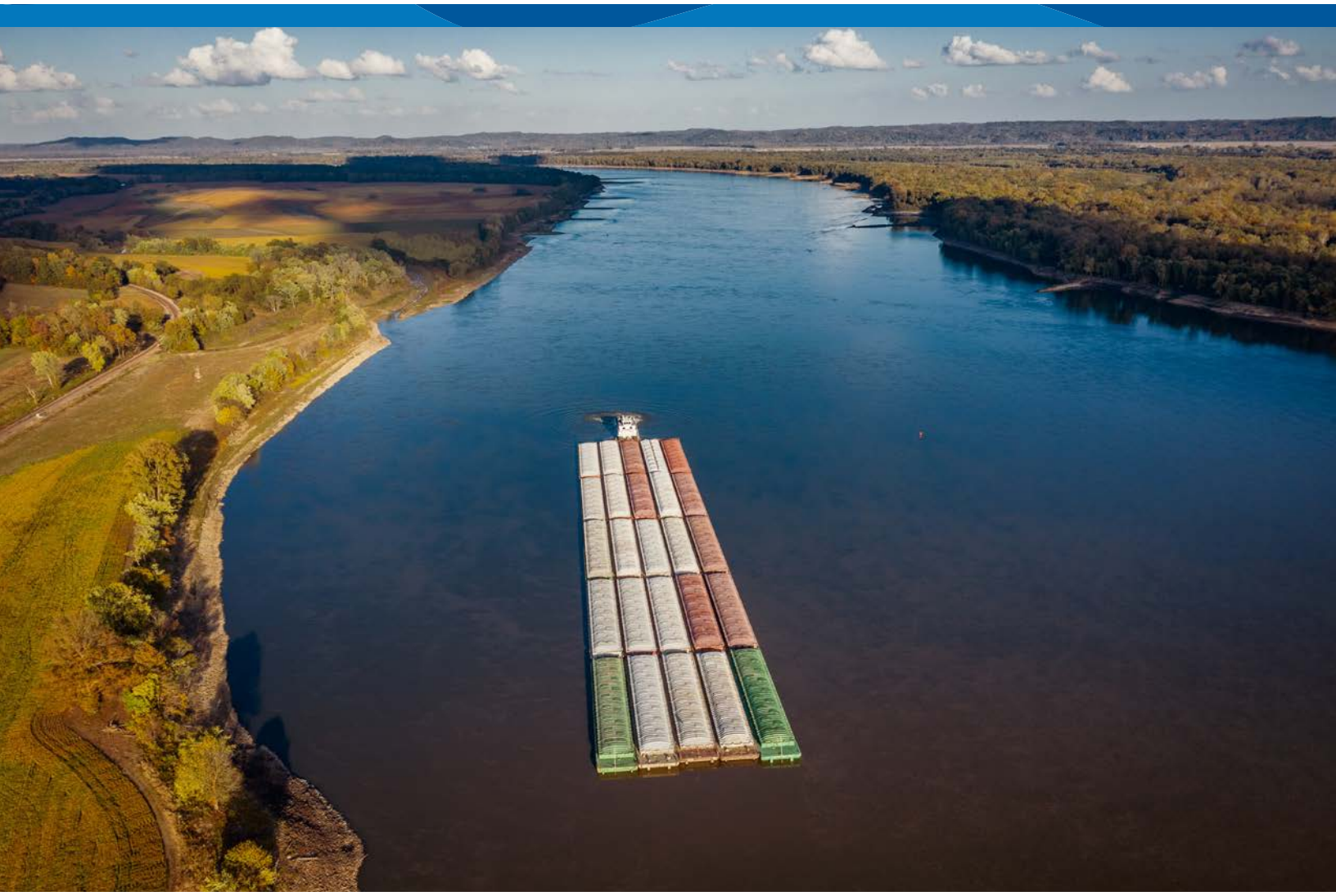

Upper Mississippi River Interstate Water Quality Monitoring

REACHES 8 & 9 PILOT CONDITION ASSESSMENT

June 30, 2022

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Introduction

This report summarizes the second pilot project conducted by the Upper Mississippi River Basin Association (UMRBA) to test the biological and water quality sampling methodologies and the assessment protocols developed as part of planning for the implementation of a comprehensive Upper Mississippi River Interstate Water Quality Monitoring Strategy (formerly known as the Clean Water Act Monitoring Strategy) (UMRBA 2014). The sampling methodologies and assessment protocols were developed over several years by the UMRBA's Water Quality Task Force (WQTF) and were summarized in the Provisional Assessment Methodology (UMRBA 2017). These methodologies and protocols were developed in consultation with a long-standing interstate water quality organization, the Ohio River Valley Water Sanitation Commission (ORSANCO), the Midwest Biodiversity Institute, and the U.S. Environmental Protection Agency's Office of Research and Development.

The goal of UMRBA's comprehensive monitoring strategy (UMRBA 2014) is to generate water quality and biological data for the Upper Mississippi River (UMR) that can be used to determine the relative degree—expressed as conditions of good, fair, or poor—to which the beneficial uses designated for the river are supported, including aquatic life, water-based recreation, drinking water, and fish consumption. The resulting condition assessments of beneficial uses are neither designed as, nor intended to serve as, replacements for state Clean Water Act (CWA) Section 305(b) water quality assessments or Section 303(d) impaired waters listings. Rather, the condition assessments are designed to improve the level of communication regarding the status of the chemical, physical, and biological condition of the UMR.

The first condition assessment report summarized the pilot project conducted by the states of Minnesota and Wisconsin in 2016 on a 160-mile segment of the UMR from Upper Saint Anthony Falls in Minneapolis, MN (river mile 854), downriver to the confluence with the Root River in southeastern Minnesota at river mile 693.7 across the UMR from La Crosse, WI (UMRBA 2019). This segment of the UMR includes CWA assessment Reaches 0-3 (**Figure 1**). The current report summarizes the pilot project conducted by the states of Illinois, Iowa, and Missouri in 2020 and 2021 on a 109-mile segment of the UMR from its confluence with the Iowa River in southeastern Iowa (across the UMR from New Boston, IL, river mile 434) downriver to Lock and Dam (L&D) 21 at Quincy, IL (river mile 324.9). This segment of the UMR includes CWA assessment Reaches 8 and 9 (herein known as "Reaches 8 and 9") (**Figure 2**).

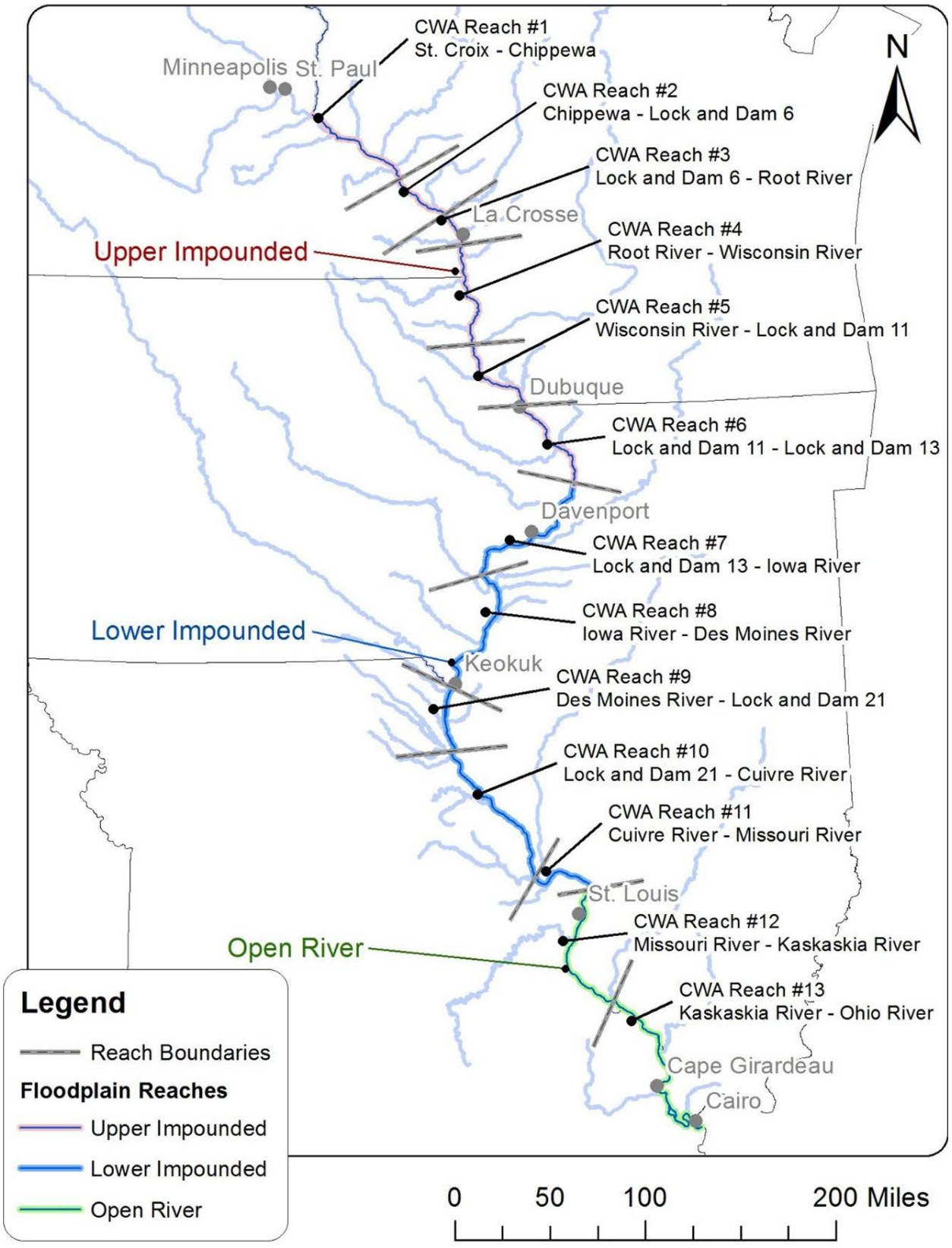

Figure 1. *UMRBA's minimum Clean Water Act assessment reaches for the Upper Mississippi River (from UMRBA 2014).*

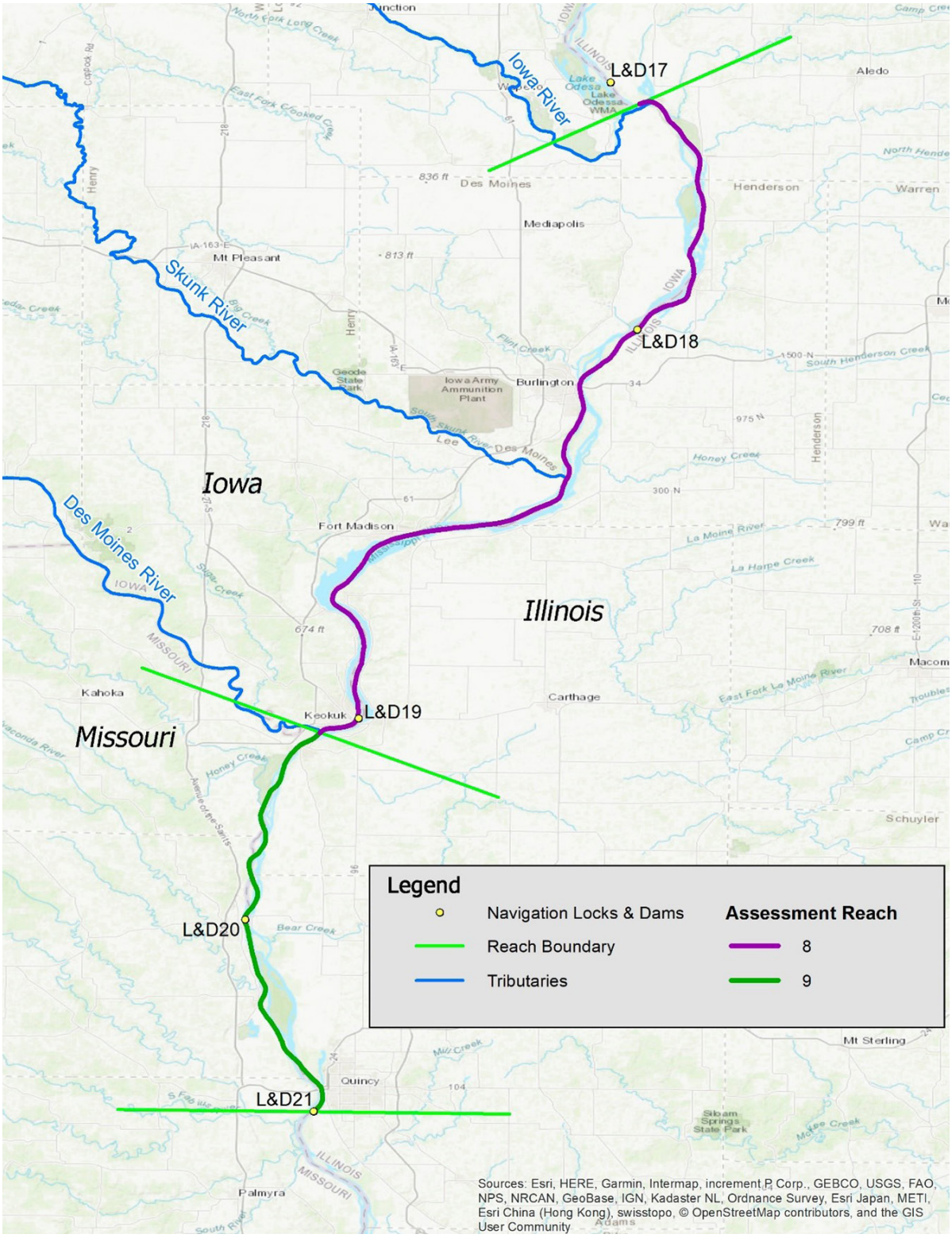

Figure 2. *Locations of assessment Reaches 8 and 9, L&D 17 through L&D 21, and major tributaries.*

Full implementation of the monitoring and assessment framework described by UMRBA (2014) recommends five years of monitoring per assessment reach to provide sufficient data for developing condition assessments. The pilot phase of this effort, however, involves monitoring for only one or two years. Thus, due to the limited amounts of water quality data generated during this shorter timeframe, the condition assessments described in this report, especially for recreation uses and drinking water uses, should be considered provisional and of relatively low confidence. Given that fish and aquatic macroinvertebrate communities are effective integrators of antecedent environmental conditions, the problem of insufficient data is less of an issue for developing condition assessments for aquatic life and fish consumption uses. Given full implementation and a five-year data collection period, overall condition assessments for the UMR's beneficial uses for the assessment reaches presented in this report would likely change, and the level of confidence in those assessment would improve. The goal of pilot phase of this project, however, is less one of developing high-confidence condition assessments than it is to identify, through field sampling and actual development of condition assessments, monitoring methods and assessment protocols that need to be modified, abandoned, or added prior to full implementation of the proposed monitoring network. Developing pilot project condition assessments based on the UMRBA's Provisional Assessment Methodology (UMRBA 2017) provides useful information on data quality and on the applicability of the condition assessment protocols.

Methods

As described in the UMRBA's Provisional Assessment Methodology, two basic types of monitoring are used to generate data for condition assessments for the Upper Mississippi River: fixed sites and probabilistic. Fixed sites are located near bridges or locks and dams and are monitored at fixed intervals (e.g., monthly or quarterly). At least one fixed site has been identified for all 14 of the UMR's minimum assessment reaches as identified in UMRBA (2017) (**Figure 1**). Results of water quality monitoring data at fixed sites include data on chemical and physical parameters, levels of indicator bacteria, algae (as measured by chlorophyll-a), and cyanobacteria toxins (cyanotoxins), as well as data on toxic contaminants. These data are used primarily to develop condition assessments for recreation and drinking water uses. See Appendix 1 for a summary of the fixed, probabilistic, and drinking water intake sites used for this Reaches 8-9 project.

An additional type of fixed site is a municipal drinking water intake. The UMR serves as a source of municipal drinking water from L&D 13 at Clinton, IA, downriver to its confluence with the Ohio River at Cairo, IL (Reaches 7-13). Results of monitoring for toxic contaminants at those intakes, combined with results of monitoring for similar toxic contaminants at fixed sites, can be used to assess the condition of the drinking water use.

The locations of the 15 probabilistic monitoring sites within an assessment reach are randomly selected. The lack of bias in site selection allows for extrapolation of results of monitoring to unmonitored portions of the assessment reach. Monitoring at probabilistic sites provides information on the river's fish and aquatic macroinvertebrate communities as well on levels of indicator bacteria, algae, and cyanotoxins that can be used to determine the condition assessment for recreation uses. Biological (fish and aquatic macroinvertebrate) monitoring at probabilistic sites provides the dataset for developing the condition assessment for aquatic life uses.

Assessment thresholds have been developed by UMRBA (2017) for all the types of data (chemical, physical, and biological) used to develop condition assessments for the UMR's beneficial uses: aquatic life, recreation, drinking water, and fish consumption. These assessment thresholds determine whether the condition class for a given beneficial use is good, fair, or poor.

Aquatic Life Use Condition Assessment

Aquatic life use refers to the ability of a surface waterbody to support viable communities of expected game fish, nongame fish, macroinvertebrates, and associated aquatic communities. The level to which aquatic life uses are supported depends on the chemical, physical, and biological characteristics of the waterbody. UMRBA's rationale of using two biological assemblages—the assemblages of fish and aquatic macroinvertebrates—to assess aquatic life use condition is that each assemblage has its own set of responses to various environmental stressors that exist in the UMR. The use of both assemblages (a dual assemblage approach) accounts for the influences of a broader range of habitat and water quality stressors and thus provides for a more robust assessment of aquatic life use condition.

The aquatic life condition use assessment methodology calls for combining the results of biological monitoring for fish and aquatic macroinvertebrates, as measured by indexes of biotic integrity (IBIs), at each of the 15 probabilistic sites allocated to an assessment reach. IBI scores are higher at least-disturbed sites and are lowest at severely disturbed sites; moderately-disturbed sites have intermediate IBI scores. These indexes are the Great River Fish Index (GRFIn) and the Wisconsin Big River (WBR) index for aquatic macroinvertebrates. The Great Rivers Fish Index (Angradi et al. 2009a, Pearson et al. 2011) was developed as part of U.S. EPA's Environmental Monitoring and Assessment Program-Great Rivers Ecosystem (EMAP-GRE) project (Angradi et al. 2009a). The GRFIn was recommended for use in the UMR Interstate Water Quality Monitoring Plan by Yoder et al. (2011). The GRFIn was based on a modeling project to identify the most, intermediate, and least-disturbed conditions on the Mississippi, Missouri, and Ohio rivers. These conditions defined a stressor gradient which was reflected in the fish assemblages present along this gradient. Several index metrics of fish assemblages were identified based on the sensitivity of the metric to the stressor gradients of these great rivers. For the Reaches 8-9 pilot project, 10 metrics that reflect the structure, composition, and function of UMR fish assemblages (Appendix 2) found in these reaches were combined into a GRFIn IBI score with a threshold IBI value of 38. Reaches 8-9 fish communities were sampled with boat electrofishing.

Similar to the development of the Great Rivers Fish Index, a macroinvertebrate index, a Great Rivers Macroinvertebrate Index (GRMIn) was developed as part of U.S. EPA's EMAP-GRE project (Angradi et al. 2009b). Similar to the GRFIn, the GRMIn was recommended for use in the UMR Interstate Water Quality Monitoring Plan (Yoder et al. 2011). Pre-pilot project evaluation of the GRMIn, however showed that it did not perform to the level necessary to be useful for monitoring and assessment. Thus, as part of the Reaches 0-3 pilot project, the Wisconsin Large River IBI (Weigel and Dimick 2009) was calibrated for use on the impounded portion of the UMR. This calibration incorporated data from the Reaches 0-3

pilot project, the Wisconsin non-wadeable Rivers IBI development project, the Minnesota Large River Survey Project, and a UMR methods comparison study. The threshold IBI value for the WBR index was set at 50. Macroinvertebrate data are collected with Hester-Dendy artificial substrate samplers that are deployed for a six-week colonization period. Ten metrics representing the structure, composition, and function of the sampled macroinvertebrate assemblage (Appendix 3) are combined into an IBI score.

Aquatic life condition at a probabilistic monitoring site is determined by comparison of IBI values for fish and macroinvertebrates to assessment thresholds (**Table 1**). According to the UMRBA Provisional Assessment Methodology (UMRBA 2017), if index values for both fish and aquatic macroinvertebrates at a site pass their respective thresholds, the site-level aquatic life condition class is considered "good." If, however, one or both index values at a sample site fails to meet the threshold, the site-level condition class is considered "poor." If one of the two index values is unavailable due to problems sampling logistics, a site level assessment is not developed for that sampling site.

The aquatic life condition class of the entire assessment reach (i.e., reach-level condition class) is determined by the percentage of probabilistic sites that have IBI scores for both fish and aquatic macroinvertebrates that pass their respective thresholds. If 75% or more of the probabilistic sites within an assessment reach have index values for both the fish and macroinvertebrate pass their respective thresholds, the aquatic life condition of the assessment reach is considered "good." If both index values meet the thresholds at between 50% and 75% of the probabilistic sites, the condition class is considered "fair." If less than 50% of the probabilistic sites have both index values above the thresholds, the condition class is "poor" (**Table 2**).

Table 1. *UMRBA aquatic life use assessment thresholds for determining aquatic life condition class (from UMRBA 2017). BCG = Biological Condition Gradient Level.*

APPLICABILITY	BASIS	INDICES	BIOCRITERIA SCORE (PERCENTILE RANK, IF APPLICABLE)	BIOLOGICAL CONDITION GRADIENT LEVEL
Impounded River (Reaches 0-11)	"Peer Rivers" GRFIn at 16th percentile of UMR range	GRFIn (Fish Index)	38 (16th percentile)	4.0
	Consensus of quadrisection of UMR and "Peer Rivers data, and BCG tier 4 of UMR data	Wisconsin Large River IBI (Macroinvertebrate Index)	50	
Open River (Reaches 12-13)	"Peer Rivers" Missouri River GRFIn and GRMIn at 16th percentile of UMR range	Missouri River GRFIn (Fish Index)	38 (16th percentile)	4.0
		Missouri River GRMIn (Macroinvertebrate Index)	39 (16th percentile)	N/A

Table 2. *Summary of the UMRBA Provisional Assessment Methodology for determining site-level and reach-level aquatic life condition class (from UMRBA 2017).*

	DETERMINING UMRBA ASSEMBLAGE LEVEL CONDITION FOR AQUATIC LIFE USE		DETERMINING UMBRA SITE- LEVEL CONDITION CLASS FOR AQUATIC LIFE USE		DETERMINING UMRBA REACH-LEVEL CONDITION CLASS FOR AQUATIC LIFE USE		
Assemblage	**Impounded River Biocriterion**	**Open River Biocriterion**	**Supporting**	**Non-supporting**	**Good**	**Fair**	**Poor**
Fish	GRFIn (fish index) score of 38 or greater	Missouri River GRFIn score of 38 or greater	Both assemblages meet their respective biocriterion	One or both assemblages fail to meet their respective biocriterion	Greater than or equal to 75% of the sites within the reach are reflective of a condition in which both assemblages meet their respective biocriterion.	Greater than or equal to 50% and less than 75% of the sites within the reach are reflective of a condition in which both assemblages meet their respective biocriterion.	Less than 50% of the sites within the reach are reflective of a condition in which both assemblages meet their respective biocriterion.
Macro-invertebrate	Wisconsin Large River IBI (macro-invertebrate index) score of 50 or greater	Missouri River GRMIn score of 39 or greater					

Biological monitoring was conducted in summer 2021 at the 15 probabilistic monitoring sites in each of the two reaches (Reaches 8 and 9). Due to a loss of two Hester-Dendy macroinvertebrate samplers in both Reach 8 and Reach 9, IBIs for both fish and macroinvertebrates were only developed for 13 probabilistic monitoring locations in each reach. Results of biological monitoring at the probabilistic monitoring sites in Reaches 8 and 9 showed good biotic integrity for their respective fish communities, with all GRFIn index values at the combined 30 monitoring sites above the assessment threshold (**Figure 3**, top). The IBI values for the aquatic macroinvertebrate communities of Reaches 8 and 9, however, tended to fall at and below the assessment threshold (**Figure 3**, bottom).

The variation in fish IBIs (i.e., GRFIn scores) in lower Reach 8, especially the decline in scores immediately upriver from L&D 19 at Keokuk, Iowa (**Figure 3**, top), is possibly due to low levels of dissolved oxygen in Pool 19 (**Figure 4**). The midday readings of dissolved oxygen in the 4 to 5 mg/l range in lower Pool 19 suggest nighttime and early morning levels of dissolved oxygen that may adversely affect the fish community as well as other aquatic communities in this portion of the UMR. Interestingly, the drop (sag) in levels of dissolved oxygen observed in summer 2021 in the lower portion of Pool 19 at Keokuk shown in Figure 4 seemed to persist downriver through much of Reach 9, with recovery to levels seen above Pool 19 not occurring until L&D at Quincy, IL. Note: the missing datapoints for Reach 9 dissolved oxygen in September, as shown in **Figure 4**, were due to equipment (dissolved oxygen meter) failure.

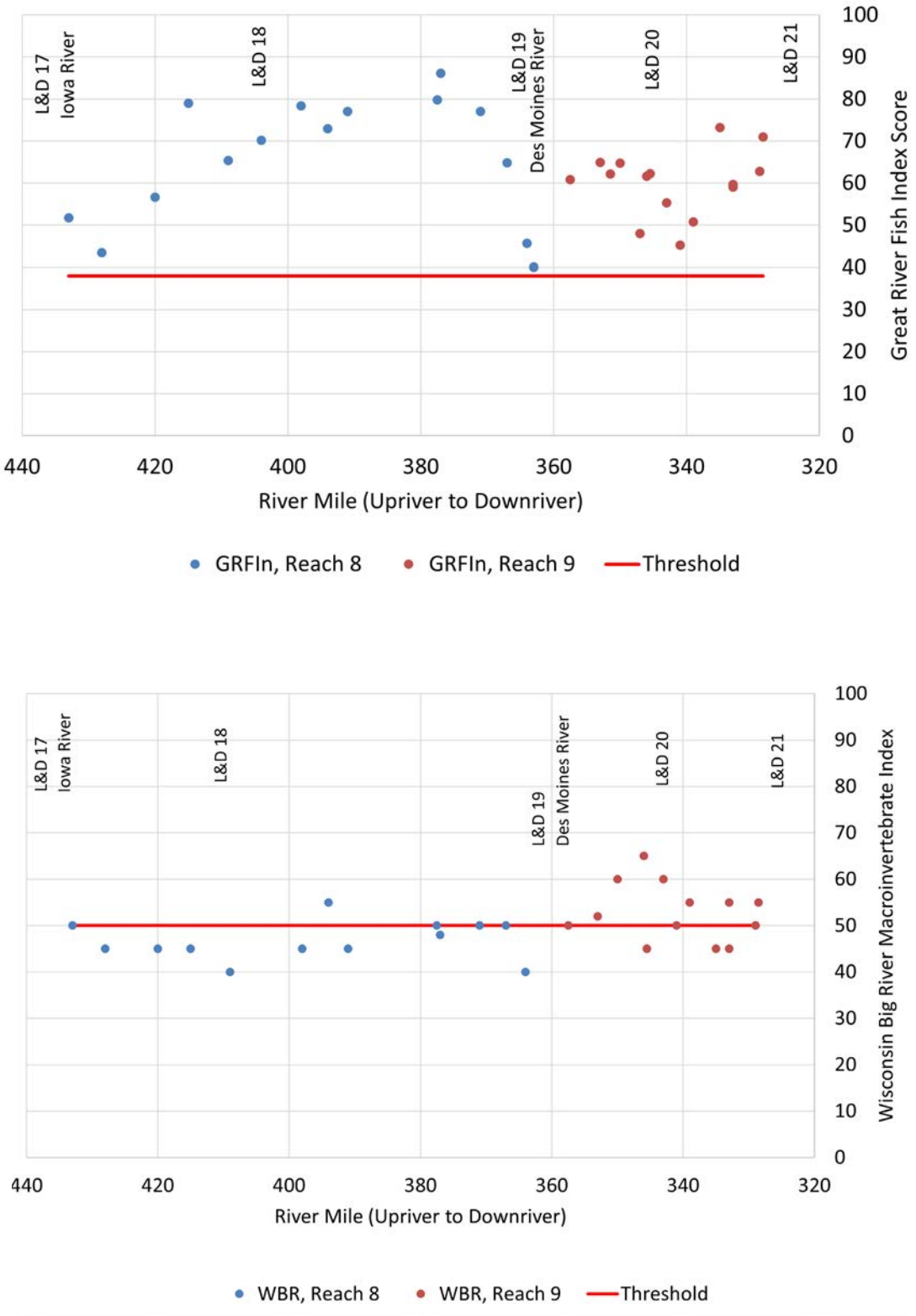

Figure 3. *Summary of 2021 fish and macroinvertebrate indexes of biotic integrity scores as measured by the Great Rivers Fish Index (GRFIn) (top figure) and the Wisconsin Big River Macroinvertebrate Index (WBRIn) (bottom figure) for the probabilistic monitoring sites in reaches 8 and 9. The GRFIn threshold is 38; the WBR threshold is 50; both thresholds are indicated by a red line.*

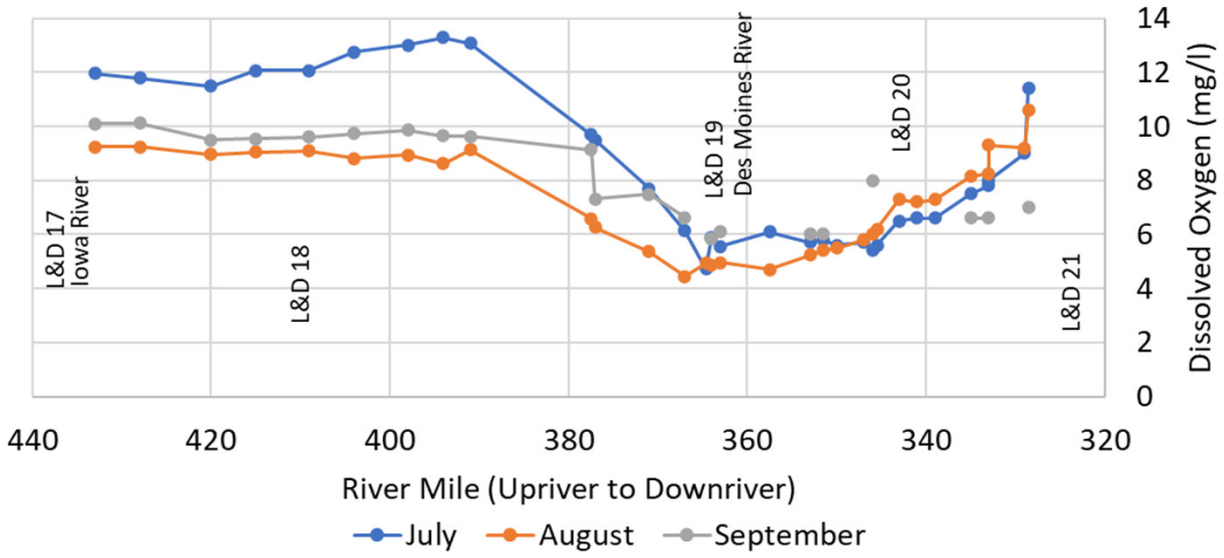

Figure 4. *Levels of dissolved oxygen at probabilistic monitoring sites in Reaches 8 and 9 from July to September 2021. Data were collected during the three rounds of biological monitoring. The decline in levels of dissolved oxygen in the lower half of Pool 19 above Keokuk may suggest potential adverse impacts on the fish community (see Figure 3).*

Based on these results, the Provisional Assessment Methodology (UMRBA 2017) suggests that the aquatic life condition class is "poor" in Reach 8. That is, the percentage of Reach 8 probabilistic sites where both fish and macroinvertebrate indexes of biotic integrity met their respective thresholds (5 of 13 sites, 38.5%) was below the threshold for the "fair" condition class (50% of sites) (**Table 3**). In Reach 9, just over 75% of the probabilistic sites (10 of 13) had index values for fish and macroinvertebrate that passed their respective thresholds of biotic integrity. Thus, the aquatic life condition for Reach 9 is assessed as "good" (**Table 4**).

Table 3. *Aquatic life condition assessment for Reach 8 (from confluence with the Iowa River downriver near New Boston, IL, to confluence with the Des Moines River at Keokuk, IA). The condition class assessment is based on biological monitoring at probabilistic sites. NA = not applicable. Data were collected between July and September 2021.*

REACH	POOL	RIVER MILE	LOCATION	SAMPLE ID	GRFIN VALUE	WI BIG RIVER INDEX	DOES SITE MEET THRESHOLDS FOR BOTH FISH AND MACRO-INVERTEBRATES?	SITE LEVEL CONDITION CLASS
8	18	433	at New Boston, IL;	182	51.75	50	Yes	Good
		428	at Keithsburg, IL;	186	43.4	45	No	Poor
		420	Huron, IA	190	56.65	45	No	Poor
		415	at Oquawka, IA,	194	78.95	45	No	Poor
	19	409	1 mile downriver from L &D 18	193	65.32	40	No	Poor
		404	at Burlington, IA	184	70.13	lost sampler	N/A	N/A
		398	4 miles downriver from Burlington, IA	195	78.34	45	No	Poor
		394	2 miles downriver from Skunk R.	192	72.94	55	Yes	Good
		391	at Dallas City, IL,	188	76.99	45	No	Poor
		377.5	2.5 miles upriver from Montrose, IA	183	79.79	50	Yes	Good
		377	at Montrose, IA	187	86.1	48	No	Poor
		371	3 miles downriver from Montrose	191	77.05	50	Yes	Good
		367	1 mile upriver from Keokuk marina	181	64.83	50	Yes	Good
	20	364	at L&D 19 at Keokuk, IA	185	45.61	40	No	Poor
		363	1 mile downriver of L&D 19 at Keokuk	189	40.04	lost sampler	N/A	N/A
							Number of sites with both fish and macroinvertebrate data:	13
							Number of sites meeting both fish and macroinvertebrate thresholds:	5
							Percentage meeting both fish and macroinvertebrate thresholds:	38.5%
							Reach 8 aquatic life use condition assessment:	POOR

Table 4. *Aquatic life condition assessment for Reach 9 (from confluence with the Des Moines River downriver at Keokuk, IA, to L&D 21 at Quincy, IL). The condition class assessment is based on biological monitoring at probabilistic sites. NA = not applicable. Data were collected between July and September 2021.*

REACH	POOL	RIVER MILE	LOCATION	SAMPLE ID	GRFIN VALUE	WI BIG RIVER INDEX	DOES SITE MEET THRESHOLDS FOR BOTH FISH AND MACRO-INVERTEBRATES?	SITE LEVEL CONDITION CLASS
9	20	357.5	1 mile downriver Warsaw, IL	34	60.82	50	Yes	Good
		353	0.2 miles downriver L&D 20 at Canton, MO	45	64.9	52	Yes	Good
		351.5	8.5 miles upriver from Canton, MO	42	62.1	lost sampler	N/A	N/A
		350	7 miles upriver from Canton, MO	38	64.71	60	Yes	Good
		347	4 miles upriver from Canton, MO	37	47.99	lost sampler	N/A	N/A
		346	3 miles upriver from Canton, MO	33	61.61	65	Yes	Good
		345.5	2.5 miles upriver from Canton, MO	41	62.22	45	No	Poor
	21	343	3 miles downriver Canton, MO	44	55.31	60	Yes	Good
		341	1 mile downriver from Canton, MO	40	45.21	50	Yes	Good
		339	8.5 miles upriver from Canton, MO	43	50.7	55	Yes	Good
		335	1 mile downriver LaGrange, MO	32	73.18	45	No	Poor
		333	3 miles downriver La Grange, MO	31	59.65	55	Yes	Good
		333	3 miles downriver La Grange, MO	35	59.05	45	No	Poor
		329	2 miles upriver from Quincy, IL	39	62.78	50	Yes	Good
		328.5	at Quincy, IL;	36	71	55	Yes	Good
							Number of sites with both fish and macroinvertebrate data:	13
							Number of sites meeting both fish and macroinvertebrate thresholds:	10
							Percentage meeting both fish and macroinvertebrate thresholds:	76.9%
							Reach 8 aquatic life use condition assessment:	GOOD

Recreation Use Condition Assessment

The condition assessment for water-based recreation (i.e., primary contact or swimming-type recreation uses) in the UMR is based on results of monitoring for three indictors of water quality: indictor bacteria (E. coli), chlorophyll-a, and cyanotoxins (**Table 5**). Although not typically pathogenic, the strains of E. coli measured in rivers and lakes indicate the relative health risk of contracting waterborne diseases, such as Salmonella, from primary contact recreational use of lakes or rivers. Levels of E. coli were measured during the April to October 2021 recreation season at fixed and probabilistic monitoring sites in Reaches 8 and 9. To determine the condition class for recreation uses in these reaches, levels of E. coli were compared to two types of thresholds for indicator bacteria: an average (geometric mean) threshold and the frequency (percentage) of samples with excessively high levels of bacteria.

High levels of chlorophyll in lakes and rivers indicate nutrient enrichment of surface waters, and the resulting green color of the water can be perceived as an aesthetically-objectionable nuisance condition that discourages water-based recreation uses such as swimming or water skiing. Levels of chlorophyll were measured during the June to September 2021 portion of the recreation season at both fixed and probabilistic monitoring sites in Reaches 8 and 9. The levels of chlorophyll measured in the river were compared to assessment thresholds designed to indicate algae-related nuisance conditions that suggest limitations to the full use of the UMR for water-based recreation (**Table 5**). The assessment thresholds for chlorophyll-a are based on recommendations from the Minnesota Pollution Control Agency (Minnesota PCA 2013, Heiskary and Wilson 2005). These recommendations identify levels of chlorophyll-a at which people (recreational users) perceive a "nuisance condition" or a "very serious nuisance condition."

The third indicator used to determine the recreation condition class of the UMR for water-based recreation uses is the level of cyanotoxins present in the water during the June to September 2021 portion of the recreation season. These toxins are produced by cyanobacteria typically during bloom conditions. Blooms often occur in mid to late summer when weather conditions are warm, dry, and calm. Blooms can occur in both lakes and rivers. In rivers, low discharge conditions, lowered water velocities, and higher residence times are all conducive to growth of cyanobacteria.[1] Exposure of humans to high levels of these toxins during water-based recreation has been implicated in several types of human health problems, including gastrointestinal illness, neurological conditions, impacts to the liver, and skin rashes. Additionally, high cyanotoxin levels can be harmful and sometimes fatal to pets such as dogs that either directly ingest water or that ingest the toxins through licking of their fur. Levels of cyanotoxins were measured at both fixed and probabilistic monitoring sites from June through September 2021. As part of determining the recreation condition class for Reaches 8 and 9, the results of this monitoring were compared to thresholds for recreational use of rivers and lakes recommended by the U.S. Environmental Protection Agency for two of the most common cyanotoxins, microcystin and cylindrospermopsin.

1 Upper Mississippi River (UMR) pools 18 and 19, which comprise most of Reach 8, have relatively long times-of travel compared to other pools on the UMR (personal communication, U.S. Army Corps of Engineers, Rock Island District, May 26, 2022).

Table 5. *Summary of the UMRBA Provisional Assessment Methodology for combining results of monitoring for indicator bacteria (E. coli), chlorophyll-a, and cyanotoxins into a reach level condition class for water-based recreation uses (from UMRBA 2017). STV = Statistical Threshold Value.*

	DETERMINING UMRBA REACH-LEVEL CONDITION CLASS FOR RECREATION USE		
DATA SOURCE:	**GOOD**	**FAIR**	**POOR**
Fixed Site Monitoring during recreation season with monthly sampling over 5 years	**Overall geometric mean < 126 cfu/100 ml & < 10% of samples exceed STV (410 cfu/100 ml) for E. coli and the overall average chlorophyll-a level is less than 35 ug/l and < 2 excursions annually of Microcystin or Cylindrospermopsin toxins.**	**Overall geometric mean < 126 cfu/100 ml but significantly > 10% of samples exceed STV (410 cfu/100 ml) for E. coli or the overall average chlorophyll-a level is between 35 and 60 ug/l or > 1 and < 4 (2 or 3) excursions annually of Microcystin or Cylindrospermopsin toxins.**	**Overall geometric mean > 126 cfu/100 ml for E. coli or the overall average chlorophyll-a level is 60 ug/ or greater or > 3 excursions annually of Microcystin or Cylindrospermopsin toxins.**
Probabilistic Site Monitoring during recreation season at 15 sites sampled 3 times in 1 of 5 years	**On average over the three rounds of sampling/year, the percentage of probabilistic samples exceeding the STV (410/100 ml) is not significantly > 10% and the overall average of chlorophyll-a for all three rounds of probabilistic samples is less than 35 ug/l and < 2 excursions annually of Microcystin or Cylindrospermopsin toxins.**	**On average over the three rounds of sampling in 1 of 5 years, significantly greater than 10% exceed the STV of 410 cfu/100 ml, or the overall average level of chlorophyll-a of the probabilistic samples is 35 ug/l or greater for any of the three rounds of sampling or > 1 and < 4 (2 or 3) excursions annually of Microcystin or Cylindrospermopsin toxins.**	**Category not used with results of probabilistic monitoring.**
Overall Condition Class	**Fixed site geometric mean < 126 cfu/100 ml & < 10% of samples exceed STV (410 cfu/100 ml), and average percentage of probabilistic samples exceeding the STV is not significantly > 10%, and the overall average level of chlorophyll-a is less than 35 ug/l and < 2 excursions annually of Microcystin or Cylindrospermopsin toxins.**	**Fixed site geometric mean < 126 cfu/100 ml but significantly > 10% of samples exceed STV (410 cfu/100 ml) or average percentage of probabilistic samples exceeding the STV is significantly > 10% or the overall average chlorophyll-a level is between 35 and 60 ug/l or > 1 and < 4 (2 or 3) excursions annually of Microcystin or Cylindrospermopsin toxins.**	**Fixed site geometric mean > 126 cfu/100 or the overall average chlorophyll-a level is 60 ug/l or greater or > 3 excursions annually of Microcystin or Cylindrospermopsin toxins.**

Indicator bacteria (*E. coli*): Levels of *E. coli* in Reach 8 were low in the 2021 recreation season (April to October) and were below the geometric mean threshold of 126 colony forming units (cfu)/100 ml; less than 10% of the samples had levels of E. coli that exceeded the STV threshold of 410 cfu/100 m (**Figure 5**). These results suggest a condition assessment for recreation uses in Reach 8 of "good."

In Reach 9, however, levels of E. coli were higher (**Figures 6 and 7**), and the geometric mean for E. coli at the fixed site at Quincy, IL, exceeded the threshold of 126 cfu/100 ml. In addition, more than 10% of the samples (1 of 4) had a level of E. coli that exceeded the STV threshold of 410 cfu/100 ml (**Figure 5**). These results indicate a "poor" condition class for recreation uses in Reach 9. This condition class of "poor," however, is likely due to a lack of sufficient data for developing the condition assessment. That is, relatively few data points for E. coli were available from the fixed monitoring sites in Reaches 8 and 9 (from 4 to 6 samples).[2]

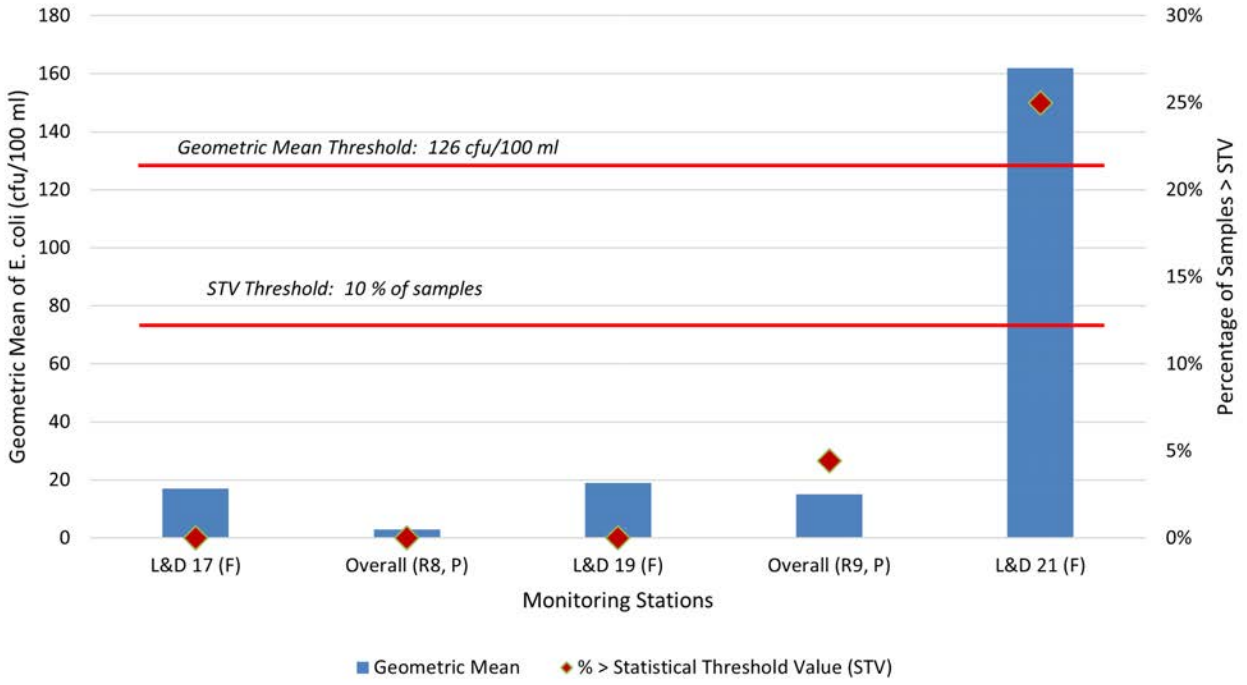

Figure 5. *Comparisons of levels of indicator bacteria (E. coli) monitored in Reaches 8 (R8) and 9 (R9) at fixed (F) and probabilistic (P) sites during the recreation season (April-October) of 2021 to assessment thresholds for geometric means (126 cfu/100 ml) and for the percentage of samples that exceed a maximum level of E. coli (statistical threshold value or STV) of 410 cfu/100 ml.*

2 The quantity of data collected for the Reaches 8-9 pilot was in accordance with the UMR Interstate WQ Monitoring Plan. The UMRBA WQTF should consider the quantity of samples needed to confidently report WQ results.

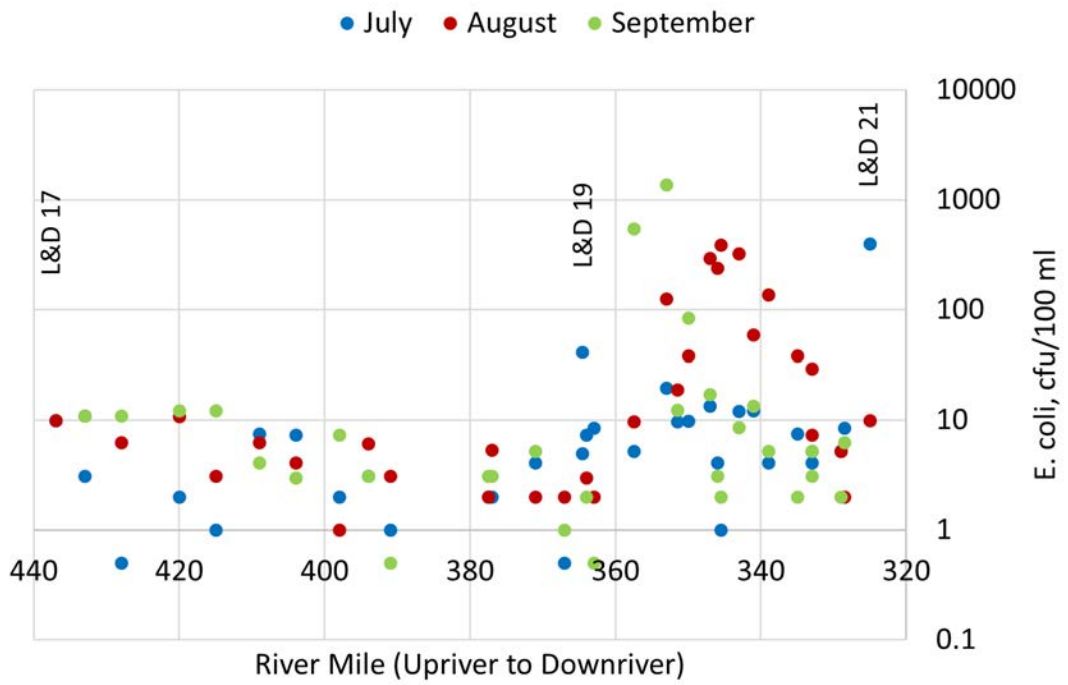

Figure 6. *Sample values for E. coli in summer 2021 for Reaches 8 and 9. The boundary between Reach 8 and Reach 9 is at L&D 19 (Keokuk, IA).*

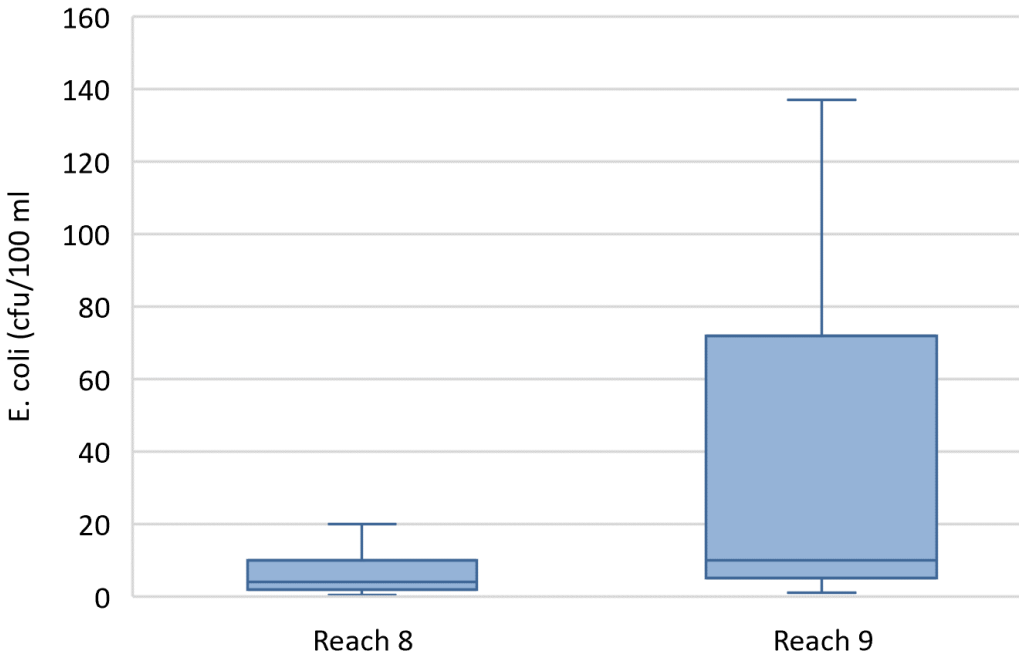

Figure 7. *Box and whisker plot for sample values of E. coli in summer 2021 for Reaches 8 and 9. The plot shows the median (horizonal line within the box), the 25th and 75th percentile values for levels of E. coli at the upper and lower sides of the box, and the maximum and minimum values (whiskers).*

Chlorophyll: Levels of algae suspended in the water column, as measured by chlorophyll-a, were generally high during the recreation season of 2021, with levels in Reach 8 higher than in Reach 9 (**Figures 8** and **9**). According to the UMRBA Provisional Assessment Methodology, the condition class for recreation uses based on levels of chlorophyll depends on the overall average level of chlorophyll from both the fixed sites and from the three rounds (July August and September) of water quality monitoring at the 15 probabilistic sites per reach (**Table 5**). The overall average levels of chlorophyll in both Reaches 8 and 9 exceeded the threshold of 60 ug/l (**Figures 10** and **11**), thus indicating a "serious nuisance condition" and a poor condition class for recreation uses. These high levels of chlorophyll are likely related to relatively warm and dry summer season in 2021 in the upper Midwest that reduced discharges in the UMR, thus reducing turbidity related to inorganic solids suspended in the water column and facilitating growth of algae (see Appendix 4for additional nutrient and suspended solids information). **Figure 12** shows discharge levels at the USGS gage station on the UMR at Clinton, IA (about 80 river miles upriver from Reach 8).[3] Discharge levels at this gaging station were well below long-term daily median discharge during much of June and July 2021, thus suggesting similarly low discharge levels in Reaches 8 and 9. These early summer low discharge levels may have facilitated blooms of algae during mid-summer and late summer that resulted in elevated levels of chlorophyll at the Reach 8 and Reach 9 monitoring sites.

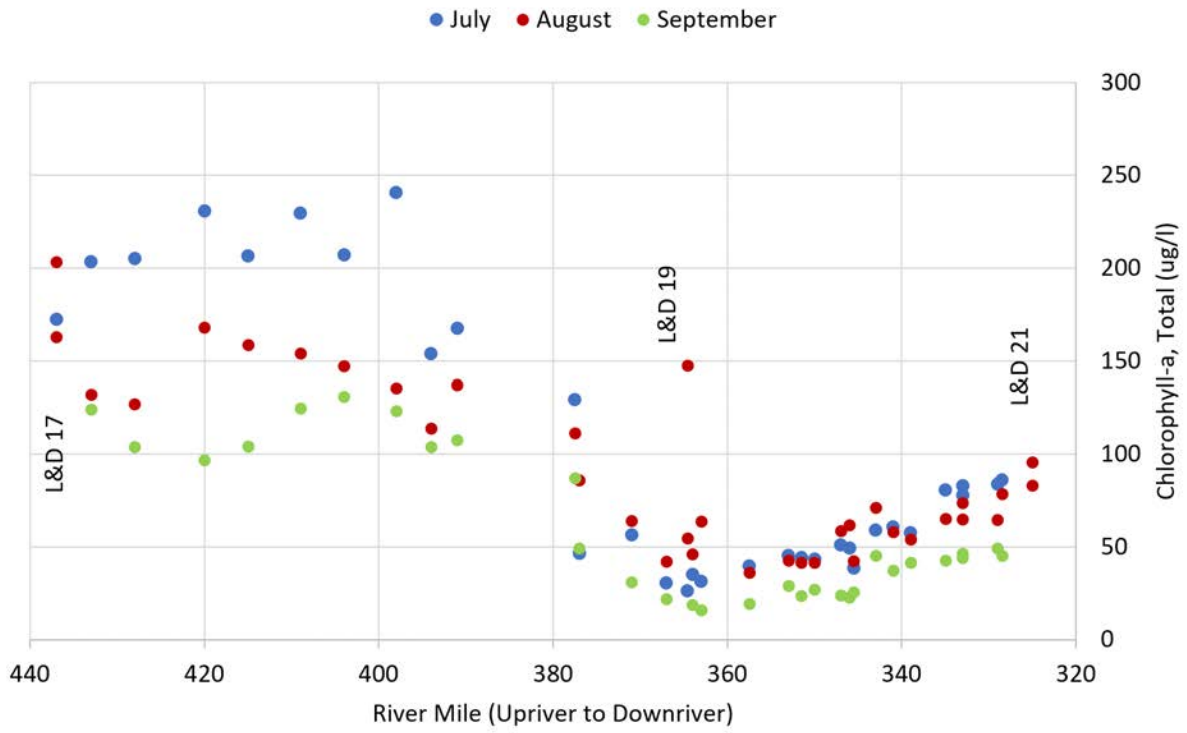

Figure 8. *Sample values for chlorophyll-a in summer 2021 for Reaches 8 and 9. The boundary between Reach 8 and Reach 9 is at L&D 19 (Keokuk, IA).*

3 The USGS gaging station at Clinton, Iowa, is the closest station to Reaches 8 and 9 that has long-term daily median discharge values.

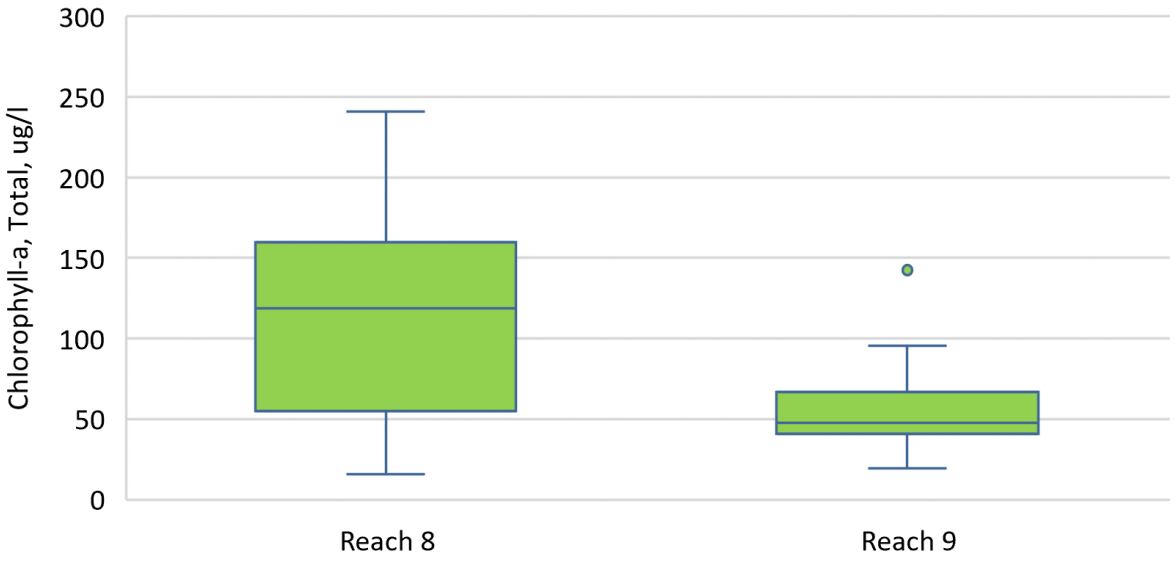

Figure 9. *Box and whisker plot for sample values of chlorophyll-a in summer 2021 for Reaches 8 and 9. The plot shows the median (horizonal line within the box), the 25th and 75th percentile values for levels of chlorophyll at the upper and lower sides of the box, and the maximum and minimum values (whiskers).*

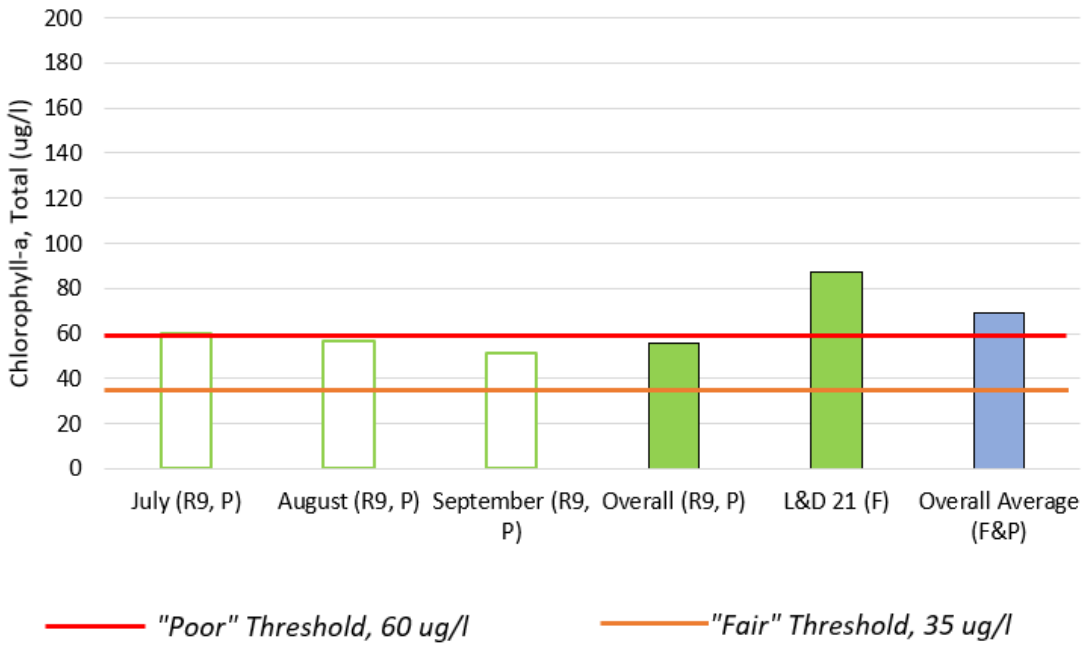

Figure 10. *Summary of average levels of chlorophyll-a at probabilistic (P) monitoring sites and fixed (F) sites in Reach 8 (R8) in summer 2021. Open bars are the probabilistic site averages for the three rounds of monitoring. The overall probabilistic site average (also called reach-level average) was combined with the fixed site averages to determine the reach-level assessment. Average levels of chlorophyll-a between 35 ug/l and 60 ug/l indicate a "serious nuisance," and average levels above 60 ug/l indicate a "very serious nuisance."*

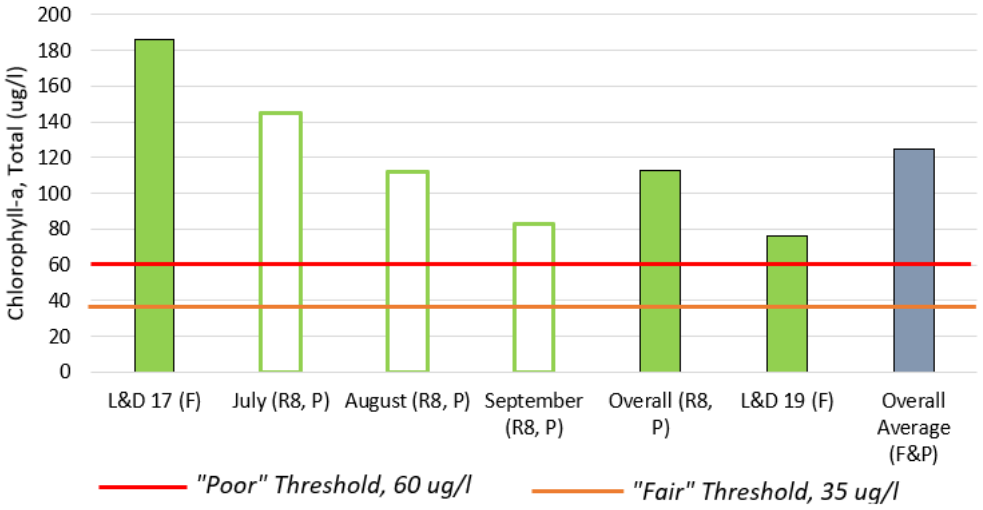

Figure 11. *Summary of average levels of chlorophyll-a at probabilistic (P) monitoring sites and fixed (F) sites in Reach 9 (R9) in summer 2021. Open bars are the probabilistic site averages for the three rounds of monitoring. The overall probabilistic site average (also called reach-level average) was combined with the fixed site average to determine the reach-level assessment. Average levels of chlorophyll-a between 35 ug/l and 60 ug/l indicate a "serious nuisance," and average levels above 60 ug/l indicate a "very serious nuisance."*

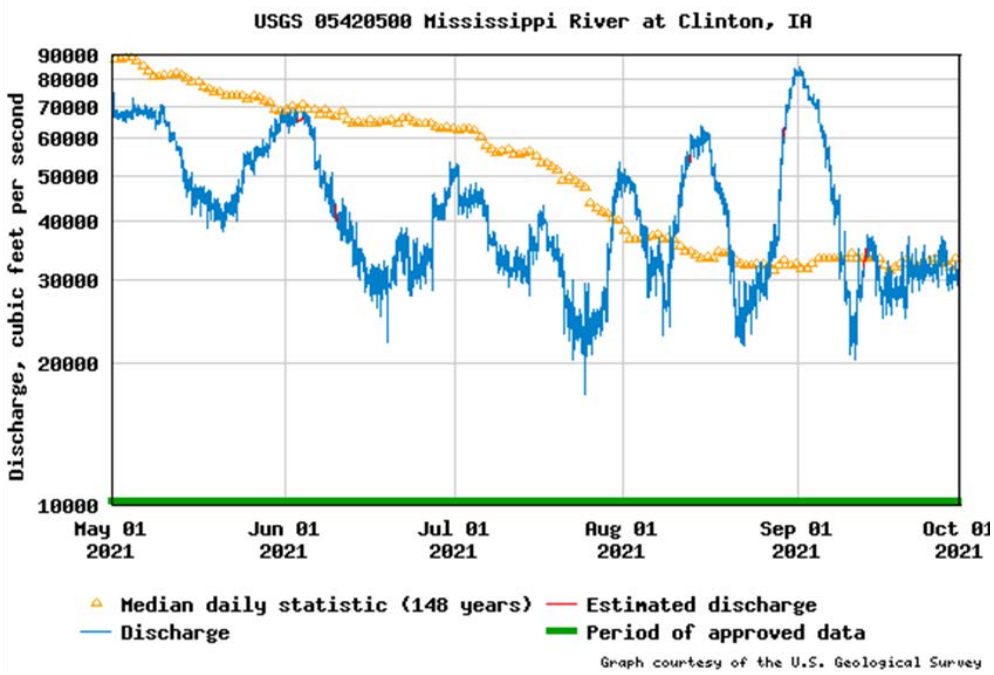

Figure 12. *Discharge levels in the Upper Mississippi River for May through September 2021 at the U.S. Geological Survey's gaging station at Clinton, IA (https://waterdata.usgs.gov/nwis/uv?05420500).*

Cyanotoxins: Condition class assessments for water-based recreation uses based on levels of the cyanotoxins microcystin and cylindrospermopsin depend on the number of excursions above U.S. EPA-recommended recreation thresholds of 8 ug/l for microcystin and 15 ug/l for cylindrospermopsin (U.S. EPA 2019). Based on comparisons to these thresholds, levels of cyanotoxins in Reaches 8 and 9 were low in summer 2021. All levels of cylindrospermopsin were reported at the analytical detection level of 0.04 ug/l and were thus below U.S. EPA's recommended human health criterion of 15 ug/l. While detectable levels of microcystin were found at all fixed and probabilistic monitoring sites in both Reaches 8 and 9, maximum levels were below the U.S. EPA recommended human health criterion of 8 ug/ (**Figure 13**).

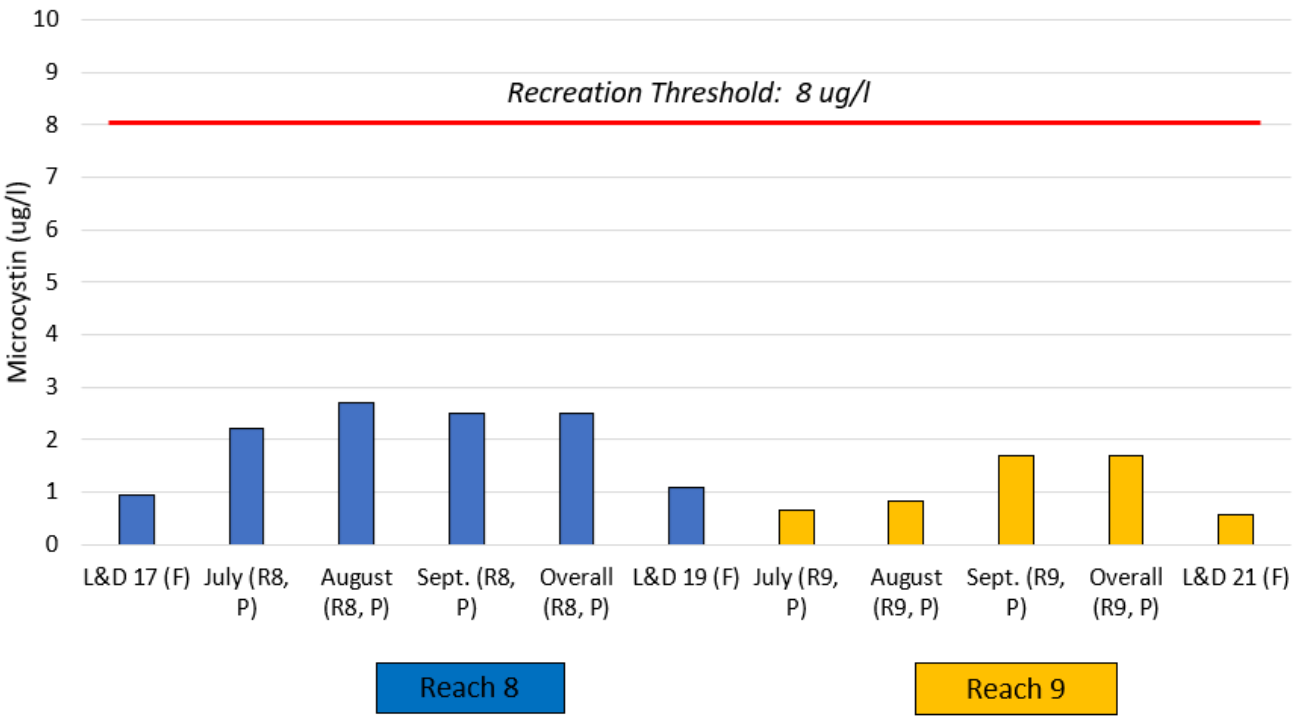

Figure 13. *Maximum levels of the cyanotoxin microcystin at fixed (F) and probabilistic (P) monitoring sites in Reaches 8 (R8) and 9 (R9) during the recreation season (June to September) of 2021.*

In order to arrive at the reach-level recreation condition classes for reaches 8 and 9, the site-level condition assessments for all three indictors (E. coli, chlorophyll-a, and cyanotoxins) were reviewed to identify the lowest site level condition class. According to UMRBA's Provisional Assessment Methodology, the reach-level condition assessment is based on the lowest site-level condition class suggested by any of the three indicators (**Table 5**). For Reach 8 in 2021, high levels of chlorophyll at the fixed monitoring sites at New Boston, IL, and at Keokuk, IA, exceeded the chlorophyll-a assessment threshold (60 ug/l) that indicates a "very serious nuisance" due to algae suspended in the water column. These results indicate a "poor" recreation condition class (**Table 6**). For Reach 9, average levels of chlorophyll-a also exceeded 60 ug/l, thus indicating a "very serious nuisance." Also in Reach 9, levels of E. coli at the fixed monitoring site at Quincy, IL, exceeded both the geometric mean threshold and the STV threshold for the percentage of samples with high levels of

E. coli, thus indicating a "poor" recreation condition class (**Table 7**). The overall condition class of "poor" identified for water-based recreation uses for Reaches 8 and 9, however, should be considered low-confidence assessments due to the availability of only one year's worth of data from fixed monitoring sites for this pilot project. Due to year-to-year variability in water quality, the UMRBA Provisional Assessment Methodology for determining recreation condition classes requires data from five consecutive years of fixed site monitoring in order to develop a high-confidence assessment of condition class (UMRBA 2017).

Table 6. *Summary of condition assessment for water-based recreation uses for the Upper Mississippi River in Reach 8. STV = Statistical Threshold Value.*

PARAMETER	EXPLANATION	CONDITION CLASS
E. coli at fixed sites	Geometric means all below the threshold; no single sample values above the STV of 410 cfu/100 ml	GOOD
E. coli at probabilistic sites	No single sample values above the STV	GOOD
Chlorophyll at fixed sites	Average level at both fixed sites exceeded the "very serious nuisance" threshold of 60 ug/l	POOR
Chlorophyll at probabilistic sites	Overall average for the three rounds of sampling was > 60 ug/l	FAIR
Cyanotoxins at fixed and probabilistic sites	All levels of both cyanotoxins were below recommended recreational thresholds	GOOD
Reach-level Assessment	(Due to high levels of chlorophyll)	POOR

Table 7. *Summary of condition assessment for water-based recreation uses for the Upper Mississippi River in Reach 9. STV = Statistical Threshold Value.*

PARAMETER	EXPLANATION	CONDITION CLASS
E. coli at fixed sites	At the Quincy, IL, fixed site, the geometric mean was above the 126 cfu/100 ml threshold, and the percentage of samples with E. coli levels above the STV of 410 cfu/100 ml was > 10%	POOR
E. coli at probabilistic sites	Less than 10% of sample values were greater than the STV	GOOD
Chlorophyll at fixed sites	Average level at the fixed site exceeded the "very serious nuisance" threshold of 60 ug/l	POOR
Chlorophyll at probabilistic sites	Overall average for the three rounds of sampling was exceeded the "serious nuisance" threshold of 35 ug/l	FAIR
Cyanotoxins at fixed and probabilistic sites	All levels of both cyanotoxins were below recommended recreational thresholds	GOOD
Reach-level Assessment	(Due to high levels of E. coli and chlorophyll)	POOR

Drinking Water Use Condition Assessment

According to the UMRBA Provisional Assessment Methodology (UMRBA 2017), the condition class assessment for drinking water uses is based on three indicators of the suitability of the UMR as a source of drinking water for public water supplies:

1. Results of water quality monitoring data from fixed sites and intakes of municipal water supplies for drinking water contaminants (e.g., nitrate, pesticides, metals, and volatile organic compounds (VOCs)) with thresholds specified by the Safe Drinking Water Act (see **Appendix 5**);
2. Results of monitoring for cyanotoxins and comparison of those results to U.S. EPA's (2015) recommended drinking water guidelines (0.3 ug/l for microcystin and 0.7 ug/l for cylindrospermopsin);
3. The need for extraordinary water treatment at a municipal or industrial facility to meet the applicable Safe Drinking Water Act requirements.

This pilot project is the first to determine the condition class for drinking water uses. Municipalities and industries in the portion of the UMR upriver from L&D 13 at Clinton, IA (Reaches 0-6, **Figure 1**), do not use the river as a source of municipal drinking water. Thus, the Reaches 0-3 (Minnesota-Wisconsin) pilot (UMRBA 2019) did not include a condition assessment for drinking water uses. Downriver from L&D 13 at Clinton, IA (Reaches 7-13), however, the UMR is used as a source of municipal drinking water.

Assessing the condition class of UMR drinking water uses relies on data for levels of contaminants generated from fixed monitoring sites and on data from public water suppliers (PWS) along the river. Monitoring data for drinking water contaminants from each fixed site are used to develop a site-level assessment. Depending on the type of contaminant, the site-level condition assessment is determined either by average contaminant levels or by the number of excursions above a drinking water threshold at the monitoring site (**Table 8**). The reach-level condition class is determined by the lowest site-level condition class within a reach (**Table 9**).

Although not addressed in the UMRBA Provisional Assessment Methodology (UMRBA 2017), PFAS substances were included in the drinking water condition class assessment for Reaches 8 and 9. PFAS substances are in the group of per-and polyfluoroalkyl substances (aka perfluorochemicals) that have been used for decades to make polymer coatings and products that resist heat, oil, stains, grease, and water. Commonly-used products with PFAS-based polymer coatings include clothing, furniture, adhesives, food packaging, heat-resistant non-stick cooking surfaces, and the insulation of electrical wire. Two PFAS substances, PFOS (perfluorooctane sulfonic acid) and PFOA (perfluorooctanoic acid), are of special concern because they are resistant to breakdown in the environment and are known to contaminate drinking water sources. Although the U.S. EPA (2016) health advisory levels of 70 ng/l for PFOS and PFOA are intended to be applied to

finished (treated) drinking water, these advisory levels were measured in raw (untreated) water and were used as drinking water assessment thresholds for this project.[4] A summary of all analyses for PFAS substances in Reaches 8 and 9 is provided in **Appendix 6**.

Table 8. *Methods for determining* ***site-level condition class*** *for UMR drinking water uses (from UMRBA 2017). Data are to be generated by monthly monitoring at fixed sites over a five-year assessment period and at UMR public water suppliers. All indicators are applied independently to determine condition class. MCL = Maximum Contaminant Level.*

INDICATOR	CONDITION CLASS:		
	GOOD	FAIR	POOR
Nitrate	No excursions* above the 10 mg/l MCL	One excursion above the 10 mg/l MCL	Two or more excursions above the 10 mg/l MCL
Pesticides	Annual average does not exceed WQ threshold	Running quarterly average is greater than the WQ threshold	Annual average exceeds WQ threshold
Other contaminants	Annual average does not exceed WQ threshold	Maximum sample value is greater than the WQ threshold	Annual average exceeds WQ threshold
Microcystin	No excursions above the assessment threshold of 0.3 ug/l**	One excursion above the assessment threshold of 0.3 ug/l	More than 1 excursion above assessment threshold of 0.3 ug/l
Cylindrospermopsin	No excursions above the assessment threshold of 0.7 ug/l**	One excursion above the assessment threshold of 0.7 ug/l	More than 1 excursion above assessment threshold of 0.7 ug/l
Level of treatment	Conventional treatment sufficient to meet MCLs in finished water	Extra-ordinary treatment needed to meet MCLs in finished water	Category not used

*Excursions must be at least 30 days apart in order to capture separate or extended source water quality events.

**Drinking water guidelines for microcystin-LR and cylindrospermopsin from U.S. EPA, 2015.

Results of monitoring in Reaches 8 and 9 from December 2019 through August 2021 showed low levels of nearly all the drinking water contaminants listed in **Appendix 5**. The only contaminant to exceed a drinking water threshold was the cyanotoxin microcystin (**Appendix 7**). As per the UMRBA Provisional Assessment Methodology, however, the thresholds used in this assessment (see **Appendix 5**) were applied to raw (untreated) water. Data for levels of cyanotoxins in finished (treated) water were not available. PWS are likely to address and lower levels of cyanotoxins through the water treatment

4 Federal Clean Water Act water quality assessments, such as those developed for sections 305(b) and 303(d) of the Act, require comparison of state water quality criteria for designated drinking water uses to raw (untreated) water. These state water quality criteria are often identical to maximum contaminant levels (MCLs) for finished (treated) water as specified in the federal Safe Drinking Water Act. These MCLs were used to determine drinking water condition class as per the UMRBA Provisional Assessment Methodology (UMRBA 2017; see **Appendix 5**).

process.[5] Regardless, excursions of the cyanotoxin microcystin above the U.S. EPA's recommend guideline resulted in a condition class of "poor" for drinking water uses in both Reach 8 and 9 (**Tables 10 and 11**). The levels of microcystin above the U.S. EPA's guideline occurred during warm weather in late July and August 2021. Discharges in the UMR at this time were not unusually low (see **Figure 12**), but warm, late summer temperatures and warm water favor growth of cyanobacteria and their production of cyanotoxins.

Table 9. *Methods for determining* ***reach-level condition class*** *for UMR drinking water uses (from UMRBA 2017). SDWA = Safe Drinking Water Act. MCL = Maximum Contaminant Limit.*

DATA SOURCE	ASSESSMENT STATISTIC:	DETERMINING UMRBA REACH-LEVEL CONDITION CLASS FOR DRINKING WATER USE:		
		GOOD	FAIR	POOR
Results of monthly monitoring for parameters with SDWA MCLs (Appendix 5) or other assessment thresholds over a five- year period and information on water treatment methods	Site-level condition class determination	All site-level determinations for a given assessment reach suggest "good" water quality condition	The lowest site-level condition class within an assessment segment over the five-year period is "fair." Or, use of extraordinary treatment technology to meet MCLs.	The lowest site-level condition class within an assessment segment over the five-year period is "poor."

Table 10. *Summary of condition assessments for drinking water uses in Reach 8. The number of parameters analyzed within a contaminant category is in parentheses.*

PARAMETER	EXPLANATION	CONDITION CLASS
Cyanotoxins (2)	3 excursions of microcystin above the guideline of 0.3 ug/l at both the New Boston, IL, and Keokuk, IA, fixed sites	POOR
Toxic metals (12)	All sample levels below MCLs or guidelines	GOOD
Nitrate, fluoride, and chloride	All sample levels of nitrate below the MCL of 10 mg/l (maximum =4.3 mg/l)	GOOD
PFOS (perfluorooctyl sulfonate) and PFOA (perfluorooctanoate)6	No PFOA detected; all PFOS levels less than guideline of 70 ng/l (maximum = 12.3 ng/l)	GOOD
Pesticides (21)	All sample levels below MCLs or other guidelines	GOOD
Volatile organic compound (28)	All sample levels below MCLs or other guidelines	GOOD
Reach-level Assessment	Based on excursions of cyanotoxins (microcystin)	POOR

5 See https://www.epa.gov/ground-water-and-drinking-water/summary-cyanotoxins-treatment-drinking-water for information on reductions in cyanotoxin levels via the drinking water treatment process.

6 The U.S. EPA (2016) health advisory for PFOS and PFOA in drinking water of 70 ng/l was used for this assessment.

Table 11. *Summary of condition assessments for drinking water uses for in Reach 9. The number of parameters analyzed within a contaminant category is in parentheses.*

PARAMETER	EXPLANATION	CONDITION CLASS
Cyanotoxins (2)	2 excursions of microcystin above the guideline of 0.3 ug/ at the Quincy, IL, fixed site	POOR
Metals (12)	All sample levels below MCLs or guidelines	GOOD
Nitrate, fluoride, and chloride	All sample levels of nitrate below the MCL of 10 mg/l (maximum =4.3 mg/l)	GOOD
PFOS (perfluorooctyl sulfonate) and PFOA (perfluorooctanoate)	No PFOA detected; all PFOS levels less than guideline of 70 ng/l (maximum = 10.5 ng/l)	GOOD
Pesticides (21)	All sample levels below MCLs or other guidelines	GOOD
Volatile organic compounds (23)	All sample levels below MCLs or other guidelines	GOOD
Reach-level Assessment	Based on excursions of cyanotoxins (microcystin)	POOR

Fish Consumption Use Condition Assessment

The goals of UMRBA fish consumption use monitoring are to determine the condition class of the fish consumption use (good, fair, or poor) in each of the 14 assessment reaches (**Figure 1**) and to identify trends and patterns in levels of toxic contaminants in fish over time. In addition, information on levels of contaminants in fish can be used by states for the purposes of Clean Water Act Section 305(b) reporting and Section 303(d) impaired waters listing as well as for the purposes of establishing or removing fish consumption advisories.

As per guidance in the UMRBA Provisional Assessment Methodology (UMRBA 2017), the Reaches 8-9 pilot project used fish species from two trophic levels to determine the condition class of fish consumption use: the predator (piscivorous) level is represented by Largemouth Bass (Micropterus salmoides), and the bottom-feeder (omnivorous) level is represented by Common Carp (Cyprinus carpio). Fish were collected at several randomly-selected probabilistic sample sites in both reaches (**Table 12**). Twenty fish were collected from Reach 8 (10 Largemouth Bass and 10 Common Carp), and fifteen fish were collected from Reach 9 (five Largemouth Bass and 10 Common Carp). Field sampling staff were unable to collect ten Largemouth Bass in Reach 9 within the specified length as described in the UMRBA Provisional Assessment Methodology. A summary of length and weight of the fish collected is presented in **Table 13**. Length/weight information for individual fish analyzed for this project is available in **Appendix 8**.

Both Largemouth Bass and Common Carp are common in the Upper Mississippi River, and both species are routinely used by state environmental agencies for fish contaminant monitoring programs. The Largemouth Bass is a top predator and a popular sport fish that, through the tendency of mercury to biomagnify upward through the food chain, can accumulate mercury to high levels in its muscle tissue, especially in older and larger fish. The Common Carp, a bottom feeder, comes in contact with sediments potentially contaminated with polychlorinated biphenyls (PCBs). Chlorinated hydrocarbon contaminants such as PCBs are fat-soluble and thus can accumulate to high levels in the fat-rich muscle tissue of Common Carp.

Table 12. *Fish species and numbers of individuals per species collected in 2021 from probabilistic monitoring sites in Reaches 8 and 9 for analysis of tissue for toxic contaminants.*

REACH	LOCATION OF PROBABILISTIC SITE	RIVER MILE	COLLECTION DATE	LARGE-MOUTH BASS	COMMON CARP	NO. FISH AT SITE
8	at New Boston, IL; 2 mile downriver from Toolsboro Landing, IA	433	8/10/2021	1	2	3
8	at Keithsburg, IL; 5 mile upriver from Hawkeye Dolbee Landing at Huron Island, IA	428	8/17/2021		2	2
8	at Oquawka, IA, Casey Borrow Landing, IA; 10 mile downriver from Huron Island, IA	415	8/10/2021		1	1
8	2 mile downriver from Skunk River mouth, 10 mile upriver from Fort Madison, IA	398	8/18/2021		2	2
8	2.5 mile upriver from Montrose, IA, 0.5 mile upriver from Nauvoo, IL ramp	377.5	9/1/2021	1		1
8	at Montrose, IA and Nauvoo, IL	377	8/24/2021	6	2	8
8	1 mile upriver from Keokuk marina	367	9/21/2021	2		2
8	1 mile downriver of L&D 19 at Keokuk, IA	363	9/28/2021		1	1
			Reach 8 Totals:	10	10	20
9	1 mile downriver of Alexandria, MO and Warsaw, IL	357.5	7/28/2021		1	1
9	near Gregory Landing and gage in MO	353	9/21/2021	1*	2	3
9	7 mile upriver from Canton, MO near Buzzard Island	350	7/29/2021		1	1
9	0.2 mile downriver of L&D 20 at Canton, MO	343	8/4/2021	1	1	2
9	1 mile downriver from Canton, MO	341	8/4/2021		1	1
9	3 miles downriver from La Grange, MO	333	9/20/2021	1*	1	2
9	2 miles upriver from Quincy, IL	329	8/2/2021	1	2	3
9	at Quincy, IL; 3.5 miles upriver of L&D 21	328.5	7/27/2021	1	1	2
			Reach 9 Totals:	5	10	15
			Reach 8 and 9 Totals:	15	20	35

*Fish were collected but data for levels of mercury in tissue are not available.

Table 13. *Summary of length and weight data for Common Carp and Largemouth Bass collected from Reaches 8 and 9 in 2021 and analyzed for toxic contaminants. All available length and weight data are available in Appendix 8. NA = not available.*

		AVERAGE		MAXIMUM		MINIMUM	
REACH AND SPECIES:	NO. OF FISH	LENGTH (MM)	WEIGHT (GRAMS)	LENGTH (MM)	WEIGHT (GRAMS)	LENGTH (MM)	WEIGHT (GRAMS)
Reach 8 Common Carp	10	505	1674	528	1944	462	1318
Reach 8 Largemouth Bass	10	393	972	423	1371	374	380
Reach 9 Common Carp	10	492	N/A	546	N/A	431	N/A
Reach 9 Largemouth Bass	5	326	N/A	385	N/A	286	N/A

Fish tissue samples were analyzed as skin-off fillets for mercury and total PCBs. The decision to analyze the fillets with skin-off was a deviation from the UMRBA Provisional Assessment Methodology (UMRBA 2017) because most state environmental agencies do not analyze fillets with skin on. Although not provided for in the Provisional Assessment Methodology, tissue samples from six fish from Reach 9—three Largemouth Bass and three Common Carp—were analyzed for PFAS substances. Two of these substances, PFOS (perfluorooctane sulfonic acid) and PFOA (perfluorooctanoic acid) are of potential concern because they are resistant to breakdown in the environment and are known to accumulate in tissues of fish. The additional fish tissue analysis for PFAS substances was conducted in partnership with the Missouri Department of Health and Senior Services. All tissue analysis was conducted by Pace Analytical Services of Green Bay, WI. Results of all fish tissue analyses are summarized in **Table 14**.

Table 14. *Summary of analyses of tissue samples from individual fish collected from Reaches 8 and 9 in 2021. All tissue samples were analyzed as skin-off fillets. Results of analysis are organized by reach, by contaminant, and by descending river mile. LMB = Largemouth Bass (Micropterus salmoides); CC = Common Carp (Cyprinus carpio). NA = Data Not Available. Flag codes: J = Estimated Value; U = Analyte Undetected; ND = Not Detected.*

REACH	RIVER MILE	FIELD ID NUMBER	SPECIES	COLLECTION DATE	LENGTH (MM)	WEIGHT (GRAMS)	CONTAMINANT	FLAG	RESULT	UNITS
8	433	21018208101F005	LMB	8/10/2021	383	820	Mercury		0.2	mg/kg
8	377.5	21018309011F011	LMB	9/1/2021	423	1371	Mercury		0.26	mg/kg
8	377	21018708241D001	LMB	8/24/2021	376	380	Mercury		0.14	mg/kg
8	377	21018709011H001	LMB	9/1/2021	376	887	Mercury		0.12	mg/kg
8	377	21018709011J001	LMB	9/1/2021	405	1024	Mercury		0.18	mg/kg
8	377	21018709102D007	LMB	9/10/2021	392	1163	Mercury		0.23	mg/kg
8	377	21018709102J004	LMB	9/10/2021	401	961	Mercury		0.18	mg/kg
8	377	21018709102J006	LMB	9/10/2021	378	818	Mercury		0.14	mg/kg
8	367	21018109211A008	LMB	9/21/2021	414	1147	Mercury		0.19	mg/kg
8	367	21018109211I001	LMB	9/21/2021	389	1154	Mercury		0.12	mg/kg
8	433	21018208101F009	CC	8/10/2021	528	NA	PCB, Total		48.8	ug/kg
8	433	21018208101F010	CC	8/10/2021	523	1904	PCB, Total	J	11	ug/kg
8	428	21018608171B009	CC	8/17/2021	508	1659	PCB, Total	J	11.8	ug/kg
8	428	21018608171B011	CC	8/17/2021	493	1622	PCB, Total	J	12.4	ug/kg
8	415	21019408161B001	CC	8/10/2021	483	1430	PCB, Total		62.6	ug/kg
8	398	21019508181B010	CC	8/18/2021	520	1944	PCB, Total		46.2	ug/kg
8	398	21019508181I005	CC	8/18/2021	523	1924	PCB, Total	J	10.1	ug/kg
8	377	21018708241I006	CC	8/24/2021	502	1578	PCB, Total	J	8.8	ug/kg
8	377	21018708241I013	CC	8/24/2021	462	1318	PCB, Total	U	8.2	ug/kg
8	363	21018909281C004	CC	9/28/2021	518	1684	PCB, Total		47.2	ug/kg
9	343	21004408041E011	LMB	8/4/2021	312	NA	Mercury		0.15	mg/kg
9	333	21003908021D001	LMB	8/2/2021	309	NA	Mercury		0.14	mg/kg
9	329	21003607271E004	LMB	7/27/2021	286	NA	Mercury		0.14	mg/kg

Table 14 (continued)

REACH	RIVER MILE	FIELD ID NUMBER	SPECIES	COLLECTION DATE	LENGTH (MM)	WEIGHT (GRAMS)	CONTAMINANT	FLAG	RESULT	UNITS
9	357.5	21003407281C001	CC	7/28/2021	528	NA	PCB, Total		28.2	ug/kg
9	353	21004507281A002	CC	7/28/2021	431	NA	PCB, Total	J	11.2	ng/g
9	353	21004507281G001	CC	7/28/2021	442	NA	PCB, Total	J	8.9	ng/g
9	350	21003807291G002	CC	7/29/2021	522	NA	PCB, Total		39.9	ug/kg
9	343	21004408041G001	CC	8/4/2021	500	NA	PCB, Total	J	12.7	ug/kg
9	341	21004008041F018	CC	8/4/2021	531	NA	PCB, Total	J	9.8	ug/kg
9	333	21003908021F037	CC	8/2/2021	490	NA	PCB, Total	J	14	ug/kg
9	333	21003908021J012	CC	8/2/2021	473	NA	PCB, Total	J	12.8	ug/kg
9	329	21003607271C001	CC	7/27/2021	459	NA	PCB, Total		28	ug/kg
9	329	21003607271D002	CC	7/27/2021	546	NA	PCB, Total		68.3	ug/kg
9	353	21004509211B022	LMB	9/21/2021	339	NA	PFOA	ND	0.24	ng/g
9	343	21004408041G001	CC	8/4/2021	500	NA	PFOA	ND	0.24	ng/g
9	333	21003109201G001	LMB	9/20/2021	385	NA	PFOA	ND	0.24	ng/g
9	333	21003908021F037	CC	8/2/2021	490	NA	PFOA	ND	0.24	ng/g
9	333	21003908021J012	CC	8/2/2021	473	NA	PFOA	ND	0.24	ng/g
9	329	21003607271E004	LMB	7/27/2021	286	NA	PFOA	ND	0.24	ng/g
9	353	21004509211B022	LMB	9/21/2021	339	NA	PFOS		16	ng/g
9	343	21004408041G001	CC	8/4/2021	500	NA	PFOS		3	ng/g
9	333	21003109201G001	LMB	9/20/2021	NA	NA	PFOS		8.1	ng/g
9	333	21003908021F037	CC	8/2/2021	490	NA	PFOS		8.1	ng/g
9	333	21003908021J012	CC	8/2/2021	473	NA	PFOS		3.3	ng/g
9	329	21003607271E004	LMB	7/27/2021	286	NA	PFOS		5.9	ng/g

PCBs: Results of fish tissue analysis showed low levels of PCBs in the bottom-feeder trophic level (Common Carp) in Reaches 8 and 9. All levels of PCBs in Common Carp from both reaches were below the threshold (200 ug/kg (parts per billion)) that separates the "good" from the "fair" condition class for fish consumption use. The average concentration of PCBs in Common Carp fillets from six probabilistic monitoring sites in Reach 8 was 31.4 ug/kg (standard error = 5.7 ug/kg) (**Figure 14**). This average level is below the condition assessment threshold of 200 ug/kg. In Reach 9, the average level of PCBs in 10 Common Carp fillets from seven sites was 23.7 ug/kg (standard error = 5.9 ug/kg) (**Figure 14**). Again, this average level of PCBs is below the threshold.

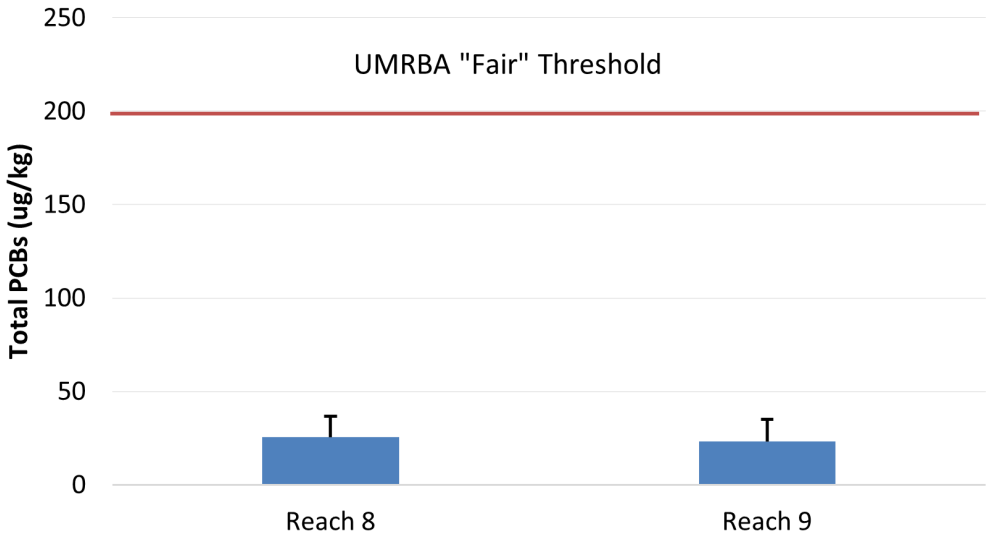

Figure 14. *Average levels of total PCBs (ug/kg or ppb) in skin-off filets of Common Carp in Reaches 8 and 9 in 2021. Ten fish from six sites in Reach 8 were analyzed; ten fish from eight sites in Reach 9 were analyzed. Error bars are twice the standard error of the average values.*

These results are consistent with data from other state and U.S. EPA-sponsored fish contaminant monitoring networks. That is, the production of PCBs was banned by the U.S. Environmental Protection Agency in 1979. Since that time, levels of PCBs in fish have gradually declined from levels in the several part per million range in the 1970s and 1980s to a fraction of a part per million today. Areas with relatively high levels of PCBs in bottom-feeding fish, however, continue to exist and are usually associated an industrial source of the contaminant. PCBs are resistant to degradation in the environment, and their persistence in the environment, although at generally low levels, is demonstrated by their presence in the tissues of Common Carp in Reaches 8 and 9.

Mercury is a global contaminant, typically from industrial (power generation) sources, and is distributed primary through atmospheric deposition with resulting levels of mercury in fish tissue often dependent on local water chemistry. Levels of mercury in fillets of Largemouth Bass from Reaches 8 and 9 approached or slightly exceeded the threshold (0.2 mg/kg) that separates the "good" from "fair" condition class for fish consumption uses.

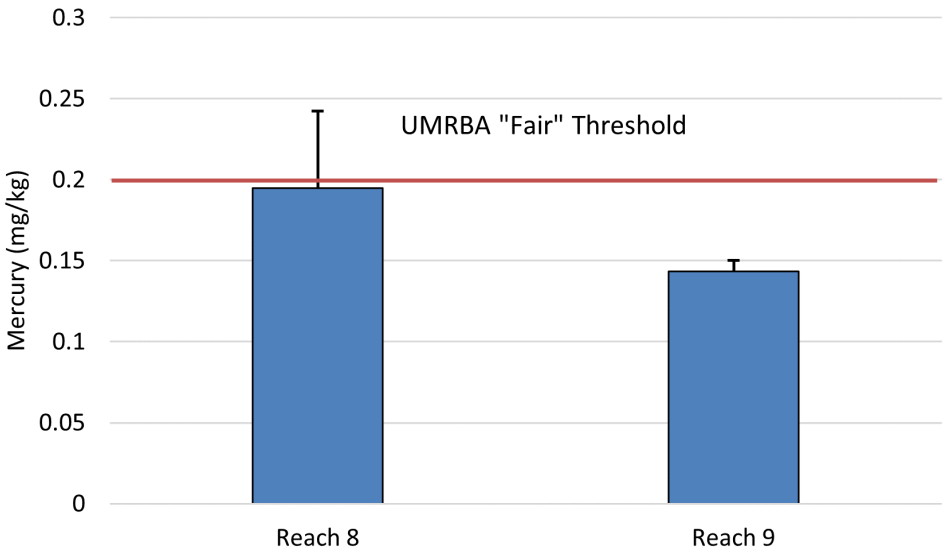

Figure 15. *Average levels of mercury (ug/kg or ppb) in skin-off filets of Largemouth Bass in Reaches 8 and 9 in 2021. Ten fish from four sites in Reach 8 were analyzed; three fish from three sites in Reach 9 were analyzed. Error bars are twice the standard error of the average values.*

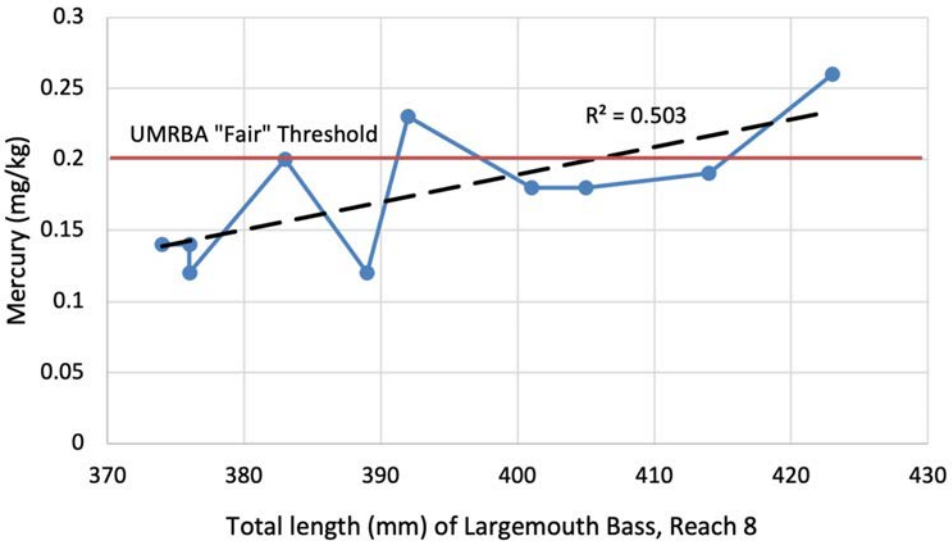

Figure 16. *Relationship between total lengths of Largemouth Bass from Reach 8 and concentrations of mercury in skin-off fillets.*

Reach 8, the average level of mercury in the 10 Largemouth Bass fillets from four sites was 0.195 mg/kg (standard error of 0.024 mg/kg) (**Figure 15**). This average level of mercury is not statistically different from the 0.200 mg/kg "fair" threshold but is below the "poor" threshold of 1 mg/kg. In addition, some of the smaller fish from this sampling had levels of mercury that approached or exceeded the threshold for "fair" condition class (**Figure 16**). Thus, despite an average level of mercury that was below the assessment threshold, the number of fish with levels of mercury that equaled or exceeded the "fair" threshold suggest that the fish consumption condition class for Reach 8 should be considered "fair" as opposed to "good."

Levels of mercury in fillet of Largemouth Bass from Reach 9, however, were lower, although fillets from only three fish from three sites were analyzed (**Figure 15**). The average level of mercury in the fillets from those three fish was 0.14 mg/kg (standard error of 0.003 mg/kg). This average level of mercury is below the "fair" assessment threshold of 0.200 mg/kg.

STATE-ISSUED FISH CONSUMPTION ADVISORIES

Many state environmental agencies have fish contaminant monitoring programs, and states use results of that monitoring to establish consumption advisories to protect the health of human consumers of locally-caught fish. The following are fish consumption advisories issued for the UMR by the states of Illinois, Iowa, and Missouri that include assessment Reaches 8 or 9:

- **Illinois:** Due to high levels of PCBs, the state of Illinois has issued fish consumption advisories for Channel Catfish (Ictalurus punctatus) and Common Carp that cover the entire length of both Reaches 8 and 9. These advisories recommend that no more than one meal per week be consumed of either species of any size (Illinois DPH 2022).
- **Iowa:** The state of Iowa does not have fish consumption advisories that cover any portion of Reaches 8 or 9 (Iowa DNR 2022).
- **Missouri:** Due to high levels of PCBs, chlordane, and mercury, the state of Missouri has a 1 meal/month consumption advisory for several bottom-feeding species that covers the length of the Mississippi River along its border, including all of Reach 9 (**Table 15**).

Table 15. *Summary of fish consumption advisory issued by the Missouri Department of Health and Senior Services for the state's portions of the Mississippi and Missouri rivers (from Missouri DHSS 2020).*

LOCATION	SPECIES	LENGTH (>) greater than	SERVING ADVICE no more than	CONTAMINANT
Mississippi and Missouri Rivers	Shovelnose Sturgeon (excluding eggs)	All sizes	1/month	PCBs, Chlordane, Mercury
	Sturgeon eggs		Do not eat	
	Flathead, Channel, Blue Catfish	>17"	1/week	
	Buffalo	All sizes	1/month	
	Common Carp	>21"	1/week	

DETERMINING CONDITION CLASS FOR FISH CONSUMPTION USE

According to the UMRBA Provisional Assessment Methodology (UMRBA 2017), the condition class for the fish consumption use depends, in part, on the average levels of fish contaminants in the fish species for each trophic level (predator and bottom-feeder) (**Table 16**).

Table 16. *Assessment thresholds (mg/kg or ppm) for levels of toxic contaminants in fish tissue. Average levels of PCBs and mercury for each trophic level (predator and bottom-feeding species) are compared to the assessment thresholds to determine fish consumption condition class (from UMRBA 2017).*

CONTAMINANT	WATER QUALITY CONDITION CLASS			RATIONALE
	GOOD	FAIR	POOR	
PCBs	≤0.2	>0.2 but ≤ 2.0	>2.0	A PCB concentration of 0.2 mg/kg in fish tissue is a threshold of concern and is a level at which restricted consumption advisories may be issued. A concentration of PCBs greater than 2.0 mg/kg is considered a "do not eat"threshold by many states.
Mercury	≤0.2	>0.2 but ≤ 1.0	>1.0	A methyl-mercury concentration of 0.2 mg/kg in fish tissue is a threshold of concern and is a level at which restricted consumption advisories may be issued. A concentration of methyl-mercury greater than 1.0 mg/kg is considered a "do not eat" threshold by many states.

In addition to levels of PCBs and mercury in fish, the UMRBA Provisional Assessment Methodology (UMRBA 2017) incorporates state-issued fish consumption advisories into the condition class assessment for fish consumption uses. The condition class based on consumption advisories depends on the consumption level recommended in the advisory (**Table 17**).

Table 17. *Determining reach-level condition class for fish consumption use in assessment reaches based on existence of active state-issued fish consumption advisories.*

	WATER QUALITY CONDITION CLASS		
	GOOD	FAIR	POOR
Fish Consumption Advisory Level:	**No more restrictive advisory than one meal per week**	**Most restrictive advisory is a one meal per month for any species**	**Most restrictive advisory is a "do not eat" advisory for any species**

According the UMRBA Provisional Assessment Methodology (UMRBA 2017), the reach-level fish consumption use is determined by the lowest condition class for PCBs, mercury, or the restrictiveness of fish consumption advisories. In Reach 8, the somewhat elevated level of mercury in fillets of Largemouth Bass indicate that the reach-level condition class for fish consumption uses should be assessed as "fair" (**Figure 15, Table 18**).

Table 18. *Summary of condition class assessment for fish consumption use in Reach 8.*

PARAMETER	EXPLANATION	CONDITION CLASS
PCBs	**Average level of PCBs in Common Carp below the "fair" assessment threshold.**	**GOOD**
Mercury	**Average level of mercury in Largemouth Bass is approximately equal to the "fair" threshold.**	**FAIR**
Consumption advisories	**Most restrictive advisory is a one meal / week advisory issued by Illinois.**	**GOOD**
Reach-level Assessment	**Based on average level of mercury in Largemouth Bass.**	**FAIR**

In Reach 9, it is the moderately restrictive fish consumption advisory of one meal per month issued by the state of Missouri (**Table 15**) that suggests a "fair" reach-level condition class for fish consumption use (**Table 19**).

Table 19. *Summary of condition class assessment for fish consumption use in Reach 9.*

PARAMETER	EXPLANATION	CONDITION CLASS
PCBs	**Average level of PCBs in Common Carp well below the "fair" assessment threshold.**	**GOOD**
Mercury	**Average level of mercury in Largemouth Bass is below the "fair" threshold.**	**GOOD**
Consumption advisories	**Most restrictive advisory is a one meal / month advisory issued by Missouri.**	**FAIR**
Reach-level Assessment	**Based on fish consumption advisory issued by Missouri.**	**FAIR**

PFAS substances: In order begin to characterize the levels of PFAS substances in Reaches 8 and 9, skin-off fillets from six fish (three Largemouth Bass and three Common Carp) collected from Reach 9 were analyzed for PFOA and PFOS. Levels of PFOA were all below the analytical level of detection (0.240 ng/g) (**Figure 17**). Levels of PFOS, however, were above levels of detection and ranged from 3 to 16 ng/g (**Figure 18, Table 14**). There were no consistent species-specific patterns in the results at a given site, with levels in Largemouth Bass versus Common Carp varying between sites. Levels of PFOS in Largemouth Bass, however, appeared to decline from the upriver portion of Reach 9 near Keokuk, Iowa, downriver to near Quincy, Illinois (**Figure 18**).

There are currently no criteria for determining the levels of PFAS substances in fish tissue that present a health risk to persons consuming PFAS-contaminated fish.[7] The UMRBA Provisional Assessment Methodology (UMRBA 2017) does not address PFAS substances in terms of fish consumption use condition class. The results of monitoring for PFAS substances, however, establish the presence of PFOS in UMR fish species. Based on the results of this Reach 8-9 pilot project, Missouri DNR is considering adding PFAS fish tissue sampling to their fish contaminant monitoring program.

7 U.S. EPA, however, has recently released draft aquatic life criteria for PFOA (https://www.epa.gov/wqc/aquatic-life-criteria-perfluorooctanoic-acid-pfoa) and for PFOS (https://www.epa.gov/wqc/aquatic-life-criteria-perfluorooctane-sulfonate-pfos).

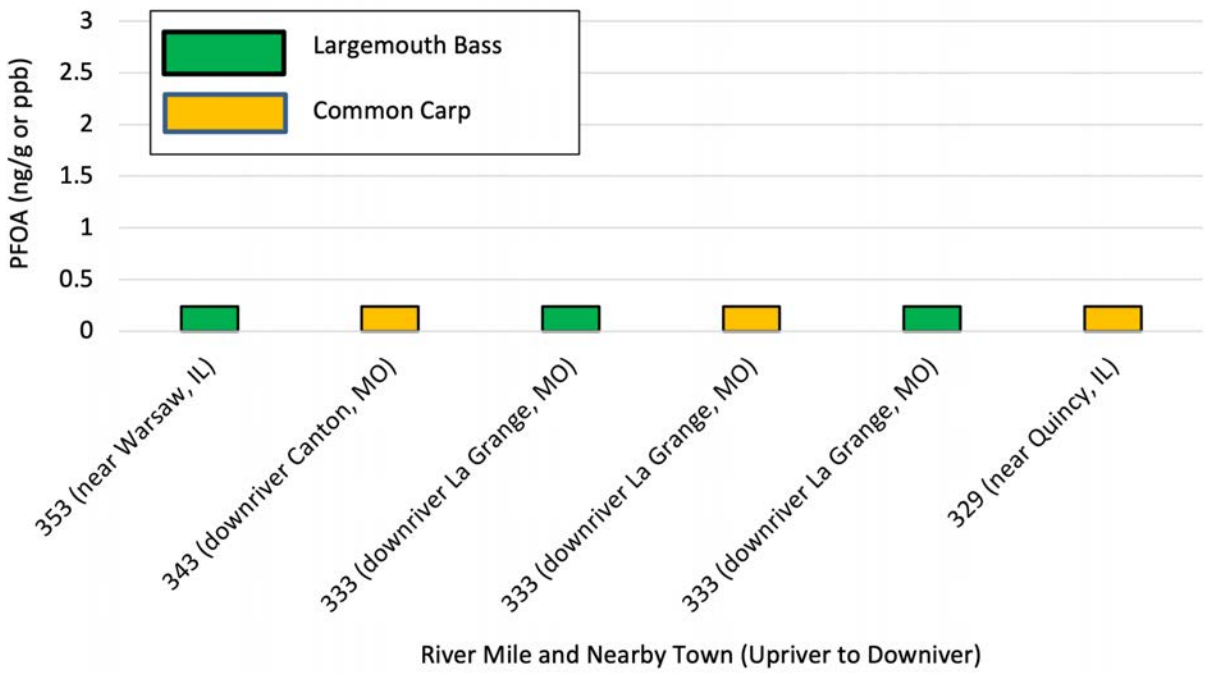

Figure 17. *Levels of PFOA in skin-off fillets from Largemouth Bass and Common Carp from Reach 9 in 2021. All levels of PFOA were less than the analytical level of detection of 0.240 ng/g. Levels are presented from upriver (left) to downriver. Each bar represents the PFOA concentration in an individual fish.*

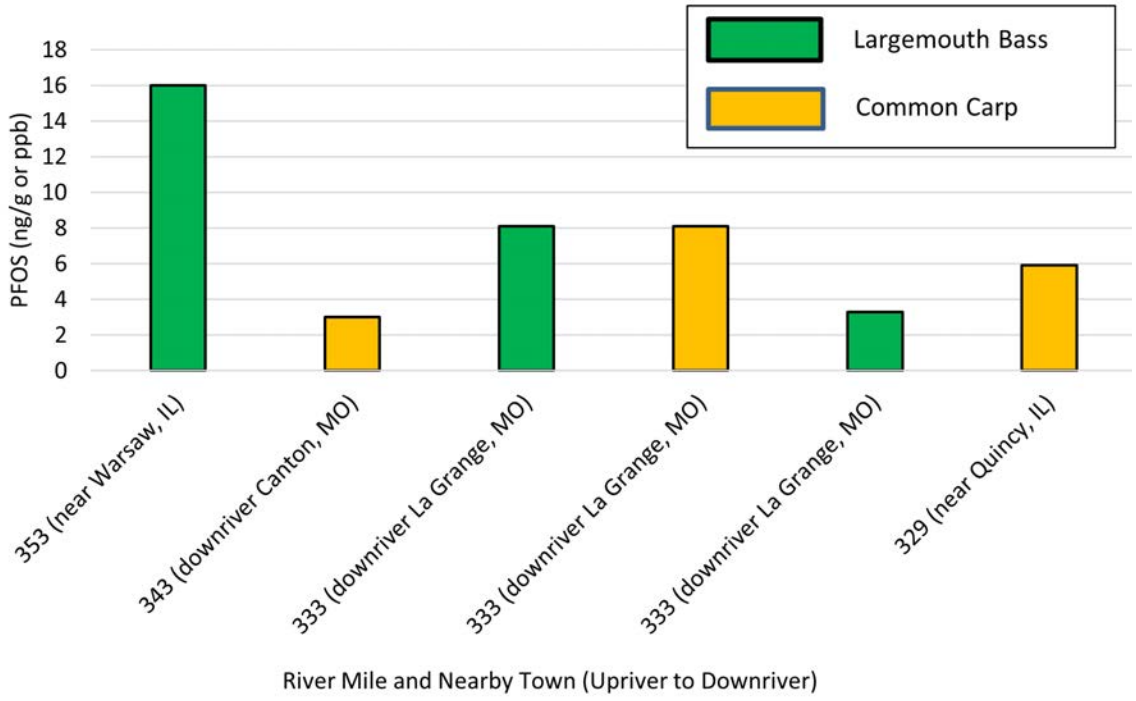

Figure 18. *Levels of PFOS in skin-off fillets from Largemouth Bass and Common Carp from Reach 9 in 2021. Levels are presented from upriver (left) to downriver. Each bar represents the PFOS concentration in an individual fish.*

Discussion and Summary

As shown in **Table 20**, the condition assessments of the beneficial uses designated for assessment Reaches 8 and 9 of the Upper Mississippi River were generally assessed as "poor" or "fair." Only the aquatic life condition in Reach 9 was assessed as "good."

Table 20. *Summary of the reach-level condition assessments for Reaches 8 and 9 based on chemical, physical and biological monitoring conducted in 2020 and 2021. NA = Not Applicable.*

BENEFICIAL USE	REACH 8 CONDITION ASSESSMENT	REACH 8 ISSUES:	REACH 9 CONDITION ASSESSMENT	REACH 9 ISSUES:
Aquatic Life	POOR	Poor biotic integrity of macroinvertebrate community	GOOD	N/A
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

Results of biological sampling conducted in summer 2021 at the 15 probabilistic sites in each assessment reach suggest that the biotic integrity of fish communities in both Reaches 8 and 9, as measured by the Great River Fish Index (Angradi et al. 2009a), are good, with all index values being above the assessment threshold (**Figure 3**, top). The biotic integrity of the UMR's aquatic macroinvertebrate communities in both reaches, however, as measured by the Wisconsin Big River index (Weigel and Dimick 2011), was lower than that of the fish community, with WBR index values in both reaches clustered around the assessment threshold (**Figure 3**, bottom). Less than 50% (38%) of the WBR index values for Reach 8 macroinvertebrate communities passed the assessment threshold, thus indicating a "poor" condition class for aquatic life uses. In Reach 9, 76% of the 15 WBR index values passed the assessment threshold, thus indicating an aquatic life condition class of "good."

The compressed timeframe of the pilot project (that is, from one to two years of fixed site monitoring versus the five years recommended in UMRBA's Provisional Assessment Methodology (UMRBA 2017) may have influenced the condition assessment of recreation uses. The high levels of chlorophyll monitored in summer 2021 at fixed sites in Reaches 8 and 9 led to the "poor" condition class assessment. Most of the chlorophyll data for the condition assessment of recreation uses came from the warm and dry summer of 2021 with the result that levels of algal populations—and thus levels of chlorophyll—were relatively high. Having additional chlorophyll data from years with more typical discharge regimes and levels inorganic turbidity would likely result in lower levels of chlorophyll and an improved condition assessment for recreation uses. In general, levels of indicator bacteria (E. coli) were low during the recreation season of 2021 with average and maximum levels of E. coli below their respective assessment thresholds (**Figure 5**). Levels of E. coli at the Quincy, IL, monitoring site, however, were elevated in summer 2021 such that both average and maximum levels exceeded assessment thresholds resulting in a "poor" reach-level condition assessment for Reach 9 recreation uses. Given full implementation of the UMR Interstate Water Quality Monitoring Plan, which would provide E. coli data from additional years of fixed site monitoring, the overall average levels and the percentages of samples exceeding the threshold for maximum levels could be lower and might show and improved condition class for recreation uses.

The condition assessments of drinking water uses in both Reaches 8 and 9 were assessed as "poor," due to the levels of the cyanotoxin microcystin. However, the cyanotoxin thresholds used in this assessment (**Appendix 7**), which are intended to be applied to finished (treated) drinking water, were applied to raw (untreated) water. Due to the reduction in cyanotoxin levels during the water treatment process, the levels of microcystin seen in Reaches 8 and 9, although they do exceed the assessment thresholds, do not appear to constitute a threat to public health.

Levels of the other 63 drinking water contaminants monitored in both assessment reaches were below assessment thresholds. Only three of the 21 pesticides analyzed for the pilot project (atrazine, carbofuran, and hexachlorobenzene) were reported above analytical levels of detection, and none of the detected levels of those three pesticides approached their respective maximum contaminant level thresholds. None of the 23 volatile organic compounds analyzed were reported above analytical detection levels (see **Appendix 9**). Although frequently detected, levels of all 12 toxic metals were below assessment thresholds. Levels of nitrate were all less than one-half of the MCL of 10 mg/l. Again, the compressed timeframe of the pilot project may have influenced the condition assessments of drinking water uses.

The reach-level fish consumption condition class in both Reaches 8 and 9 was assessed as "fair." Average and maximum levels of PCBs in Common Carp were below the fair threshold in both reaches. Average levels of mercury in Reach 8, however, were at or slightly above the "fair" threshold of 0.2 mg/kg, thus suggesting a "fair" condition class assessment for fish consumption use. In Reach 9, levels of mercury were below the "fair" threshold. According to the UMRBA Provisional Assessment Methodology, however, the one meal/month consumption advisory issued by the Missouri Department of Health Senior Services (DHSS) for Missouri's entire portion of the Upper Mississippi River (Missouri DHSS 2022) suggests that the Reach 9 fish consumption uses should be assessed as "fair."

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Appendix 1

Fixed, probabilistic, and public water supplier (PWS) intake monitoring sites sampled in 2020 and 2021 for the Reaches 8-9 pilot project. Sites are listed from upriver to downriver.

REACH	POOL	RIVER MILE	LOCATION	SITE TYPE	FIELD NUMBER
8	17	437	IL L-04; L&D 17 at New Boston, IL	Fixed	UMR-437.7
8	18	433	at New Boston, IL; 2 miles downriver from Toolsboro Landing, IA	Probabilistic	UMR15-0182
8	18	428	at Keithsburg, IL; 5 miles upriver from Hawkeye Dolbee Landing at Huron Island, IA	Probabilistic	UMR15-0186
8	18	420	2 miles downriver from Hawkeye Dolbee Landing at Huron, IA	Probabilistic	UMR15-0190
8	18	415	at Oquawka, IA, Casey Borrow Landing, IA; 10 miles downriver from Huron Island, IA	Probabilistic	UMR15-0194
8	19	409	1 mile downriver from L&D 18, 5 mile upriver from Burlington, IA	Probabilistic	UMR15-0193
8	19	404	at Burlington, IA	Probabilistic	UMR15-0184
8	19	398	4 miles downriver from Burlington, IA	Probabilistic	UMR15-0195
8	19	394	2 miles downriver from Skunk River mouth, 10 miles upriver from Fort Madison, IA	Probabilistic	UMR15-0192
8	19	391	at Dallas City, IL, 7 miles upriver from Fort Madison, IA	Probabilistic	UMR15-0188
8	19	377.5	2.5 miles upriver from Montrose, IA, 0.5 mile upriver from Nauvoo, IL ramp	Probabilistic	UMR15-0183
8	19	377	at Montrose, IA and Nauvoo, IL	Probabilistic	UMR15-0187
8	19	371	3 miles downriver from Montrose	Probabilistic	UMR15-0191
8	19	367	1 mile upriver from Keokuk marina	Probabilistic	UMR15-0181
8	19	365	Keokuk Municipal Water Works Drinkable Water	Drinking Water	UMR-365.8WF
8	19	365	Keokuk Municipal Water Works	Drinking Water	UMR-365.8WR
8	19	364.6	IL K-22; L&D 19 at Keokuk, IA	Fixed	UMR-365.8
8	20	364	Warsaw Water Works Facility Drinkable Water	Drinking Water	UMR-364.8WF

Appendix 1 (continued)

REACH	POOL	RIVER MILE	LOCATION	SITE TYPE	FIELD NUMBER
8	20	364	Warsaw Water Works Facility	Drinking Water	UMR-364.8WR
8	20	364	At L&D 19 at Keokuk, IA	Probabilistic	UMR15-0185
8	20	363	1 mile downriver of L&D 19 at Keokuk, IA	Probabilistic	UMR15-0189
9	20	357.5	1 mile downriver of Alexandria, MO and Warsaw, IL	Probabilistic	UMR15-0034
9	20	353	near Gregory Landing and gage in MO	Probabilistic	UMR15-0045
9	20	351.5	8.5 miles upriver from Canton, MO near Lifers Light	Probabilistic	UMR15-0042
9	20	350	7 miles upriver from Canton, MO near Buzzard Island	Probabilistic	UMR15-0038
9	20	347	4 miles upriver from Canton, MO near Blue Goose Island	Probabilistic	UMR15-0037
9	20	346	3 miles upriver from Canton, MO	Probabilistic	UMR15-0033
9	20	345.5	2.5 miles upriver from Canton, MO	Probabilistic	UMR15-0041
9	21	343	0.2 miles downriver of L&D 20 at Canton, MO	Probabilistic	UMR15-0044
9	21	341	1 mile downriver from Canton, MO	Probabilistic	UMR15-0040
9	21	339	3 miles downriver from Canton, MO	Probabilistic	UMR15-0043
9	21	335	1 mile downriver from LaGrange, MO	Probabilistic	UMR15-0032
9	21	333	3 miles downriver from La Grange, MO	Probabilistic	UMR15-0031
9	21	333	3 miles downriver from La Grange, MO	Probabilistic	UMR15-0035
9	21	329	2 miles upriver from Quincy, IL	Probabilistic	UMR15-0039
9	21	328.5	at Quincy, IL; 3.5 miles upriver of L&D 21	Probabilistic	UMR15-0036
9	21	327	City of Quincy PWS	Drinking water	UMR-327.9WF
9	21	327	City of Quincy PWS	Drinking water	UMR-327.9WR
9	21	325	IL K-17; L&D 21, 0.75 miles SW of Quincy, IL	Fixed	UMR-325.9

Appendix 2

Great River Fish Index metrics. Adapted from Pearson et al. (2011)

FISH ASSEMBLAGE METRIC	METRIC CLASS
Proportion of invertivore individuals	Trophic
Proportion of non-indigenous individuals	Composition
Proportion of individuals with DELTS	Fish Health
Proportion of detritivore Individuals	Trophic
Proportion of native individuals	Composition
Total deep-bodied sucker biomass (kg)	Biomass
Total number of fish species (exclusive)	Richness
Number of darter species	Richness
Catch per unit effort of native species	Relative Abundance
Number of minnow species	Richness

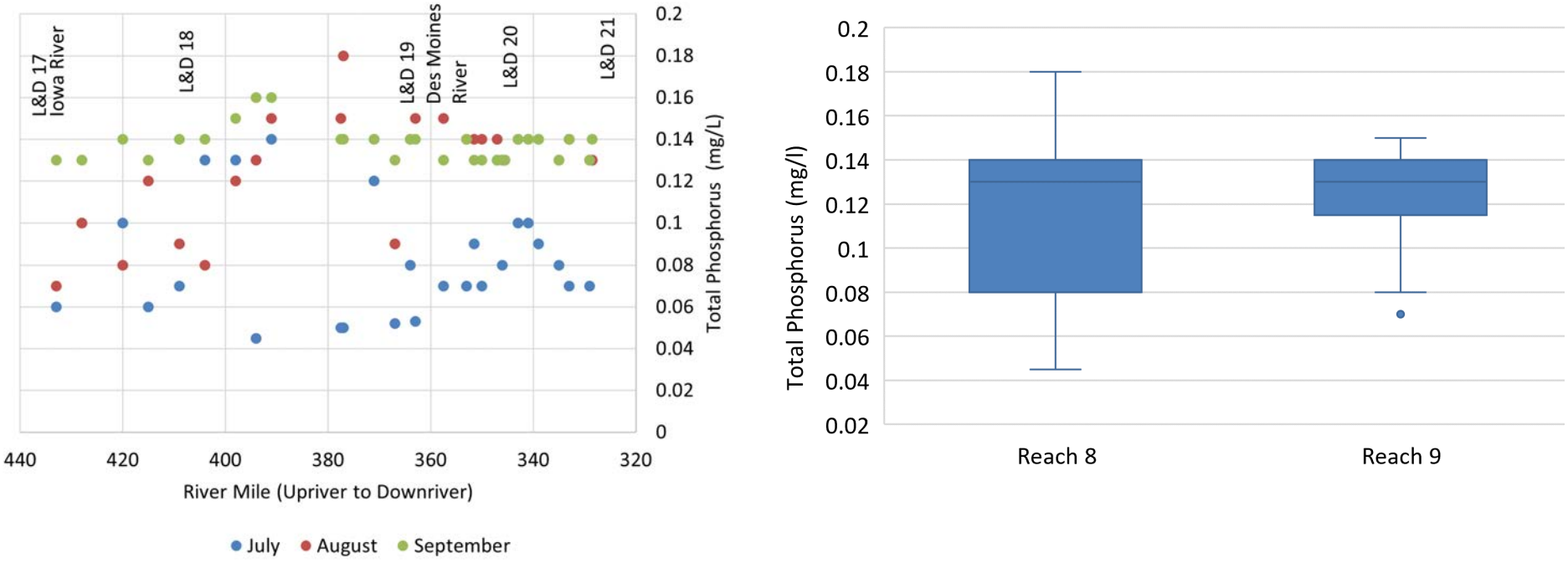
Appendix 3

Wisconsin Large River Macroinvertebrate Index metrics. EPT = Ephemeroptera, Plecoptera, Trichoptera (Weigel and Dimick 2011).

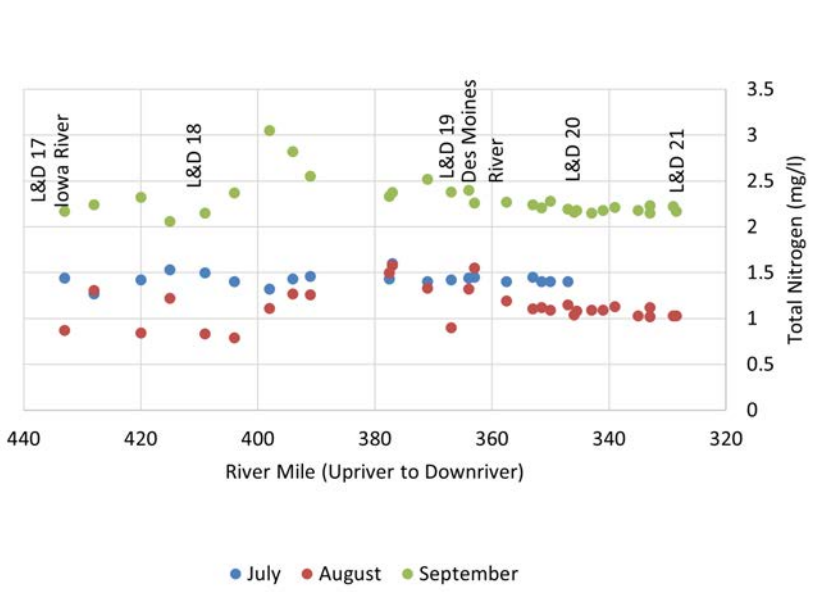
METRIC CATEGORY	METRIC (ABBREVIATION)
Taxon Richness and Composition	Number of insect taxa (Insect-T)
	% insect individuals (Insect-%I)
	Number of EPT taxa (EPT-T)
	% individuals in the top 3 taxa (Dom3-%I)
Tolerance and Composition	Mean pollution tolerance value (MPTV)
	% intolerant EPT individuals with maximum tolerance = 2 (IntolEPT2-%I)
	% tolerant chironomid individuals with minimum tolerance value = 8 (TolChir8-%I)
Ecology	Number of unique combinations of the 4 ecology trait niches (rheophily, thermal preference, habitat, and trophic status) (EcoFTN)
	% gathering insects (Gath-%I)
	% scraper insects (Scr-%I)

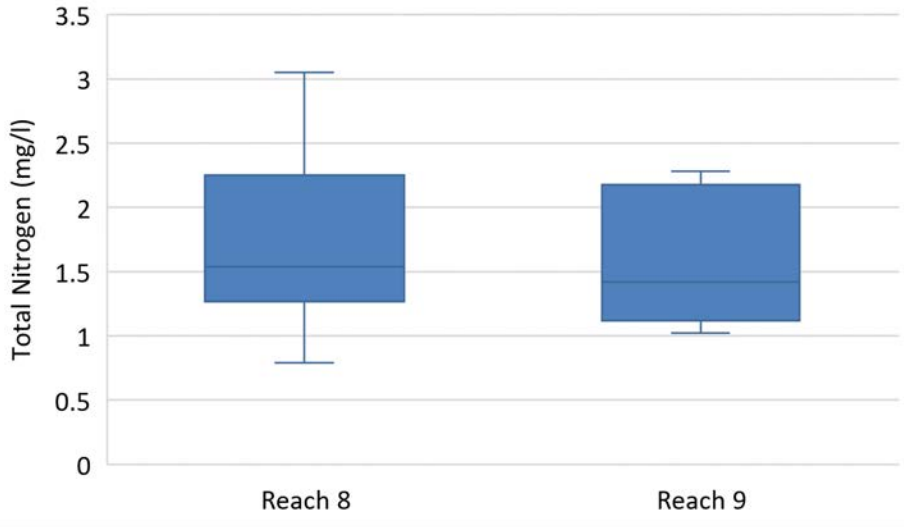
Appendix 4

Supplemental water quality data for total phosphorus, total nitrogen, and total suspended solids in Reaches 8 and 9. Data were collected during three rounds of monitoring (July, August and September) at 15 probabilistic sites per reach in 2021. Left side plots show individual values for the each of three rounds of monitoring. Right side plots are box and whisker plots that show the median (horizonal line within the box), the 25th and 75th percentile values (upper and lower sides of the box), and the maximum and minimum values (whiskers). The dots beyond the whiskers are outlier values.

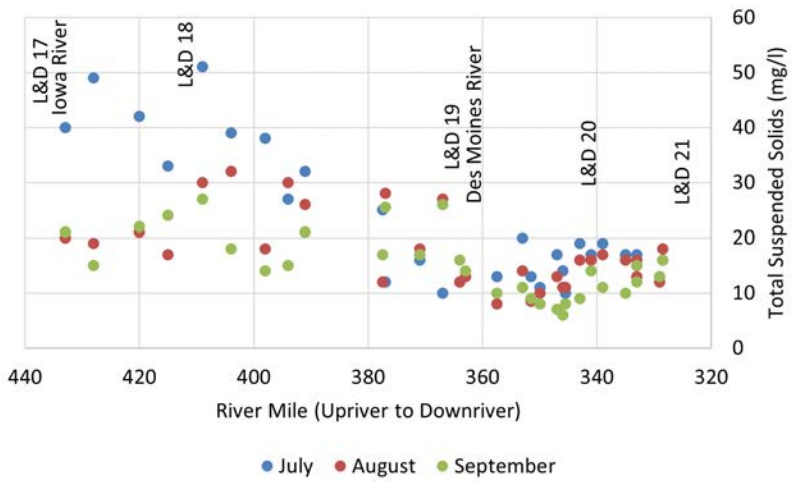


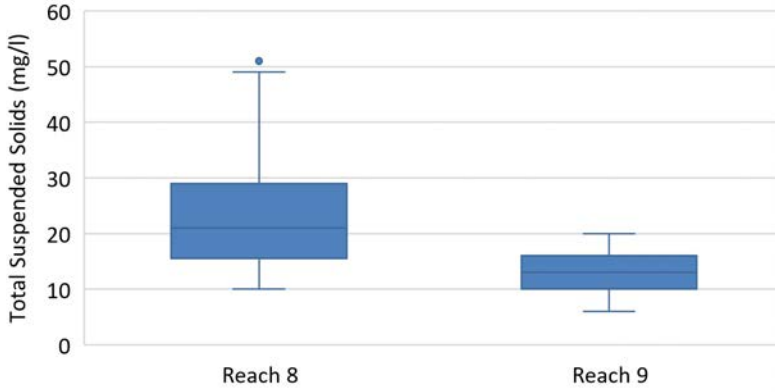
Total phosphorus at Reach 8 and Reach 9 probabilistic monitoring sites in 2021.





Total nitrogen at Reach 8 and Reach 9 probabilistic monitoring sites in 2021.





Total suspended solids at Reach 8 and Reach 9 probabilistic monitoring sites in 2021.

Appendix 5

Assessment thresholds to determine support of drinking water uses. Unless otherwise noted, thresholds are taken from U.S. EPA website https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water-regulations. Table from UMRBA (2017). SWDA = Safe Drinking Water Act. MCL = Maximum Contaminant Level.

CONTAMINANT	SDWA MCL OR OTHER VALUE AS NOTED	NOTES
Alachlor	2 ug/l	
Antimony	6 ug/l	
Arsenic	10 ug/l	This is a ***total*** arsenic value.
Atrazine	3 ug/l	
Barium	2000 ug/l	
Benzene	5 ug/l	
Benzo(a)Pyrene	0.2 ug/l	
Beryllium	4 ug/l	
Cadmium	5 ug/l	
Carbofuran	40 ug/l	
Carbon Tetrachloride	5 ug/l	
Chlordane	2 ug/l	
Chloride	250 mg/l	This is a secondary standard.
Chlorobenzene	100 ug/l	
Chromium VI	100 ug/l	This is a ***total*** chromium value.
Copper	1,300 ug/l	This is an ***action*** level, rather than an MCL.
Cyanide	200 ug/l	
Dalapon	200 ug/l	
Dibromochloropropane (DBCP)	0.2 ug/l	
o-Dichlorobenzene	600 ug/l	
p-dichlorobenzene	75 ug/l	

Appendix 5 (continued)

CONTAMINANT	SDWA MCL OR OTHER VALUE AS NOTED	NOTES
1,2-Dichloroethane	5 ug/l	
1,1-Dichloroethylene	7 ug/l	
cis-1,2-Dichloroethylene	70 ug/l	
trans-1,2-Dichloroethylene	100 ug/l	
Dichloromethane	5 ug/l	
1,2-Dichloropropane	5 ug/l	
Dinoseb	7 ug/l	
2,3,7,8-TCDD (Dioxin)	0.00003 ug/l	
Diquat	20 ug/l	
2,4-D	70 ug/l	
Endothall	100 ug/l	
Endrin	2 ug/l	
Ethylbenzene	700 ug/l	
Ethylene dibromide	0.005 ug/l	
Di(2-ethylhexyl)adipate	400 ug/l	
Bis(2-ethylhexyl)phthalate	6 ug/l	
Fluoride	4,000 ug/l	
Glyphosate	700 ug/l	
Heptachlor	0.4 ug/l	
Heptachlor epoxide	0.2 ug/l	
Lead	15 ug/l	This is an ***action*** level; the former MCL of 50 ug/l was rescinded when the action level put into place.
Gamma-BHC (Lindane)	0.2 ug/l	
Mercury (II)	2 ug/l	This is an inorganic mercury value.
Methoxychlor	40 ug/l	
Microcystin	1 ug/l	

Appendix 5 (continued)

CONTAMINANT	SDWA MCL OR OTHER VALUE AS NOTED	NOTES
Nitrate as N	10 mg/l	
Nitrite as N	1 mg/l	
Oxamyl (Vydate)	200 ug/l	
Pentachlorophenol (PCP)	1 ug/l	
Phenols	1 ug/l	Value taken from Illinois water quality standards (IAC 302.304).
Picloram	500 ug/l	
Polychlorinated Biphenyls	0.5 ug/l	
Selenium	50 ug/l	
Silver	100 ug/l	This is a secondary standard.
2,4,5-TP (Silvex)	50 ug/l	
Simazine	4 ug/l	
Styrene	100 ug/l	
Tetrachloroethylene	5 ug/l	
Thallium	2 ug/l	
Toluene	1,000 ug/l	
Toxaphene	3 ug/l	
1,2,4-trichlorobenzene	70 ug/l	
1,1,1-trichloroethane	200 ug/l	
Trichloroethylene	5 ug/l	
Trihalomethanes (total)	80 ug/l	
Vinyl chloride	2 ug/l	
Xylenes (total)	10 mg/l	
Zinc	5 mg/l	This is a secondary standard.

Appendix 6

Summary of all PFAS substances analyzed from 2019 to 2021 in raw (untreated) water from Reaches 8 and 9. Samples were collected at Illinois EPA fixed water quality monitoring sites at L&D 17 (New Boston, IL), L&D 19 (Keokuk, IA), and L&D 21 (Quincy, IL). Limited sampling and analysis were conducted during the winter of 2019-2020 by public water suppliers at Warsaw, IL, and Quincy, IL. Note: a spike of PFAS substances that came through Reaches 8 and 9 in late August and early September 2021, and high values were found at all the fixed sites. This spike resulted in the similarity of maximum detected values for many of the PFAS substances.

PARAMETER	NO. OF ANALYSES	MAXIMUM DETECTED VALUE	UNITS
1H, 1H, 2H, 2H-perfluordecane sulfonate (8:2 FTS)	42	5.083	ng/l
1H, 1H, 2H, 2H-perfluorohexane sulfonate (4:2 FTS)	42	5.083	ng/l
1H,1H,2H,2H-perfluorooctane sulfonate (6:2 FTS)	25	5.083	ng/l
N-ethylperfluoro-1-octanesulfonamidoacetic acid (NEtFOSAA)	42	5.083	ng/l
N-methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)	42	5.083	ng/l
Perfluoro-1-decanesulfonate (PFDS)	42	5.083	ng/l
Perfluoro-1-heptanesulfonate	42	5.083	ng/l
Perfluoro-1-nonanesulfonate (PFNS)	42	5.083	ng/l
Perfluoro-1-octanesulfonamide (FOSA)	42	5.083	ng/l
Perfluoro-1-pentanesulfonate (PFPeS)	42	5.083	ng/l
Perfluorobutanoate (PFBA)	42	25.417	ng/l
Perfluorobutyl sulfonate (PFBS)	37	5.083	ng/l
Perfluorodecanoate (PFDA)	42	5.083	ng/l
Perfluorododecanoate	42	5.083	ng/l
Perfluoroheptanoate (PFHpA)	41	5.083	ng/l
Perfluorohexanoate (PFHxA)	42	5.083	ng/l
Perfluorohexyl sulfonate (PFHxS)	42	5.083	ng/l
Perfluorononanoate (PFNA)	42	5.083	ng/l
Perfluorooctanoate (PFOA)	42	5.083	ng/l
Perfluorooctyl sulfonate (PFOS)	33	4.828	ng/l
Perfluoropentanoate (PFPeA)	42	25.417	ng/l
Perfluorotetradecanoate (PFTreA)	42	5.083	ng/l
Perfluorotridecanoate	42	5.083	ng/l
Perfluoroundecanoate	42	5.083	ng/l

Appendix 7

Summary of analyses for drinking water contaminants listed in Appendix 5 at fixed monitoring sites and at public water supplier (PWS) intakes in Reaches 8 and 9 from December 2019 through August 2021. MCL = Maximum Contaminant Level. NA = Not Analyzed.

			REACH 8								REACH 9			
			NEW BOSTON, IL, FIXED SITE		KEOKUK, IA PWS		KEOKUK, IA, FIXED SITE		WARSAW, IL PWS		QUINCY, IL, PWS		QUINCY, IL, FIXED SITE	
CONTAMINANT	TYPE	SDWA MCL OR OTHER VALUE AS NOTED	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions
Cylindrospermopsin	Cyanotoxin	0.7 ug/l	15	0	6	0	15	0	5	0	*NA*	-	17	0
Microcystin	Cyanotoxin	0.3 ug/l	15	3	3	0	15	3	5	0	*NA*	-	8	0
Antimony	Metal	6 ug/l	12	0	3	0	12	0	3	0	3	0	14	0
Arsenic (total)	Other	10 ug/l	16	0	3	0	16	0	3	0	3	0	8	0
Barium	Metal	2000 ug/l	16	0	3	0	16	0	3	0	*NA*	-	*NA*	-
Beryllium	Metal	4 ug/l	16	0	3	0	16	0	3	0	3	0	11	0
Cadmium	Metal	5 ug/l	16	0	3	0	16	0	3	0	3	0	11	0
Chromium VI (total)	Metal	100 ug/l	16	0	3	0	16	0	3	0	3	0	11	0
Copper (action level)	Metal	Action level: 1,300 ug/l	16	0	3	0	16	0	3	0	3	0	15	0
Lead	Metal	Action level: 15 ug/l	16	0	3	0	16	0	3	0	3	0	15	0
Mercury (II)	Metal	2 ug/l	*NA*	-	*NA*	-	*NA*	-	*NA*	-	3	0	15	0
Selenium	Metal	50 ug/l	16	0	3	0	16	0	3	0	3	0	15	0
Silver	Metal	100 ug/l	16	0	3	0	16	0	3	0	3	0	11	0
Thallium	Metal	2 ug/l	12	0	3	0	12	0	3	0	3	0	11	0

Appendix 7 (continued)

			REACH 8								REACH 9			
			NEW BOSTON, IL, FIXED SITE		KEOKUK, IA PWS		KEOKUK, IA, FIXED SITE		WARSAW, IL PWS		QUINCY, IL, PWS		QUINCY, IL, FIXED SITE	
CONTAMINANT	TYPE	SDWA MCL OR OTHER VALUE AS NOTED	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions
Zinc	Metal	5 mg/l	16	0	3	0	16	0	3	0	3	0	15	0
Chloride	Other	250 mg/l	16	0	*NA*	-	16	0	*NA*	-	*NA*	-	17	0
Cyanide	Other	200 ug/l	8	0	*NA*	-	8	0	*NA*	-	*NA*	-	8	0
Fluoride	Other	4,000 ug/l	14	0	3	0	14	0	3	0	3	0	14	0
Nitrate as N	Other	10 mg/l	8	0	3	0	8	0	3	0	3	0	8	0
Nitrite as N	Other	1 mg/l	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-
PFAS	Other	70 ng/l	12	0	*NA*	-	13	0	3	0	3	0	11	0
PFOA	Other	70 ng/l	12	0	*NA*	-	13	0	3	0	3	0	11	0
Phenols	Other	1 ug/l*	10	0	3	0	10	0	3	0	3	0	11	0
2,4,5-TP (Silvex)	Pesticide	50 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
2,4-D	Pesticide	70 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
Alachlor	Pesticide	2 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
Atrazine	Pesticide	3 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
Carbofuran	Pesticide	40 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Chlordane	Pesticide	2 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Dalapon	Pesticide	200 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
Dinoseb	Pesticide	7 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
Diquat	Pesticide	20 ug/l	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-
Endothall	Pesticide	100 ug/l	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-

*From the Illinois Water Quality standards, IAC 302.304.

Appendix 7 (continued)

			REACH 8								REACH 9			
			NEW BOSTON, IL, FIXED SITE		KEOKUK, IA PWS		KEOKUK, IA, FIXED SITE		WARSAW, IL PWS		QUINCY, IL, PWS		QUINCY, IL, FIXED SITE	
CONTAMINANT	TYPE	SDWA MCL OR OTHER VALUE AS NOTED	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions
Endrin	Pesticide	2 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
Gamma-BHC (Lindane)	Pesticide	0.2 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Glyphosate	Pesticide	700 ug/l	11	0	2	0	14	0	3	0	2	0	15	0
Heptachlor	Pesticide	0.4 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
Heptachlor epoxide	Pesticide	0.2 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
Hexachlorocyclopentadiene	Pesticide	50 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Methoxychlor	Pesticide	40 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
Oxamyl (Vydate)	Pesticide	200 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Polychlorinated Biphenyls	Pesticide	0.5 ug/l	10	0	3	0	14	0	3	0	3	0	15	0
Pentachlorophenol (PCP)	Pesticide	1 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
Picloram	Pesticide	500 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
Simazine	Pesticide	4 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
Toxaphene	Pesticide	3 ug/l	12	0	3	0	14	0	3	0	3	0	15	0
1,1,1-trichloroethane	VOC	200 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
1,1-Dichloroethylene	VOC	7 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
1,2,4-trichlorobenzene	VOC	70 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
1,2-Dichloroethane	VOC	5 ug/l	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-
1,2-Dichloropropane	VOC	5 ug/l	10	0	3	0	10	0	3	0	*3*	0	*11*	0
2,3,7,8-TCDD (Dioxin)	VOC	0.00003 ug/l	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-
Benzene	VOC	5 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Benzo(a)Pyrene	VOC	0.2 ug/l	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-

Appendix 7 (continued)

			REACH 8								REACH 9			
			NEW BOSTON, IL, FIXED SITE		KEOKUK, IA PWS		KEOKUK, IA, FIXED SITE		WARSAW, IL PWS		QUINCY, IL, PWS		QUINCY, IL, FIXED SITE	
CONTAMINANT	TYPE	SDWA MCL OR OTHER VALUE AS NOTED	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions	No. samples	Excursions
Bis(2-ethylhexyl)phthalate	VOC	6 ug/l	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-
Carbon Tetrachloride	VOC	5 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Chlorobenzene	VOC	100 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
cis-1,2-Dichloroethylene	VOC	70 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Di(2-ethylhexyl)adipate	VOC	400 ug/l	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-
Dibromochloropropane (DBCP)	VOC	0.2 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Dichloromethane	VOC	5 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Ethylbenzene	VOC	700 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Ethylene dibromide	VOC	0.005 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Hexachlorobenzene	VOC	1 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
o-Dichlorobenzene	VOC	600 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
p-dichlorobenzene	VOC	75 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Styrene	VOC	100 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Tetrachloroethylene (PCE)	VOC	5 ug/l	10	0	2	0	10	0	2	0	2	0	11	0
Toluene	VOC	1,000 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Trans-1,2-Dichloroethylene	VOC	100 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Trichloroethylene (TCE)	VOC	5 ug/l	10	0	1	0	10	0	2	0	2	0	11	0
Trihalomethanes (total)	VOC	80 ug/l	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-	*NA*	-
Vinyl chloride	VOC	2 ug/l	10	0	3	0	10	0	3	0	3	0	11	0
Xylenes (total)	VOC	10 mg/l*	10	0	3	0	10	0	3	0	3	0	11	0

Appendix 8

Length and weight of fish collected from Reaches 8 and 9 in 2021 from which skin-off fillets were analyzed for PCBs, mercury, and PFAS substances. NA = Not Available.

REACH	RIVER MILE	PARENT FIELD NUMBER	FISH SPECIES	DUPLICATE SAMPLE (Y/N)	FISH TISSUE FIELD NUMBER	LENGTH (MM)	WEIGHT (GRAMS)
8	433	UMR15-0182	Common Carp	N	21018208101F009	528	NA
8	433	UMR15-0182	Largemouth Bass	N	21018208101F005	383	820
8	433	UMR15-0182	Common Carp	N	21018208101F010	523	1904
8	428	UMR15-0186	Common Carp	N	21018608171B011	493	1622
8	428	UMR15-0186	Common Carp	N	21018608171B009	508	1659
8	415	UMR15-0194	Common Carp	N	21019408161B001	483	1430
8	398	UMR15-0195	Common Carp	N	21019508181B010	520	1944
8	398	UMR15-0195	Common Carp	N	21019508181I005	523	1924
8	377.5	UMR15-0183	Largemouth Bass	N	21018309011F011	423	1371
8	377	UMR15-0187	Largemouth Bass	Y	21018709102D007	392	1163
8	377	UMR15-0187	Largemouth Bass	Y	21018709102J006	374	818
8	377	UMR15-0187	Largemouth Bass	N	21018709011J001	405	1024
8	377	UMR15-0187	Largemouth Bass	N	21018708241D001	376	380
8	377	UMR15-0187	Common Carp	N	21018708241I006	502	1578
8	377	UMR15-0187	Common Carp	N	21018708241I013	462	1318
8	377	UMR15-0187	Largemouth Bass	N	21018709011H001	376	887
8	377	UMR15-0187	Largemouth Bass	Y	21018709102J004	401	961
8	367	UMR15-0181	Largemouth Bass	N	21018109211I001	389	1154

Appendix 8 (continued)

REACH	RIVER MILE	PARENT FIELD NUMBER	FISH SPECIES	DUPLICATE SAMPLE (Y/N)	FISH TISSUE FIELD NUMBER	LENGTH (MM)	WEIGHT (GRAMS)
8	367	UMR15-0181	Largemouth Bass	N	21018109211A008	414	1147
8	363	UMR15-0189	Common Carp	N	21018909281C004	518	1684
9	357.5	UMR15-0034	Common Carp	N	2100347281C001	528	NA
9	353	UMR15-0045	Common Carp	N	21004507281A002	431	NA
9	353	UMR15-0045	Common Carp	N	21004507281G001	442	NA
9	353	UMR15-0045	Largemouth Bass	Y	21004509211B022	339	NA
9	350	UMR15-0038	Common Carp	N	21003807291G002	522	NA
9	343	UMR15-0044	Common Carp	N	21004408041G001	500	NA
9	343	UMR15-0044	Largemouth Bass	N	21004408041E011	312	NA
9	341	UMR15-0040	Common Carp	N	21004008041F018	531	NA
9	333	UMR15-0031	Largemouth Bass	N	21003109201G001	385	NA
9	329	UMR15-0039	Largemouth Bass	N	21003908021D001	309	NA
9	329	UMR15-0039	Common Carp	N	21003908021F037	490	NA
9	329	UMR15-0039	Common Carp	N	21003908021J012	473	NA
9	328.5	UMR15-0036	Common Carp	N	21003607271D002	546	NA
9	328.5	UMR15-0036	Common Carp	N	21003607271C001	459	NA
9	328.5	UMR15-0036	Largemouth Bass	N	21003607271E004	286	NA

Appendix 9

Summary of the numbers of samples analyzed for drinking water contaminants and the percentages of samples with detectable levels of contaminants during monitoring in 2020 and 2021 for the Reaches 8-9 pilot project. MCL = Maximum Contaminant Level. NA = Not Analyzed. VOC = Volatile Organic Compound.

CONTAMINANT	TYPE OF CONTAMINANT	SAFE DRINKING WATER ACT MCL OR OTHER VALUE	ANALYSES IN REACHES 8 & 9	NO. OF DETECTS	PERCENT OF SAMPLES WITH DETECTS
Cylindrospermopsin	Cyanotoxin	0.7 ug/l	140	0	0%
Microcystin	Cyanotoxin	0.3 ug/l	152	71	47%
Antimony	Mestal	6 ug/l	46	12	26%
Arsenic	Metal	10 ug/l	58	46	79%
Barium	Metal	2000 ug/l	58	58	100%
Beryllium	Metal	4 ug/l	58	1	2%
Cadmium	Metal	5 ug/l	58	1	2%
Chromium VI	Metal	100 ug/l	58	33	57%
Copper	Metal	1,300 ug/l	58	41	71%
Cyanide	Metal	200 ug/l	24	3	13%
Lead	Metal	15 ug/l	58	33	57%
Mercury (II)	Metal	2 ug/l	NA	-	-
Selenium	Metal	50 ug/l	58	5	9%
Silver	Metal	100 ug/l	58	1	2%
Thallium	Metal	2 ug/l	46	12	26%
Zinc	Metal	5 mg/l	58	42	72%
Chloride	Other	250 mg/l	139	139	100%
Fluoride	Other	4,000 ug/l	51	51	100%

Appendix 9 (continued)

CONTAMINANT	TYPE OF CONTAMINANT	SAFE DRINKING WATER ACT MCL OR OTHER VALUE	ANALYSES IN REACHES 8 & 9	NO. OF DETECTS	PERCENT OF SAMPLES WITH DETECTS
Nitrate as N	Other	10 mg/l	122	122	100%
Nitrite as N	Other	1 mg/l	NA	-	-
PFOA	Other	70 ng/l	42	0	0%
PFOS	Other	70 ng/l	42	9	21%
Phenols	Other	1 ug/l	24	6	25%
2,4,5-TP (Silvex)	Pesticide	50 ug/l	50	0	0%
2,4-D	Pesticide	70 ug/l	50	0	0%
Alachlor	Pesticide	2 ug/l	50	0	0%
Atrazine	Pesticide	3 ug/l	50	13	26%
Carbofuran	Pesticide	40 ug/l	40	1	3%
Chlordane	Pesticide	2 ug/l	40	0	0%
Dalapon	Pesticide	200 ug/l	50	0	0%
Dinoseb	Pesticide	7 ug/l	50	0	0%
Diquat	Pesticide	20 ug/l	NA	-	-
Endothall	Pesticide	100 ug/l	NA	-	-
Endrin	Pesticide	2 ug/l	50	0	0%
Gamma-BHC (Lindane)	Pesticide	0.2 ug/l	40	0	0%
Glyphosate	Pesticide	700 ug/l	47	0	0%
Heptachlor	Pesticide	0.4 ug/l	50	0	0%
Heptachlor epoxide	Pesticide	0.2 ug/l	50	0	0%
Hexachlorobenzene	Pesticide	1 ug/l	50	5	10%
Hexachlorocyclopentadiene	Pesticide	50 ug/	40	0	0%

Appendix 9 (continued)

CONTAMINANT	TYPE OF CONTAMINANT	SAFE DRINKING WATER ACT MCL OR OTHER VALUE	ANALYSES IN REACHES 8 & 9	NO. OF DETECTS	PERCENT OF SAMPLES WITH DETECTS
Methoxychlor	Pesticide	40 ug/l	50	0	0%
Oxamyl (Vydate)	Pesticide	200 ug/l	40	0	0%
Pentachlorophenol (PCP)	Pesticide	1 ug/l	50	0	0%
Picloram	Pesticide	500 ug/l	50	0	0%
Simazine	Pesticide	4 ug/l	50	0	0%
Toxaphene	Pesticide	3 ug/l	50	0	0%
1,1,1-trichloroethane	VOC	200 ug/l	40	0	0%
1,1-Dichloroethylene	VOC	7 ug/l	40	0	0%
1,2,4-trichlorobenzene	VOC	70 ug/l	40	0	0%
1,2-Dichloroethane	VOC	5 ug/l	NA	-	-
1,2-Dichloropropane	VOC	5 ug/l	40	0	0%
2,3,7,8-TCDD (Dioxin)	VOC	0.00003 ug/l	NA	-	-
Benzene	VOC	5 ug/l	40	0	0%
Benzo(a)Pyrene*	VOC	0.2 ug/l	NA	-	-
Bis(2-ethylhexyl)phthalate	VOC	6 ug/l	NA	-	-
Carbon Tetrachloride	VOC	5 ug/l	40	0	0%
Chlorobenzene	VOC	100 ug/l	40	0	0%
cis-1,2-Dichloroethylene	VOC	70 ug/l	40	0	0%
Di(2-ethylhexyl)adipate	VOC	400 ug/l	NA	-	-
Dibromochloropropane (DBCP)	VOC	0.2 ug/l	40	0	0%
Dichloromethane	VOC	5 ug/l	40	0	0%
Ethylbenzene	VOC	700 ug/l	40	0	0%

Appendix 9 (continued)

CONTAMINANT	TYPE OF CONTAMINANT	SAFE DRINKING WATER ACT MCL OR OTHER VALUE	ANALYSES IN REACHES 8 & 9	NO. OF DETECTS	PERCENT OF SAMPLES WITH DETECTS
Ethylene dibromide	VOC	0.005 ug/l	40	0	0%
o-Dichlorobenzene	VOC	600 ug/l	40	0	0%
p-dichlorobenzene	VOC	75 ug/l	40	0	0%
Polychlorinated Biphenyls	VOC	0.5 ug/l	40	0	0%
Styrene	VOC	100 ug/l	40	0	0%
Tetrachloroethylene	VOC	5 ug/l	37	0	0%
Toluene	VOC	1,000 ug/l	40	0	0%
trans-1,2-Dichloroethylene	VOC	100 ug/l	40	0	0%
Trichloroethylene	VOC	5 ug/l	37	0	0%
Trihalomethanes (total)	VOC	80 ug/l	NA	-	-
Vinyl chloride	VOC	2 ug/l	40	0	0%
Xylenes (total)	VOC	10 mg/l*	40	0	0%