | U.S. Environmental Protection Agency |
| Tom Wall | U.S. Environmental Protection Agency |
| Whitney King | U.S. Environmental Protection Agency |
| Donna Keclik | U.S. Environmental Protection Agency, Region 5 |
| Janette Marsh | U.S. Environmental Protection Agency, Region 5 |
| Kathy Roeder | U.S. Environmental Protection Agency, Region 5 |
| Micah Bennett | U.S. Environmental Protection Agency, Region 5 |
| Tim Elkins | U.S. Environmental Protection Agency, Region 5 |
| Amy Shields | U.S. Environmental Protection Agency, Region 7 |
| Ann Lavaty | U.S. Environmental Protection Agency, Region 7 |
| Chelsea Paxson | U.S. Environmental Protection Agency, Region 7 |
| Madison Stieg | U.S. Environmental Protection Agency, Region 7 |
| Megan Maksimowicz | U.S. Environmental Protection Agency, Region 7 |
| Steve Schaff | U.S. Environmental Protection Agency, Region 7 |
| Zachary Leibowitz | U.S. Environmental Protection Agency, Region 7 |
| Dana Kolpin | U.S. Geological Survey, Central Midwest Water Science Center |
| Kelly Warner | U.S. Geological Survey, Central Midwest Water Science Center |
| Kelsie Ferin | University of Wisconsin Madison |
| Erin Spry | Upper Mississippi River Basin Association |
| Kirsten Wallace | Upper Mississippi River Basin Association |
| Lauren Salvato | Upper Mississippi River Basin Association |

| | |
|---|---|
| Coreen Fallat | Wisconsin Department of Agriculture, Trade, and Consumer Protection |
| Ashley Baranek | Wisconsin Department of Natural Resources |
| Greg Searle | Wisconsin Department of Natural Resources |
| Kevin Kirsch | Wisconsin Department of Natural Resources |
| Marcia Willhite | Wisconsin Department of Natural Resources |
| Mike Shupryt | Wisconsin Department of Natural Resources |
| Shawn Giblin | Wisconsin Department of Natural Resources |

# ATTACHMENT B

## *How Clean is the River?* Report Executive Summary

*(B-1 to B-2)*


Jeff Janvrin, Wisconsin DNR

UMRBA
Upper Mississippi River Basin Association

# How Clean is the River?

## A 30-YEAR EVALUATION OF WATER QUALITY IN THE UPPER MISSISSIPPI RIVER BASIN

EXECUTIVE SUMMARY

The Upper Mississippi River Basin is a nationally significant economic, environmental, social, and cultural resource that requires balanced, integrated, and collaborative management. **How Clean is the River?** provides valuable insights for those who manage this resource and all who rely upon it.

A product of the Upper Mississippi River Basin Association (UMRBA), **How Clean is the River?** is the result of a second, collective effort to understand water quality trends in the Basin, which includes Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The first report was published in 1989 and led UMRBA to focus its work on heavy metals and sediment. This new analysis includes water quality data from 1989 to 2018 and supports UMRBA's current focus on nutrients and chloride.

Based on review of 23 water quality parameters grouped into four categories—nutrients, heavy metals, salts and pathogens, and physical—the new analysis finds that **water quality between 1989 and 2018 has generally improved, while there are pollutants of concern that have varying trends**.

Decreases in legacy heavy metals, sediment, and phosphorus, for example, show that **public and private investments in managing water quality are beneficial and that the approaches taken have been effective**.

**Nitrogen, chloride, and contemporary or emerging pollutants of concern, however, are rising** and require a five-state approach to develop effective solutions.

**How Clean is the River?** underscores the value of coordinated and comprehensive water quality monitoring for the Basin. In combination with UMRBA's Interstate Water Quality Monitoring Program, the report's findings will allow the five Basin states to more effectively identify problem areas, target management actions, and measure progress in protecting water quality.

*See the report at* umrba.org/howcleanriver.
*To learn more, contact* **Lauren Salvato,** *UMRBA's Policy and Programs Director, at* lsalvato@umrba.org

The **Upper Mississippi River Basin Association** is the Governor-established forum for discussion, study, and evaluation of Upper Mississippi River-related issues of common concern to the Basin's states.

Representing its member states of Illinois, Iowa, Minnesota, Missouri and Wisconsin, UMRBA:

- **Facilitates cooperative planning and coordinated management** of the region's water and related land resources.
- **Creates opportunities** for the Basin states and federal agencies to exchange information.
- **Develops regional positions** on river resource issues and serves as an advocate of the Basin states' collective interests before Congress and the federal agencies.

**KEY FINDINGS:**

# What's in the Report?

**How Clean is the River?** suggests progress in the Upper Mississippi River Basin—and frames challenges and questions for the future.

## Nutrients (Total Phosphorus, Total Nitrogen, Nitrate & Nitrite, Ammonia, Chlorophyll-a)

Although phosphorus reduction goals are yet to be met, phosphorus continues to decline in the Basin due to successes of the Clean Water Act. Ammonia, a fraction of total nitrogen, is also generally decreasing. Ammonia can be toxic to aquatic life.

These are important improvements in water quality because excess nutrients cause algae overgrowth, which can harm water quality, food resources, habitat, and decrease oxygen concentrations, all which have an effect on aquatic life and outdoor recreation opportunities.

Excess nutrients in the river originate from various sources, including agriculture, stormwater runoff, and wastewater. Achieving nutrient reductions requires a multifaceted approach.

Even with these successes, there are some concerns. Despite efforts to reduce nitrogen and phosphorus pollution to the Gulf of Mexico Hypoxic Zone, total nitrogen is increasing. Nitrogen originates from nonpoint sources, such as urban and agricultural runoff, or pollution runoff from a broad area. The Hypoxic Zone receives attention nationwide because of its low oxygen levels—conditions that are not suitable for aquatic life to survive. Local problems with excess nutrients cause the overgrowth of algae and result in diminished recreational opportunities.

## Heavy Metals (Aluminum, Arsenic, Lead, Zinc, Copper, Mercury, Cadmium)

Significant successes have resulted from implementation of pollution reduction efforts under the Clean Water Act. There has been a general decrease in heavy metals, which are both naturally occurring from underlying geology and human-made from manufacturing and industrial processes.

Still, while well below the maximum contaminant level set by the federal Safe Drinking Water Act, lead is increasing in Pools 15 and 17 near the Quad Cities in Illinois and Iowa and New Boston, Illinois, respectively. The reasons for this are not completely understood and warrant investigation and research.

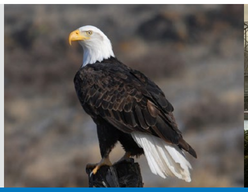
## Salts and Pathogens (Chloride, Sulfate, *E. coli*, Fecal Coliform)

Chloride increased at least 35% in the Basin. The primary source is salt used to de-ice roads during winter. While road salt makes transit safer for people, too much of it is toxic to aquatic life that live in water bodies. Other dominant chloride sources include household water softeners and fertilizers.

## Physical (Temperature, Conductivity, Total Suspended Solids, pH, Turbidity, Dissolved Oxygen)

There have been decreases in total suspended solids of at least 40% across the Basin. Turbidity and dissolved oxygen have also decreased. These reductions allow for light to reach aquatic vegetation, increasing its growth and thereby providing habitat and food for aquatic organisms.

Left: USFWS; right: Preston Keres, USDA



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# ATTACHMENT C

## UMR Interstate Water Quality Monitoring

- **Reaches 8-9 Pilot Condition Assessment and Evaluation Report Web Link:** https://umrba.org/document/reaches8-9pilot

# ATTACHMENT D

## Emerging Contaminants

- **Linking Field and Laboratory Studies: Reproductive Effects of Perfluorinated Substance on Avian Populations (2021)** *(D-1 to D-7)*

- **Fact Sheet: Draft 2022 Ambient Water Quality Criteria for PFOA and PFOS** *(D-8 to D-9))*

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Special Series

# Linking field and laboratory studies: Reproductive effects of perfluorinated substances on avian populations

*Christine M Custer*†*

*†United States Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin*



## EDITOR'S NOTE:

This article is part of the special series "Ecological Risk Assessment for Per- and Polyfluorinated Alkyl Substances." The series documents and advances the current state of the practice, with respect to ecotoxicological research, environmental exposure monitoring and modeling, ecologically based screening benchmarks, and risk assessment frameworks.

## ABSTRACT

Although both laboratory and field studies are needed to effectively assess effects and risk of contaminants to free-living organisms, the limitations of each must be understood. The objectives of this paper are to examine information on field studies of reproductive effects of perfluorinated substances (PFASs) on bird populations, discuss the differences among field studies, and then place those results in context with laboratory studies. Hypotheses to explain the divergences between field studies and between laboratory and field studies will be discussed. Those differences include mixture issues, misattribution of the mechanism or the specific PFAS causing impairments, as well as other possible reasons. Finally, suggestions to better link laboratory and field studies will be presented. *Integr Environ Assess Manag* 2021;17:690–696. Published 2021. This article is a US Government work and is in the public domain in the USA.

KEYWORDS: Tree swallows, PFAS, Reproductive success, Field and laboratory studies

## INTRODUCTION

Field studies to assess effects of a particular contaminant, or group of contaminants, are the ultimate step in an assessment of risk to wildlife populations. Assessments of potential risk often start with modeling chemical structures as they might affect modes of action and subsequent biotic effects. Examples are quantitative structure–activity relationship (QSAR) models or using known effects of similar classes or types of chemicals. The next step, which is becoming more frequent, is to use nonanimal models such as United States Environmental Protection Agency's (USEPA) Toxicity Forecaster (ToxCast; Kavlock et al. 2012) or the hundreds, if not thousands, of cell lines to test toxicity and effects (Nazerian 1987). Prior to the development of these in vitro and in silico technologies, the subsequent step was laboratory testing of a contaminant on a target organism. For birds, the common laboratory species were quail (*Coturnix* sp., *Colinus* sp.), chickens (*Gallus* sp.), and ducks (*Anas* sp.), although methods for other laboratory species have more recently been developed such as for zebra finches (*Taeniopygia* sp.), American kestrels (*Falco sparverius),* and others. The goals of the molecular and laboratory work are to predict in a more definitive fashion whether, and at what exposure concentrations or dosages, a chemical is likely to adversely affect populations of free-living organisms. The final step in this process is to assess effects in free-living organisms, knowing, however, that science does not necessarily follow in the linear fashion outlined earlier in this paragraph. Although each step has its limitations and uncertainties, field assessments have less ability than laboratory studies to control for some of the known factors that contribute to variability or differences. On the other hand, field studies reflect effects on the organism in its native environment, where it forages on a diverse array of prey and experiences natural stressors, such as weather, competition, disease, and predation. The objectives of the present paper are to summarize reproductive effects of perfluorinated substances (PFASs) in field populations of birds and to provide possible reasons for discrepancies among various field studies and between field and laboratory assessments of PFAS reproductive effects.

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Published 21 January 2021 on wileyonlinelibrary.com/journal/ieam.

### *Reproductive effect studies: Field and laboratory*

Although many studies document exposure to PFASs in birds (see review in Ankley et al. 2021), there are still relatively few field, or even laboratory, studies on PFAS

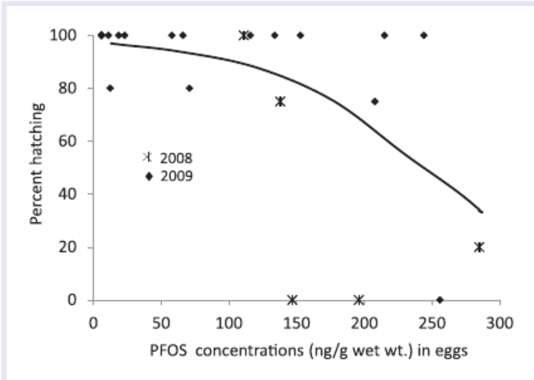


Figure 1. Association between PFOS exposure and hatching success of tree swallows at Lake Johanna, Ramsey County, Minnesota, USA, in 2008 and 2009. Reprinted from *Reproductive Toxicology*, CM Custer, TW Custer, HL Schoenfuss, BH Poganski, L Solem. Exposure and effects of perfluoroalkyl compounds on tree swallows nesting at Lake Johanna in east central Minnesota, USA, 2012;33 (4):556–562, with permission from Elsevier. PFOS = perfluorooctane sulfonate.

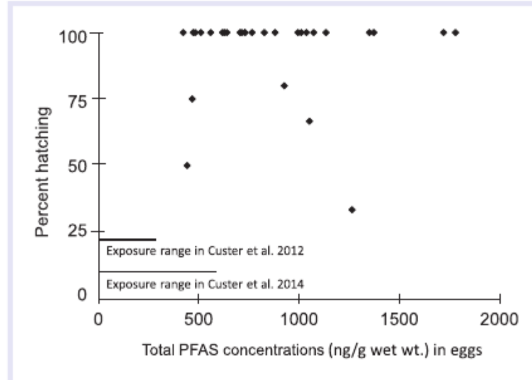


Figure 3. Association between total PFAS exposure and hatching success of tree swallows nesting near the former Wurtsmith Air Force Base, Oscoda, Michigan, USA, 2014 to 2016. Data taken from Custer et al. 2019. Note: PFOS comprised 90% of total PFAS. PFAS = perfluorinated substance; PFOS = perfluorooctane sulfonate.

reproductive effects when compared to other contaminants, such as polychlorinated biphenyls (PCBs), mercury (Hg), and *p,p*-DDE. Field reproductive effect studies on PFASs include studies on tree swallows (*Tachycineta bicolor*; Custer et al. 2012, 2014, 2017, 2018, 2019), black-legged kittiwakes (*Rissa tridactyla*; Tartu et al. 2014), great tits (*Parus major*; Groffen et al. 2019), and lesser black-backed gulls (*Larus fuscus*; Bustnes et al. 2008).

The published results on reproductive effects in field situations are contradictory. Two field studies (Custer et al. 2012, 2014; Figures 1 and 2) using tree swallows found a significant negative association with perfluorooctane sulfonate (PFOS) and hatching success with numerous total clutch failures becoming prevalent at around 150 ng/g wet weight (wet wt) PFOS in eggs. Another set of field studies (Tartu et al. 2014; Custer et al. 2019; Groffen et al. 2019), however, which included one on tree swallows but also on other avian species, found few or no reproductive effects. A field study with tree swallows, conducted at the former Wurtsmith Air Force Base, Oscoda, Michigan, USA, hereafter called "Wurtsmith," reported considerably higher PFAS exposure (geometric means in eggs between 554 and 954 ng/g wet wt and a maximum concentration of 1781 ng/g) than was found in the two previous tree swallow studies. No association was found between reproduction and total PFAS concentrations in eggs (Custer et al. 2019; Figure 3) despite much higher exposure to total PFAS. This lack of an effect at very high PFAS concentrations was similar to a study of great tits in Belgium where there was only a slight reduction in hatching success in nests that hatched at least one egg (successful nests) at their site near a fluorochemical plant (Groffen et al. 2019). Perfluorooctane sulfonate exposure in that study was 50 times higher in eggs at the site nearest the plant (34 251 ng/g wet wt) than present at Wurtsmith, the site with the highest known exposure in North America (Custer et al. 2019). The percentage of nests hatching no eggs, however, was actually higher at two sites (Rot and Fort 4) with much less PFAS contamination than at the fluorochemical plant site. A study on lesser black-backed gulls (Bustnes et al. 2008) could not be categorized into either high or low exposure because their sampling matrix, whole blood, was not used in these other studies. However, there was no effect of PFAS exposure on hatching success. A study of black-legged kittiwakes in Norway also found few reproductive effects (Tartu et al. 2014), but see more discussion in the *Hypotheses to explain differences among laboratory and field studies* section (third hypothesis).

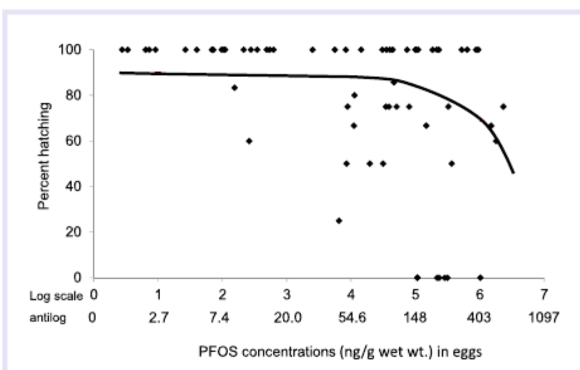


Figure 2. Association between PFOS exposure and hatching success of tree swallows from multiple sites in Minnesota and Wisconsin, USA, in 2007 to 2011. Reprinted by permission from Springer. *Archives of Environmental Contamination and Toxicology*, Exposure and effects of perfluoroalkyl substances in tree swallows nesting in Minnesota and Wisconsin, USA. CM Custer, TW Custer, PM Dummer, MA Etterson, WE Thogmartin, Q Wu, K Kannan, A Trowbridge, PC McKann. 2014;66:120–138. © 2013 Springer Science+Business Media New York. PFOS = perfluorooctane sulfonate.

The Wurtsmith, Belgium, and Norwegian field studies, with no or only slight effects on reproduction, are more consistent with the laboratory results on reproductive effects where exposure to PFOS, either via food or by egg injection, needed to be very high before effects were documented. For example, the lethal dose (LD50) for PFOS for 50% hatching success was calculated to be 4900 ng/g wet wt PFOS per egg derived from an egg injection study on chickens (*Gallus gallus domesticus*; Molina et al. 2006). Peden-Adams et al. (2009), however, found no effect on hatching of up to 5000 ng/g injected into chicken eggs. Assuming the concentration injected is fully incorporated into the egg, this LD50 would result in egg concentrations far above most environmental levels found in tree swallows, in great tits at most sites in Belgium, or even in an apex predator such as the great blue heron (*Ardea herodias*, 340–492 ng/g), a piscivorous waterbird nesting in the Twin Cities area of Minnesota, USA (Custer et al. 2013). Although all injection levels had reduced hatching success compared to the vehicle control (Molina et al. 2006), the concentration of PFOS in liver tissue at seven days of age did not differ between the vehicle control (1100 ng/g) and two lowest dosage levels (1400–1800 ng/g), indicating that their controls had significant PFOS exposure. Those liver concentrations were five times higher than environmentally relevant levels even at the most contaminated site in North America (209 ng/g wet wt; Custer et al. 2019) but more similar to the higher liver concentrations found in great tits (86 to 11 359 ng/g) or blue tits (*Cyanistes caeruleus*, 317–3322 ng/g; Hoff et al. 2005; Dauwe et al. 2007) that nest near the 3M Company site in Belgium. This indicates that high PFOS concentrations in eggs or livers are needed to affect hatching success in laboratory studies. Further, citing two unpublished reports, Molina et al. (2006) calculated LD50 levels of 18 000 and 21 000 ng/g in mallard (*Anas platyrhynchos*) and bobwhite quail (*Colinus virginianus*) eggs when fed 10 μg PFOS per gram of feed. Using a different PFAS, Cassone et al. (2012) also did not find an effect on hatching when 9300 ng/g of perfluorohexane sulfonate (PFHxS) was injected into the air cell, but there was a significant effect when 38 000 ng/g was injected. Although whole egg concentrations were not calculated, the concentration of PFHxS in liver tissue (36 000 ng/g) at their no-effect egg-injection level was far above the 237 ng/g wet wt found in liver tissue at Wurtsmith or at Lake Johanna (70.6 ng/g), another highly PFAS-contaminated site in the Twin Cities metro area (Custer et al. 2012). Finally, in some of the earliest laboratory work on PFASs, the no observable adverse effect level (NOAEL) for PFOS in diet was calculated to be 6200 ng/g for no impairment of survival or reproduction in mallards or bobwhite quail (Newsted et al. 2007); concentrations in diet at Wurtsmith were 141 to 190 ng/g wet wt, which was considerably below this NOAEL (Custer et al. 2019). Newsted et al. (2005) predicted a no-effect concentration of 1000 ng/mL in egg yolk. Based on these laboratory studies, direct embryo toxicity is not expected to be an issue in wild populations. The no-effect finding in tree swallows at Wurtsmith, the small reproductive effect on great tits in Belgium, and kittiwakes in Norway are supported by these laboratory data.

### *Hypotheses to explain differences among laboratory and field studies*

The question remains as to why unusually low exposure levels produced an association between PFAS exposure and reduced hatching success at sites in and near the Twin Cities but not at other locations (Michigan, Belgium, and Norway). Groffen et al. (2019) suggested differential susceptibility by species. This hypothesis can now be discounted because, although there are certainly differences among species, the differences in outcomes among the three tree swallow studies was not because of species differences.

The second hypothesis is that PFOS, the PFAS that is generally the most abundant in avian tissues, can occur in linear or branched configuration both in the environment and in biotic tissues (see review in Schultz et al. 2020). Other PFASs also have both branched and linear isomers. Most chemical analyses to date have not differentiated between these isomeric configurations, although it is becoming more common to do so. There is evidence that there can be geographic differences in the prevalence of the different isomers in the environment, especially as it relates to manufacturing methods, but also that different isomers may have different pharmacokinetic properties that could affect exposure and effects assessments (O'Brien et al. 2011). If the toxicity or effects differ among isomers, this could help explain some of the differences among avian studies.

A third hypothesis for the differences between laboratory and field studies is that other PFASs, not PFOS, are the chemicals causing adverse effects. The work by Tartu et al. (2014) may provide some insights. In that study, PFOS was not associated with reduced hatching success of black-legged kittiwakes in Svalbard, Norway; however, perfluorododecanoate (PFDoDA) was. Kittiwakes with higher PFDoDA were more likely to hatch 1 egg rather than both eggs. Concentrations of PFDoDA in plasma (2.29–2.66 ng/mL) of adult kittiwakes were three to four times higher than concentrations in 12-d-old nestlings at Wurtsmith (0.67 ng/g) where there were no associated reproductive effects, but were more similar to PFDoDA concentrations in Lake Johanna nestlings (1.63 ng/g; Custer et al. 2014) where reproductive effects were documented. Plasma concentrations in adult tree swallows are expected to be higher than in 12-d-old nestlings at the same site, so these two values are probably quite similar. In nests of great tits that hatched no eggs, there was a negative association between hatching success and perfluorodecanoate (PFDA); the median concentration was 13 ng/g in eggs and a range up to 102 ng/g (Groffen et al. 2019). At tree swallow sites that experienced reduced hatching success, PFDA averaged 5.51 and 5.47 ng/g with an individual egg as high as 22.7 ng/g (Custer et al. 2012, 2014). At Wurtsmith, the site with no reproductive impairment, PFDA concentrations averaged only 1.14 ng/g, 5 times lower than at sites with reproductive impairment. To examine this in another way, Pearson's correlation coefficient between PFDA and PFOS in tree swallow eggs at the upper Midwest sites was >0.90 (Custer 2020). With such a high degree of correlation, the statistical association between hatching success and PFDA would probably have been nearly identical to the PFOS–hatching success association (Figures 1 and 2). In contrast, the correlation coefficient for the correlation between PFDA and PFOS was only 0.24 at Wurtsmith (Custer 2020). This is therefore consistent with a lack of an association with reproductive impairment at that site if PFDA rather than PFOS was the operant PFAS. A meta analysis of all of the tree swallow reproductive data to include these other PFASs seems warranted. Although PFOS has dominated our thinking and research because it is usually the PFAS in the highest concentration, often exceeding 75% of total PFASs (Custer et al. 2014, among many other publications), it may well not be the most important despite its prevalence or its much higher concentration relative to other PFASs. These studies emphasize the need to examine other PFASs in more detail, such as PFDA and PFDoDA, as recommended by Tartu et al. (2014) and Groffen et al. (2019).

A related fourth hypothesis is that, because mixtures of PFASs differ among locations, it is these mixture differences that are causing different consequences on biological organisms. Depending on the exact mixture, the effects may not be additive, but synergistic or even antagonistic. The PFAS mixture at sites where the source is firefighting foams is expected to be more consistent and well characterized than if the source is a research and manufacturing facility where the possible PFAS mixtures seem endless because of waste products, creation of experimental PFASs, et cetera. At locations where the source is primarily from atmospheric or oceanic transport, the mixtures will be different than the original source material because of the many processes acting to modify PFASs in the air or ocean, and because many different sources may mix together.

Another explanatory hypothesis is that other contaminants may have been present in the Twin Cities locations, which caused or contributed to the reproductive effects seen there. Although all of the legacy organochlorine contaminants and some newer contaminants such as the polybrominated diphenyl ethers were assessed in those studies (Custer et al. 2012, 2014), the polycyclic aromatic hydrocarbons (PAHs) were not. A recent publication implicates PAHs as a contributor to reduced hatching success (Custer et al. 2018) in tree swallows at sites around the Great Lakes. Work is ongoing to quantify PAHs in tree swallow diet in the Twin Cities area to more fully test this fifth hypothesis.

A sixth hypothesis, which is not exclusive of the others mentioned here, is included in the theory of ecological stoichiometry (Sterner and Elser 2002). Ecological stoichiometry is concerned with the effects of an imbalance between available resources, in the current context food resources, and the physiology of an organism, in this case, the physiology of reproduction. Although this field is not well developed for avian ecotoxicology, or for vertebrates in general, ecotoxicology may benefit from the incorporation of a stoichiometric perspective. Most laboratory studies provide food ab libitum, as well as food that is nutritionally complete. However, food availability, whether quantity or quality, is rarely documented or otherwise accounted for in field studies. This lack of documentation is understandable because of the difficulty of doing this, but it may, and probably does, have consequences for assessing toxicological effects. One of the few studies on the combined effects of food stress and contaminant exposure was a laboratory study (Keith and Mitchell 1993) in which ring doves (*Streptopelia risoria*) were fed a DDE (1,1,-dichloro-2,2-bis[*p*-chlorophenyl] ethylene) contaminated diet, returned to a clean diet, and then stressed with one of three levels of food restriction (10%, 20%, and 30%). Food restrictions were imposed at three different periods in the reproductive cycle. As an example, DDE-contaminated doves reproduced as well as the control birds if they had ad libitum food. Doves, previously exposed to DDE and with only a 10% food-restricted diet, imposed prior to when they were paired with a mate, had reduced courtship behavior and did not lay eggs. Food restrictions seemed to have suppressed reproduction, but at that low level of food restriction, it did not diminish either energy reserves or compromise body condition of the doves. The type and severity of reproductive effects varied by the timing of the food restriction in that study. It is almost certain that birds in the wild are faced with reduced food availability at some point during the reproductive cycle, and this could exacerbate contaminant-related effects. Reduced food in wild populations could be the result of a short-term weather event, such as a prolonged period of wet, rainy weather that reduces foraging efficiency of an aerial insectivore like the tree swallow, or because of nesting in a habitat that has fewer resources or poorer quality food. In terms of food quality rather than quantity, Se, an essential element, has been shown to ameliorate the effects of Hg toxicity (El-Begearmi et al. 1977). The specific form of Se, however, affects how much amelioration occurs (Heinz and Hoffman 1998). The author is unaware of other avian studies assessing food quality, such as other micronutrients or caloric density, on contaminant effects in birds.

The seventh hypothesis for this apparent disconnect between laboratory and field results is misattribution of the mechanism behind the effect. Because it is well known and widely accepted that the developing embryo is one of the most sensitive life stages, direct toxicity has been the primary concern from a risk assessment standpoint. Calculation of LD50 and lethal concentration (LC50) thresholds for effects are standard practice. Direct embryo toxicity, however, may not be the only cause of reproductive impairment, as demonstrated by Keith and Mitchell (1993) for DDE and as postulated and summarized by Tartu et al. (2014) for PCBs. A third example of reproductive effects not being related to direct embryo toxicity is the probable disruption of prolactin production by polychlorinated dibenzo-*p*-dioxin and polychlorinated dibenzofuran (PCDD-F; see review for mammals in De Krey et al. 1994). This hormonal disruption may be one of the primary causes of the associated reproductive impairment related to PCDD-F exposure, not direct embryo toxicity. In 2 studies, there were total clutch failures at dioxin and furan levels considerably below the LD50 value for eggs (White and Seginak 1994; Custer et al. 2005). This reproductive impairment was most likely because of the interference of PCDD-F with prolactin that initiates and maintains incubation in birds (Halawani et al. 1980; Youngren et al. 1991). When prolactin synthesis is disrupted, incubating females abandon the nest and the breeding attempt totally fails. Nest abandonment was what occurred in both tree swallows (Custer et al. 2005) and wood ducks (*Aix sponsa*; White and Seginak 1994). There can also be less severe effects on reproductive success due to behavioral changes that occur because of contaminant exposure as found by Sullivan et al. (2013), among others. Therefore, trying to compare toxic levels in eggs as derived from laboratory studies, especially if the eggs are artificially incubated, which removes any behavior effects on parents, may not necessarily predict field effects if there is a strong behavioral or physiological effect component.

Misattribution of the actual chemical causing an effect could also result in an apparent discrepancy. Polychlorinated biphenyl ecotoxicology offers a cautionary tale. Different Aroclors or Kenechlors are composed of differing amounts of PCB congeners, which may result in differential toxicity. This is well known and the impetus for the development of toxic equivalent factors (TEFs) for various PCB congeners. Perhaps more important, however, and less well known are the different amounts of PCDD-Fs that contaminated commercial PCB formulations (Wakimoto et al. 1988; Burkhard and Lukasewicz 2008; Johnson et al. 2008). It is probable that PCDD-Fs can be the primary agents for toxicity and not necessarily the PCBs themselves. This has been demonstrated at some locations where PCDD-F contamination of the PCBs was associated with adverse reproductive effects, not the PCBs (Vos et al. 1970; Custer et al. 2003). This effect was despite PCDD-F concentrations being thousands of times lower than PCB concentrations. For example, average total PCDD-F concentration was 0.45 ng/g wet wt in eggs in 1998 at Holmes Road, Pittsfield, MA whereas total PCB concentration was 49.15 µg/g wet wt at that site (Custer et al. 2003). A similar situation could be occurring with PFASs in the Twin Cities area where an impurity or co-occurring contaminant in the PFAS was present even at very small quantifies.

A final hypothesis is that PFASs may be somehow biotransformed to reduce their toxic effects. This has been shown for Hg in birds from along the Carson River, Nevada, USA (Henny et al. 2002). At hepatic Hg concentrations exceeding 8 µg/g wet wt, Hg is increasingly demethylated to inorganic Hg, a less toxic form of Hg, thereby resulting in a concomitant reduction in toxicity. Although a mechanism has yet to be identified, perhaps the affinity of PFASs for proteins rather than lipids might provide a starting point for investigation.

### *Suggestions to improve linkages between laboratory and field studies*

To better link laboratory studies with field data, it would be useful if PFAS egg concentrations, or concentrations in other common tissue types, were measured in laboratory studies. Providing tissue concentrations applies to both egg injection studies and feeding trials. The quantity of a contaminant injected into an air cell is not necessarily what is incorporated into the developing embryo and causing an effect, so reporting the concentration and isomer content in the whole egg would be useful. Many feeding studies provided information on exposure as a dosage (mg/kg body weight per day; Newsted et al. 2005). In this study, while concentrations were not actually measured in eggs, an extrapolation to egg concentrations was made, which is very helpful when interpreting field data. Sometimes information is provided as concentration in food (Newsted et al. 2007; Bursian et al. 2021) which is more useful when comparing to field assessments, if diet items can be analyzed in the field studies. Procuring and chemically analyzing diet items during a field study would be beneficial. For tree swallow studies, ligatures on nestlings can be used, or as is more commonly done, food is taken from the stomach of nestlings sacrificed for chemical analyses. For other species, food is often regurgitated as a defense mechanism by nestlings, which can be a source of actually consumed food. If the diet of a study species has been well characterized, then collecting those diet items from feeding areas is an option, albeit a less preferable one. It usually requires additional work, sampling expertise, and equipment to do so. In the case of an aerial insectivore such as the tree swallow, collecting the aerial stage of the specific types of benthic insects is a study in itself (Mengelkoch et al. 2004). If human-caught food is used, care is needed to procure the same species, same size, at the same time, and in the same feeding area as the birds are feeding. Collecting food can present huge logistical obstacles especially for wide-ranging seabird or other waterbird species.

Laboratory studies are needed to test for effects of other PFASs such as PFDoDA and PFDA, but also to test more mixtures to determine if there are synergistic, antagonistic, or merely additive effects of different PFAS mixtures. Although the combination of multiple chemicals quickly becomes unwieldly, considerations should also be given to synergistic, antagonistic, or additive effects with other common contaminants as well. Finally, the effects of common stressors found in the wild, such as temperature, disease, or food availability could be examined. In addition to these stressors, water quality differences, such as pH or temperature, could possibly alter PFAS toxicity in aquatic organisms.

Although water is currently the abiotic sampling matrix of choice for PFASs, which is understandable because of human health concerns, sediment may be a better predictor in understanding exposure and effect levels throughout an ecosystem. Concentrations of various contaminants in water did not predict the presence and extent of many contaminants in tree swallow tissues (Custer et al. 2020), whereas sediment contaminant levels did, especially for the organochlorine contaminants (Jayaraman et al. 2009). Additional work to determine whether, or which, abiotic media adequately predict biotic exposure would be useful.

## CONCLUSIONS

A combination of laboratory and field studies is beneficial when assessing effects of contaminants on free-living organisms, with the strengths and limitations of each understood and accounted for. More effort is also needed to assess endpoints in common between different types of studies, such as measured tissue concentrations, similar biomarker response variables, and hatching success, so that different studies can be directly compared. It would be beneficial to assess a greater number of PFASs in laboratory studies, as well as study mixtures that replicate concentrations and mixtures found in the environment. Care is needed in statistical analyses and interpretation to accommodate autocorrelations that are common in field studies. Finally, studies that incorporate a behavioral component might also shed light on important effects of PFASs beyond direct toxicity.

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## DATA AVAILABILITY STATEMENT

Because this is a review paper, there are no associated data. Data are available via the mechanisms outlined in this published article.

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# Fact Sheet: Draft 2022 Aquatic Life Ambient Water Quality Criteria for Perfluorooctanoic acid (PFOA) and Perfluorooctane Sulfonic Acid (PFOS)

## Summary

As part of EPA's commitment to safeguard the environment from per- and polyfluoroalkyl substances (PFAS), the agency has published draft national recommended aquatic life criteria for PFOA and PFOS for a 30-day public comment period. These draft Clean Water Act criteria reflect the latest scientific knowledge regarding the effects of PFOA and PFOS on freshwater organisms. Elevated concentrations of PFOA and PFOS in aquatic ecosystems can result in death of aquatic organisms and affect their growth and reproduction. When finalized, states and authorized tribes can adopt these criteria into their water quality standards or can adopt other criteria that are scientifically defensible based on local or site-specific conditions. These draft aquatic life ambient water quality criteria are not a regulation, nor do they impose a legally binding requirement.

## Background

On October 18, 2021, EPA Administrator Regan announced the Agency's PFAS Strategic Roadmap—laying out a whole-of-agency approach to addressing PFAS. The PFAS Strategic Roadmap identified development of aquatic life criteria for PFOA and PFOS as a priority EPA action. The 2022 draft PFOA and PFOS aquatic life ambient water quality criteria are being released for a 30-day comment period for the public to provide their scientific views. Following the comment period, EPA will prepare a response to public comments document, update the draft PFOA and PFOS criteria documents considering public comments, and consider new toxicity data published since September 2021 prior to the agency issuing final recommended criteria.

## What are PFOA and PFOS, and How Do They Enter the Water?

PFOA and PFOS are two of the most widely used and studied chemicals in the PFAS group. PFAS have been manufactured and used by a broad range of industries since the 1940s. PFAS are used in many applications because of their unique physical properties such as resistance to high and low temperatures, resistance to degradation, and nonstick characteristics. PFOA and PFOS can enter the aquatic environment during the manufacturing, use, and disposal of industrial and consumer products. Major sources of PFOA and PFOS to aquatic environments include municipal and industrial wastewater treatment plants (WWTPs); landfill leachate, runoff and leachate from contaminated biosolids; and atmospheric deposition.

## How Do PFOA and PFOS Affect Aquatic Life?

PFOA and PFOS are not naturally occurring and have no biologically important functions or beneficial properties to aquatic life. The mechanisms underpinning the toxicity of PFOA and PFOS to aquatic organisms, like other PFAS, is an active and on-going area of research. The draft criteria are based on observed effects of PFOA and PFOS to the survival, growth, and reproduction of aquatic organisms. Based on the available ecotoxicity data, aquatic plants are generally reported to be less sensitive to PFOA and PFOS than fish and other aquatic life.

## What are the Recommended Criteria for PFOA and PFOS in Freshwater for the Protection of Aquatic Life?

The draft criteria documents provide a review of PFOA and PFOS aquatic toxicity data, quantify the toxicity of PFOA and PFOS to aquatic life, and provide criteria to protect aquatic life from the acute and chronic toxic effects of PFOA and PFOS (individually, not in combination). EPA derived these criteria based on the latest scientific knowledge using the available data on the toxicological effects of PFOA and PFOS on aquatic life. In developing these draft criteria, EPA followed the general approach outlined in the Agency's "*Guidelines for Deriving Numerical Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses.*"

EPA established the national recommended draft criteria for PFOA and PFOS to be protective of most aquatic organisms in the community (i.e., approximately 95 percent of tested aquatic organisms representing the aquatic community). The draft criteria are protective of aquatic life designated uses for freshwaters. The draft PFOA and PFOS criteria documents contain acute and chronic criteria for freshwaters (see Table 1). The draft criteria documents also contain chronic criteria expressed as tissue-based concentrations to protect aquatic life from PFOA and PFOS bioaccumulation (see Table 1). The chronic freshwater and chronic tissue criteria are intended to be independently applicable and no one criterion takes primacy.

EPA also derived acute estuarine benchmarks for PFOA and PFOS using available toxicity data supplemented with modeled estimates of acute toxicity. The acute estuarine/marine benchmarks are recommendations for states and tribes to consider as protective values in their water quality protection programs.

The draft criteria reflect the maximum concentrations, with associated frequency and duration specifications, that would support protection of aquatic life from acute and chronic effects associated with PFOA and PFOS in freshwaters (see Table 1).

## Where can I find more information?

Information on the draft PFOA criteria is available at: www.epa.gov/wqc/aquatic-life-criteria-perfluorooctanoic-acid-pfoa. Information on the draft PFOS criteria is available at: www.epa.gov/wqc/aquatic-life-criteria-perfluorooctane-sulfonate-pfos. Please email any questions to James Justice at justice.jamesr@epa.gov.

**Table 1. Draft Recommended Freshwater Aquatic Life Water Quality Criteria for PFOA and PFOS**

| Criteria Component | Acute Water Column (CMC)[1] | Chronic Water Column (CCC)[2] | Invertebrate Whole-Body | Fish Whole-Body | Fish Muscle |
|---|---|---|---|---|---|
| **PFOA Magnitude** | 49 mg/L | 0.094 mg/L | 1.11 mg/kg ww | 6.10 mg/kg ww | 0.125 mg/kg ww |
| **PFOS Magnitude** | 3.0 mg/L | 0.0084 mg/L | 0.937 mg/kg ww | 6.75 mg/kg ww | 2.91 mg/kg ww |
| **Duration** | 1-hour average | 4-day average | Instantaneous[3] | | |
| **Frequency** | Not to be exceeded more than once in three years, on average | Not to be exceeded more than once in three years, on average | Not to be exceeded more than once in ten years, on average | | |

[1] Criterion Maximum Concentration.

[2] Criterion Continuous Concentration.

[3] Tissue data provide instantaneous point measurements that reflect integrative accumulation of PFOA or PFOS over time and space in aquatic life population(s) at a given site.

# ATTACHMENT E

## Cyanotoxins

- **Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microsystins and Cylindrospermopsin** *(E-1 to E-2)*

United States Environmental Protection Agency

Office of Water
EPA 822-F-19-001
**May 2019**

# Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin

## Summary

EPA has released national recommendations for the *Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories (AWQC/SA) for Microcystins and Cylindrospermopsin*. These recommended AWQC/SA accurately reflect the latest scientific knowledge on the potential human health effects from recreational exposure to these two cyanotoxins. Primary contact recreation is protected in water bodies at or below the recommended concentrations of microcystins and cylindrospermopsin.

These recommendations are intended as guidance to states, territories and authorized tribes to consider when developing water quality standards. Alternatively, these recommendations can be used as the basis of swimming advisories for notification purposes in recreational waters to protect the public. States, territories and authorized tribes may also wish to consider using these recommendations as both water quality criteria and swimming advisory values.

## Background

Cyanobacteria, commonly called blue-green algae, are naturally-occurring photosynthetic bacteria found in freshwater and marine ecosystems. Under certain environmental conditions, such as elevated levels of nutrients, warmer temperatures, still water, and plentiful sunlight, cyanobacteria can rapidly multiply to form harmful algal blooms (HABs). HABs have been reported in ambient waters in all states. As the cyanobacteria multiply, some of the cells can produce toxic compounds, known as cyanotoxins, which can be harmful to human and animal health. Microcystins and cylindrospermopsin are two types of toxins produced by cyanobacteria. During a HAB, the toxin concentration can rapidly increase and may become elevated before a visible bloom is observed. Elevated cyanotoxin concentrations in surface waters can persist after the bloom fades, so human exposures can occur even after the visible signs of a bloom are gone or have moved downstream. Exposure to elevated-levels of microcystins can potentially lead to liver damage; the kidneys and liver appear to be the primary target organs for cylindrospermopsin toxicity.

## What are EPA's recommendations?

The recommended AWQC/SA for microcystins and cylindrospermopsin consist of three components—magnitude, duration and frequency--that are considered protective of human health in recreational waters. In developing these recommendations, EPA incorporated the existing peer-reviewed and published science on the adverse human health effects of these toxins, recreation-specific exposure parameters from the peer-reviewed scientific literature and EPA's Exposure Factors Handbook using established criteria methodologies. EPA derived these recommended values based on children's recreational exposures because children can be more highly exposed compared to other age groups. The recommendations are also protective of older age groups.

Water quality criteria recommendations are intended as guidance in establishing new or revised water quality standards. They are not regulations themselves. States and authorized tribes have the discretion to adopt other scientifically-defensible water quality criteria that differ from these recommendations. For use as swimming advisories, EPA envisions states and authorized tribes applying these recommendations in a similar manner as is currently done in their recreational water advisory programs.

The recommended magnitude for both toxins is shown in the following table:

**Table. Recommended magnitude for cyanotoxins.**

| Microcystins | Cylindrospermopsin |
|---|---|
| 8 µg/L | 15 µg/L |

**Duration and Frequency:**

For both cyanotoxins, the recommended duration and frequency depend on their application as a water quality criterion or a swimming advisory.

For application as a **recreational water quality criterion**, EPA recognizes that a single exceedance of the recommended magnitude does not necessarily indicate that the designated use is not attained. The recommended frequency and duration support the identification of a trend or pattern of elevated cyanotoxins that can be used to inform the evaluation of a waterbody. EPA recommends states use 10-day assessment periods, not a rolling 10-day period, over the course of a recreation season to evaluate ambient water body condition and recreational use attainment. The 10-day period links the water body assessment period to the adverse health effects observed from ingestion of the toxins over short-term exposures. If toxin concentrations are higher than the criterion magnitude during a 10-day assessment period, then that event should be considered an excursion from the recreational criteria. EPA recommends that when more than three excursions occur within a recreational season and that pattern reoccurs in more than one year, it is an indication the water quality has been or is becoming degraded and a water body may not be supporting the recreational use. EPA expects states and authorized tribes to indicate the number of years the pattern of degradation can occur and not impair the recreational use.

As a basis for issuing a **swimming advisory**, EPA recommends the magnitude not be exceeded on any single day. This is consistent with the goal of a swimming advisory to provide prompt information to people who wish to use the water body for recreation. EPA also recommends that any exceedance of the recommended magnitude result in a swimming advisory being issued until the toxin concentration falls below the recommended magnitude.

## Communicating risk to the public

In 2017, EPA released an online communications toolbox to support states, tribes, territories, and local governments in developing, as they deem appropriate, their own risk communication materials about cyanobacterial blooms. It includes editable press release templates, social media posts and other quick references.

EPA has also released infographics that states and communities can use to communicate basic information about HABs to the public. The infographics highlight how a HAB might affect both people and animals, and provide helpful information concerning how to identify and respond to a potential bloom. Two downloadable and printable versions of the infographic are available on the EPA's Cyanobacterial HABs website; one as a more detailed poster for display and another as an abbreviated handout. State, tribal and local governments may also customize the infographics by adding local information such as a logo, website address, email address and/or telephone number.

## Where can I find more information?

EPA has published the recommended AWQC/SA document, support documents and the Federal Register Notice online in the public docket (Docket ID No. EPA-HQ-OW-2016-0715), which can be accessed via the Agency's Recreational Water Quality Criteria website.

You can also contact John Ravenscroft (202) 566-1101 or Lesley D'Anglada (202) 566-1125 for more information.

# ATTACHMENT F

## USGS Central Midwest Water Science Center Harmful Algal Bloom Team Fact Sheet

*(F-1 to F-4)*

# Central Midwest Water Science Center—Harmful Algal Blooms Team

The U.S. Geological Survey (USGS) Central Midwest Water Science Center (CMWSC) includes three States—Illinois, Iowa, and Missouri. USGS water science centers across the Nation provide information on water resources including streamflow, water use, water availability, and the quality of surface water and groundwater (https://www.usgs.gov/mission-areas/water-resources).

The USGS CMWSC Harmful Algal Blooms (HABs) team is dedicated to studying the complexity of HABs and is currently (2021) researching ways to better predict the timing, magnitude, and toxicity of HABs. Updated information about the HABs team including current projects, data releases, and publications are available on the CMWSC website (https://www.usgs.gov/centers/cm-water/science-topics/harmful-algal-blooms).

## What are HABs?

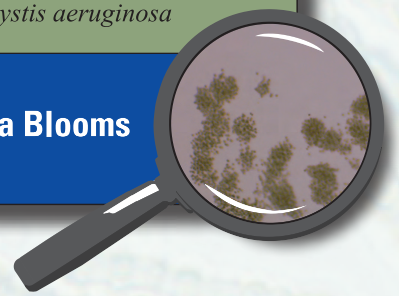
Algal blooms are defined as a rapid increase of algae populations. Algae are aquatic organisms that contain chlorophyll, most needing sunlight to grow, and have no true leaves or flowers. There are many different types of algae including green algae, red algae, diatoms, and cyanobacteria (also known as blue-green algae), which are bacteria but function like algae, and others. Algae range in size from single-celled microscopic organisms to large multicellular organisms, such as seaweed or giant kelp. Most algal blooms are composed of cyanobacteria or green algae. Algal blooms become harmful when the blooms add substantial amounts of organic matter to fresh and saltwater. After algae die, decomposers use an oxygen consuming process that can reduce dissolved oxygen concentrations below critical thresholds for living organisms and cause fish kills. Algal blooms can alter natural aquatic biodiversity and reduce recreational opportunities including swimming, boating, and fishing. Also, some cyanobacteria can produce toxins that are directly harmful to humans, pets, and wildlife, and produce taste and odor compounds that make drinking water and fish flesh smell and taste bad.

## What Causes HABs?

The conditions that trigger HABs production are complex and often site specific. Blooms are typically considered to result from excessive nutrients and warm waters, which provide ideal conditions for algal growth. However, lakes with low nutrient concentrations also experience algal blooms but much less is understood about what triggers HABs during these conditions.

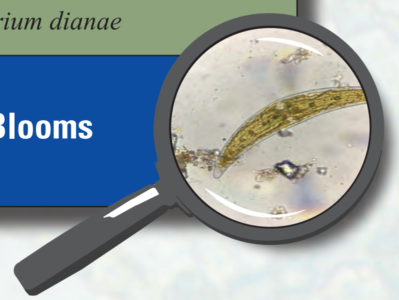
- Comprised of cyanobacteria, a group of bacteria that photosynthesize
- Prokaryotes: small simple cells containing no nucleus or organelles
- Capable of nitrogen fixation
- Can produce cyanotoxins
- Pictured: *Microsystis aeruginosa*

### Cyanobacteria Blooms



- Comprised of green algae, a group of unicellular or multicellular aquatic organisms that photosynthesize
- Eukaryotes: unicellular or multicellular organisms that contain a nucleus and organelles
- Are not known to produce toxins
- Pictured: *Closterium dianae*

### Green Algal Blooms



## Are Algae Always Harmful?

Algae are not always harmful. They have a vital role in ecosystem function—as primary producers, algae are the base of the food web and, therefore, are an important food source to many aquatic organisms, including fish. Primary producers acquire energy from sunlight (photosynthesis) or from nonliving organic sources (chemosynthesis). These processes maintain ecosystem functions, and algae also produce oxygen that is used by many respiring organisms. When algae are in appropriate concentrations, they can support a natural biodiversity and healthy ecosystem.

# Common Effects from HABs

The effects of HABs are extensive and expand across multiple disciplines including recreational management, economics, public health, and ecology. Resulting effects can include increased costs for treatment and management, reductions in public health and recreational uses, and unquantifiable ecological losses.

## Recreational Management

Many aspects of recreation involve water, including swimming, kayaking, fishing, boating, and more. However, when HABs occur, water recreation is more difficult, unpleasant, and discouraged by the U.S. Environmental Protection Agency (2021a) because of the potential toxicity to humans and pets. A recent study indicated a 10–13 percent decline in recreational fishing license sales on Lake Erie between 2011 and 2014 during a period coinciding with algal blooms (Wolf and others, 2017). Many river and lake towns rely on seasonal recreational tourism that can be affected by HABs.

## Economics

Hoagland and others (2002) analyzed a survey of experts from individual coastal States, reviewed the literature, and used their own calculations to estimate costs associated with HABs. In the United States, an estimated $20 million is spent annually on public health effects from HABs based on shellfish and ciguatera fish poisoning in humans. The effects of HABs cost commercial fisheries an average of $18 million annually, and for recreation and tourism, a total annual effect of $7 million was estimated. Hoagland and others (2002) estimated that $2 million annually goes towards monitoring and management of HABs. With the occurrence of blooms increasing, these estimates are expected to increase (Anderson and others, 2000). Estimates since this study have yet to be made because of the complexity of estimating highly variable data. Although taste and odor compounds produced by cyanobacteria have no known health effects, they can affect water supplies resulting in unpalatable drinking water. Public water suppliers spend additional funds to remove these compounds from drinking water.

## Public Health

Cyanobacterial HABs can produce cyanotoxins that are directly toxic to humans, pets, and wildlife. Exposure to cyanotoxins can occur from drinking water, recreational waters, and fish from areas of contamination. These toxins have various effects to human health including skin rashes, fever-like symptoms, respiratory, and gastrointestinal problems (Merel and others, 2013). Some cyanobacteria are capable of producing multiple toxins.

## Ecology

Toxins can buildup in an organism over time, which is a process known as bioaccumulation. Bioaccumulation can affect organisms throughout the food chain. Additionally, HABs can alter the community structure lowering species richness and biodiversity. As HABs complete their life cycle, respiring microbes break down the algae in a process known as decomposition, which consumes oxygen. Lowering dissolved-oxygen concentrations can result in concentrations below critical thresholds for most living organisms, often resulting in fish kills.

Photograph of a visible algal bloom in the Illinois River at Henry, Illinois. Photograph by Jessica Garrett, U.S. Geological Survey.

| Common Cyanotoxins | Microcystins | Cylindrospermopsin | Anatoxins | Saxitoxins |
| --- | --- | --- | --- | --- |
| | • Can affect liver (hepatotoxin), kidney, and reproductive systems<br>• Produced by *Microcystis* | • Can affect kidney (hepatotoxin) and liver<br>• Produced by *Raphidiopis, Aphanizomenon,* and other genera | • Capable of affecting the central nervous system (neurotoxin)<br>• Produced by *Chrysosporum, Cuspidothrix, Raphidiopsis* and other genera | • Commonly referred to as Paralytic Shellfish Poisoning toxins<br>• Produced by *Aphanizomenon, Dolichospermum,* and other genera |

## CMWSC HABs Team Efforts to Better Understand HABs

As of 2020 the CMWSC is working on multiple projects that involve HABs. Scientists within the CMWSC are interested in data collection and analysis to predict the timing, magnitude, and toxicity of HABs.

### Next Generation Water Observing System

USGS scientists and collaborators are monitoring algal blooms on the Illinois River. The Illinois River Basin was a selected as the third Next Generation Water Observing basin with appropriated funding directed towards monitoring, sampling, and studying the complexities of algal blooms with new technologies and methodologies. The basin is susceptible to algal blooms, which are becoming increasingly common, because of multiple urban and agricultural effects on water quality. Scientists are interested in understanding the environmental factors that affect the timing, magnitude, and toxicity of HABs. Large sampling efforts, real-time data with continuous sensors, and satellite imagery are used to improve the overall understanding of HABs and associated toxin production on the Illinois River. Large sampling efforts, real-time data with continuous sensors, and satellite imagery are used to improve the overall understanding of HABs and associated toxin production on the Illinois River.

### Upper Illinois River Hydrodynamic and Temperature Modeling

USGS scientists, in cooperation with the Illinois Environmental Protection Agency, are developing a model of an area of the upper Illinois River that is known to experience HABs (Gregg Good, Illinois EPA, written commun., 2020). Real-time water-quality monitors, streamgages, and meteorological measurements including wind speed, air temperature, and solar radiation can provide data for the model. This model can be used to better understand how hydrodynamics and meteorologic conditions contribute to the development of HABs in the Illinois River.

### Water-Quality Monitoring Plan at Mozingo Lake in Maryville, Missouri

USGS scientists, in cooperation with the Missouri Department of Natural Resources, are working to develop a water-quality monitoring plan for Mozingo Lake, a reservoir that serves as a large recreational area and provides drinking water to the city of Maryville. The lake has been susceptible to HABs, causing taste and odor issues in the drinking water and a loss of recreational opportunities. A streamgage that includes continuous water-quality data is planned to be installed at the primary inflow to the reservoir, Mozingo Creek. The streamgage data, in addition to nutrient and suspended-sediment samples within the watershed, can provide information on the timing and magnitude of nutrients and other environmental factors that are contributing to the blooms. These data can be used to support best management practices that may potentially reduce the frequency of HABs while quantifying the nutrient and sediment concentrations entering the reservoir.

Hydrologists sampling harmful algal blooms in Henry, Illinois. Photographs by the U.S. Geological Survey.

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U.S. Geological Survey scientist checking a streamgage at Starved Rock Lock and Dam, Ottawa, Illinois. Photograph by the U.S. Geological Survey.

The bullnose on the Starved Rock Lock and Dam that will house water quality and harmful algal bloom monitoring equipment as part of the Next Generation Water Observing Project. Photograph by the U.S. Geological Survey.


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