FOX RIVER IMPLEMENTATION PLAN (FRIP)

Final Draft

Fox River, IL

Submitted to

FOX RIVER STUDY GROUP

Submitted by

Geosyntec consultants

engineers | scientists | innovators

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ABBREVIATIONS

µg/L	micrograms per liter
ACEP	Agricultural Conservation Easement Program
BMP	best management practice
BOD	biochemical oxygen demand
CMAP	Chicago Metropolitan Agency for Planning
CSO	combined sewer overflow
CRP	Conservation Reserve Program
day^{-1}	per day
DNR	Department of Natural Resources
DO	dissolved oxygen
EQIP	Environmental Quality Incentives Program

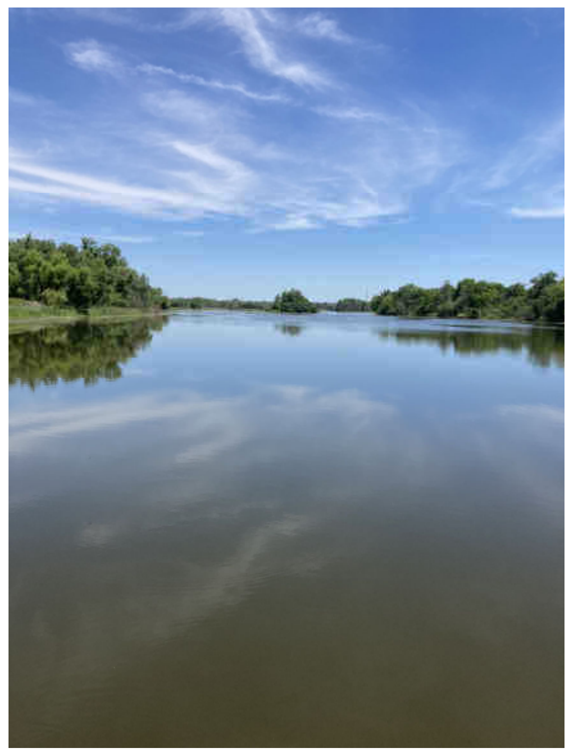
EPA	Environmental Protection Agency
FMWRD	Fox Metro Water Reclamation District
FRIP	Fox River Implementation Plan
FRSG	Fox River Study Group
FRWRD	Fox River Water Reclamation District
FWA	Fox Waterway Agency
IAC	Illinois Administrative Code
IBI	Index of Biotic Integrity
INHS	Illinois Natural History Survey
ISWS	Illinois State Water Survey
lbs	pounds
LTA	Local Technical Assistance
MCI	Macroinvertebrate Condition Index
MGD	million gallons per day
mg/L	milligram per liter
MS4	municipal separate storm sewer system
MST	microbial source tracking
ng/L	nanograms per liter
NIPC	Northeastern Illinois Planning Commission
NPDES	National Pollutant Discharge Elimination System
NWRWRF	Northwest Regional Water Reclamation Facility
P3	Public Private Partnership
QHEI	Qualitative Habitat Evaluation Index
RCPP	Regional Conservation Partnership Program
RM	river mile
SEWFRC	Southeastern Wisconsin Fox River Commission
SEWRPC	Southeastern Wisconsin Regional Planning Commission
SHAP	Stream Habitat Assessment Procedure
SMC	Stormwater Management Commission
SOD	sediment oxygen demand
Sq	square
TMDL	total maximum daily load
TP	total phosphorus
USACE	U.S. Army Corps of Engineers
USGS	United States Geologic Survey
WRDA	Water Resources Development Act
WWTP	wastewater treatment plant

SECTION 1

INTRODUCTION

1.1 Study Area

The Fox River originates in Waukesha County, Wisconsin, and drains through Southeastern Wisconsin and Northeastern Illinois into the Illinois River at Ottawa, IL (**Figure 1**). The Fox River watershed drains an area of 938 square (sq.) miles in Wisconsin and 1,720 sq. miles in Illinois. The study area for the Fox River Implementation Plan (FRIP Study Area) is the 98-mile stretch of the Fox River between the Stratton Dam in Nunda Township, McHenry County, IL and the Illinois River. The watershed area for this section of the river is 1,405 sq. miles.



Fox River at Carpentersville Dam Pool; Photo Credit: Dennis Dreher, Geosyntec Consultants

Land use in the FRIP Study Area is predominantly rural (58.9 percent) and urban (29.6 percent), with the remaining area being surface water, wetlands, and forests (11.5 percent) (**Figure 2)**. Although the FRIP Study Area watershed is only three percent of the total area in Illinois, it is home to over 10 percent of the state's population (FRSG, 2015). The Fox River is a multi-purpose resource that constitutes a critical habitat for wildlife, serves as a valuable resource for recreation, and provides source water for public water systems serving over 300,000 residents. The river is impacted by human activities such as the presence of numerous dams, discharge of treated wastewater, and urban and agricultural stormwater runoff.

There are currently 13 dams along the mainstem Fox River in the FRIP Study Area, which impound approximately 42 percent of the river length from Stratton Dam to the mouth of the Fox River. (**Figures 2 & 3**). The North Avenue Dam (in Aurora) and the South Batavia Dam were removed in 2005 and 2006, respectively. The ten dams on the Fox River between Carpentersville and Yorkville (**Figure 3**) are "run of the river" dams built in the nineteenth century first used to power sawmills and flour mills, and then later used for other basic mechanical and hydroelectric power applications. These dams have had an adverse impact on water quality and aquatic life in the river (Santucci et al. 2005).

Municipal wastewater treatment plants (WWTPs), as a major source of nutrient loading to the Fox River, also impact water quality. There are 16 major WWTPs that discharge to the mainstem Fox River with design flows ranging from 1.25 to 42 million gallons per day (MGD). Fox River tributaries also receive treated wastewater from eight major WWTPs with design flows ranging from 1 to 5.8 MGD. **Figure 2** shows the location of WWTPs in the FRIP Study Area. The average design flow for each WWTP is presented in

Table 1**.**

Sources of urban runoff into the Fox River and its tributaries include stormwater conveyed by Municipal Separate Storm Sewer Systems (MS4s) and combined sewer overflows (CSOs), serving urban areas within the FRIP Study Area. The 76 MS4s cover about 504 sq. miles (36 percent) of the study area. CSO outfalls are owned by the City of Aurora, City of Batavia, City of Elgin, Fox River Water Reclamation District (FRWRD) and Fox Metro Water Reclamation District (FMWRD).

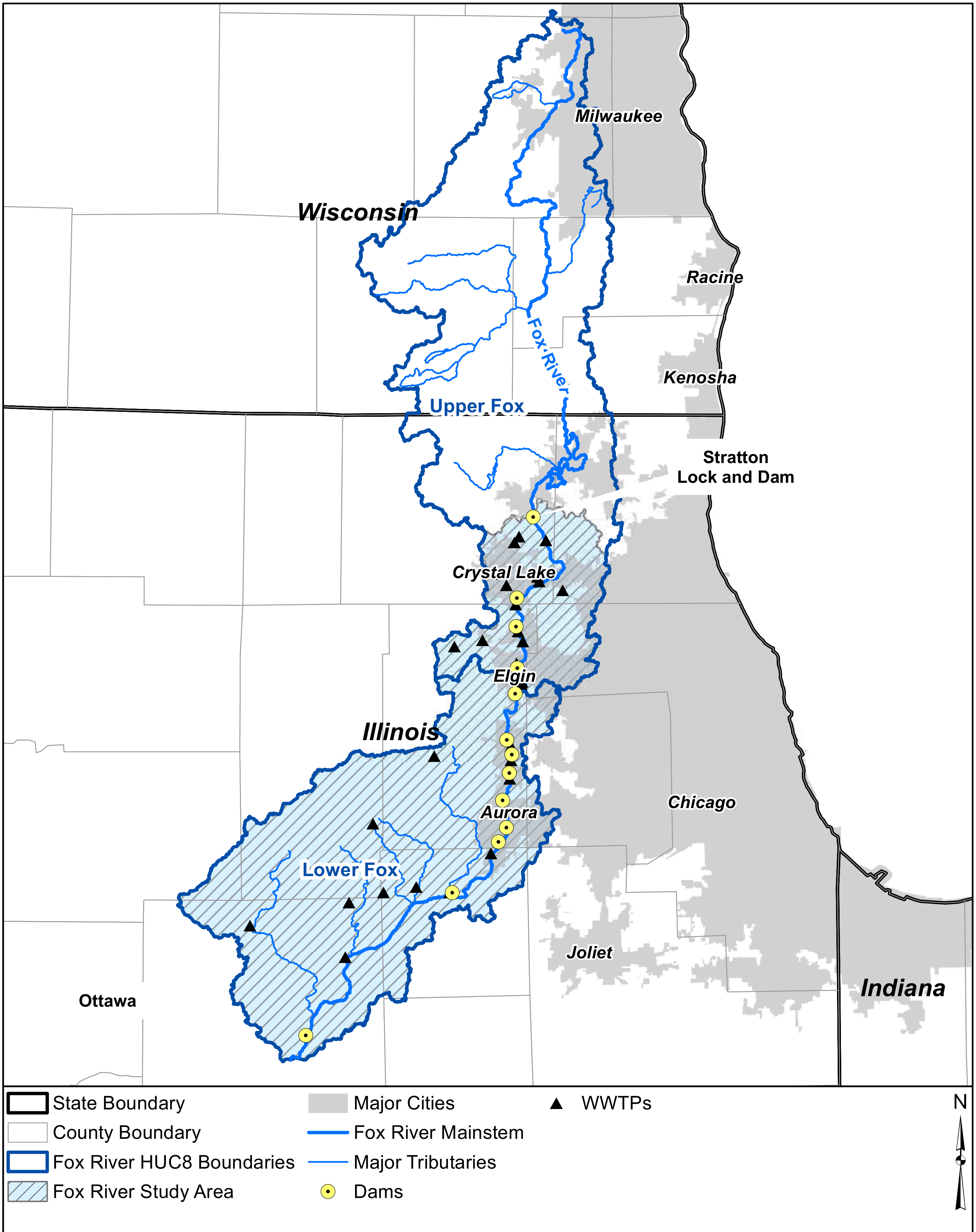


Figure 1: Fox River Study Area

Table 1: WWTPs in the FRIP Study Area

Wastewater Treatment Plant (WWTP)	Average Design Flow (MGD)	Receiving Water Body
N. Moraine Wastewater Reclamation District	2.0	Fox River mainstem
Cary	2.8	
Fox R. Grove	1.3	
Algonquin	5.0	
Carpentersville	4.5	
E. Dundee	2.3	
FRWRD N.	7.8	
FRWRD S.	25	
FRWRD W.	5.0	
St. Charles	9.0	
Geneva	5.0	
Batavia	4.2	
Fox Metro Water Reclamation District	42.0	
Yorkville-Bristol Sanitary District (YBSD)	3.6	
Sheridan	0.4	
Wauconda	1.9	Fiddle Creek
Terra Cotta	0.1	Sleepy Hollow Creek
Crystal Lake WWTP#3	1.7	Unnamed tributary of Sleepy Hollow
Crystal Lake WWTP#2	5.8	Crystal Creek (Crystal Lake Outlet)
Lake in the Hills SD	4.5	Crystal Creek (Crystal Lake Outlet)
Barrington	3.7	East Branch Flint Creek
Pingree Grove	0.7	Unnamed tributary of Tyler Creek
Gilberts	1.0	Tyler Creek
Elburn	1.3	Welch Creek
Plano	2.4	Big Rock Creek
Hinckley	0.5	Little Rock Creek
Sandwich	1.5	Harvey Creek, tributary to Little Rock Creek
Somonauk	0.3	Somonauk Creek
Earlville	0.4	unnamed tributary of Indian Creek
St. Charles Westside	0.7	Mill Creek

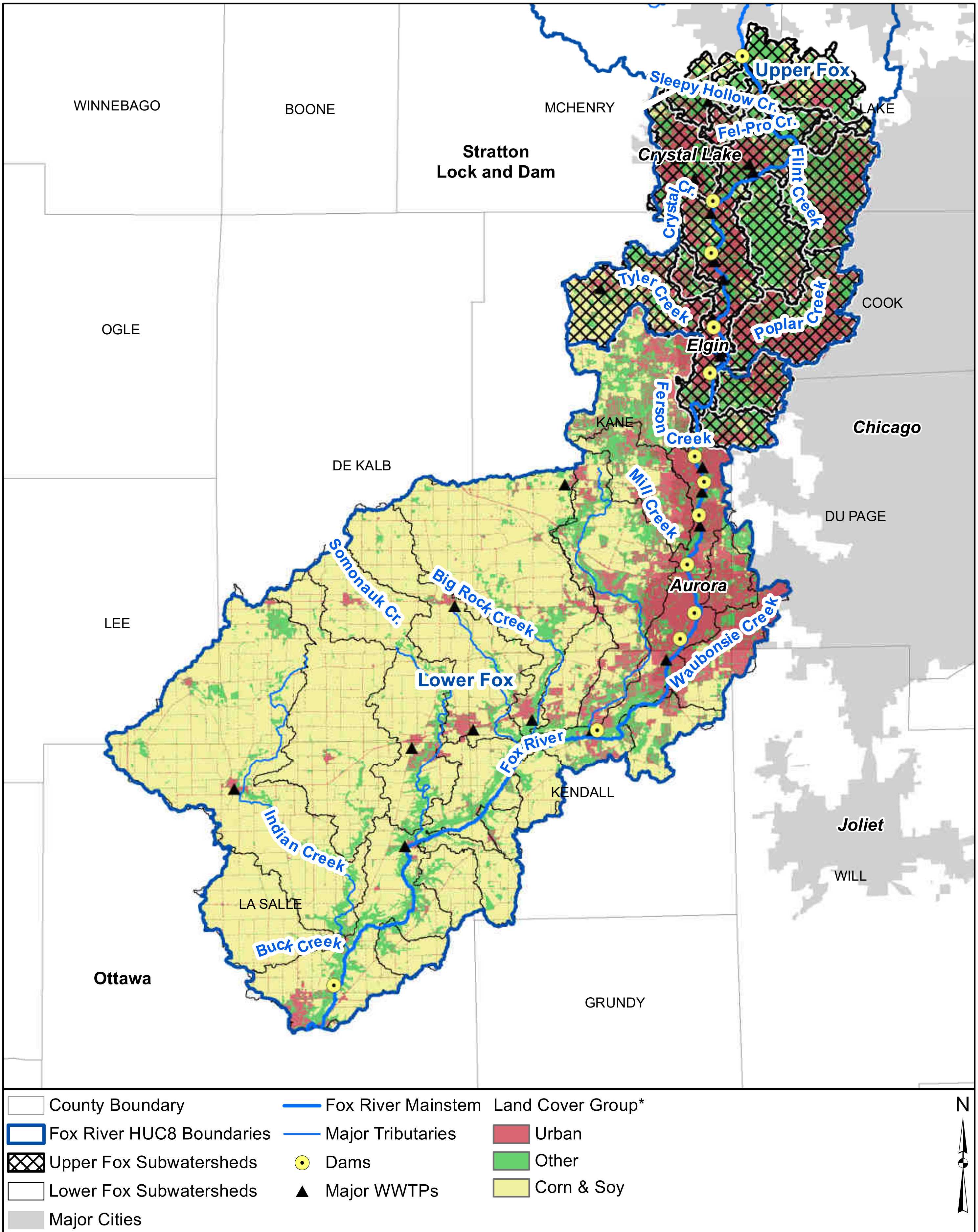


Figure 2: Land Use in the FRIP Study Area

*Modified from the 2019 National Land Cover Dataset

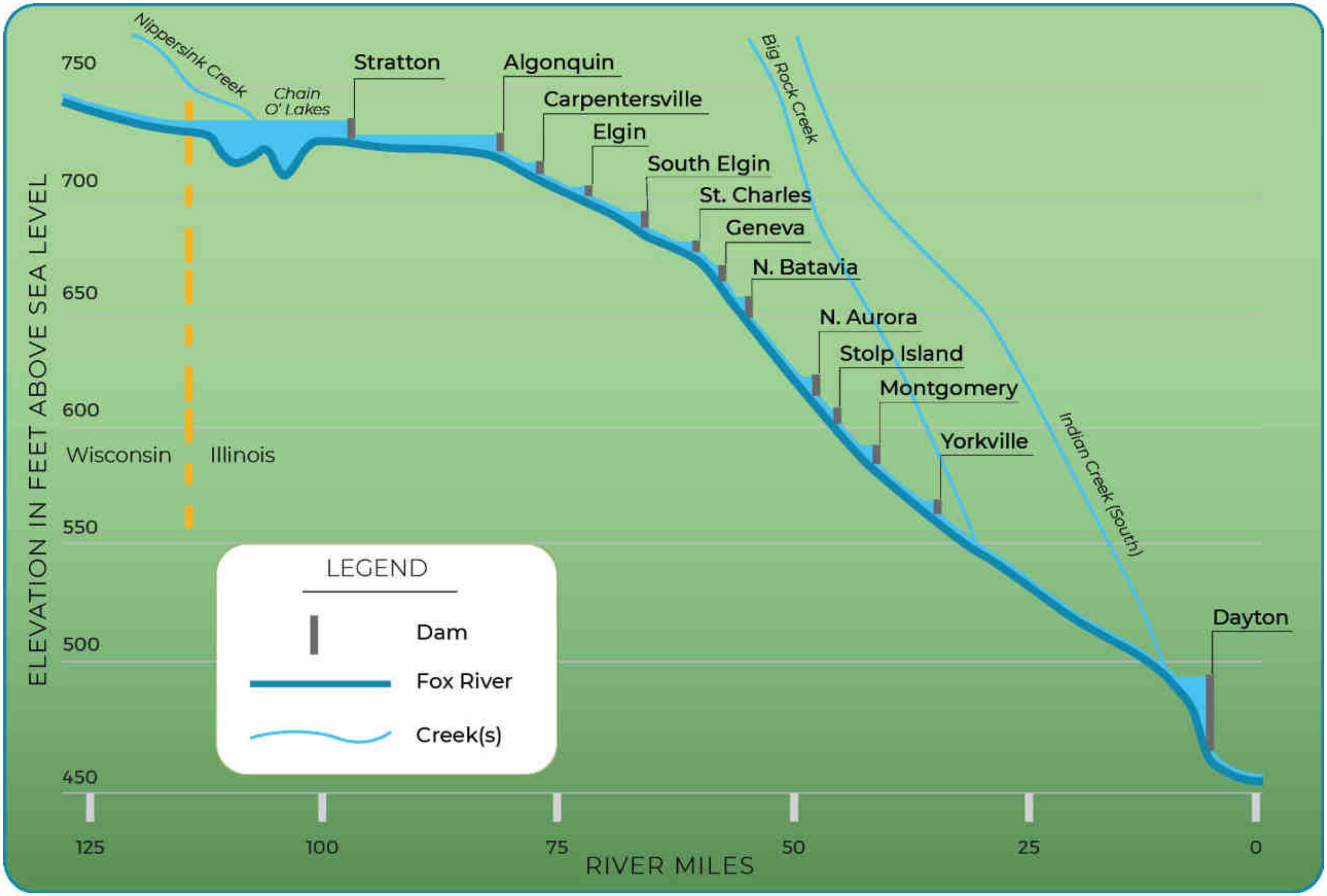


Figure 3: Dams on the Fox River

1.2 Purpose of the Fox River Implementation Plan

The Fox River Study Group (FRSG) is a regional collaboration to resolve water quality issues in the Fox River in the absence of state water quality standards for identified contributing factors to the river's impairments. The FRSG was formed in 2001 after the Illinois Environmental Protection Agency (Illinois EPA) added the Fox River to its list of impaired waters under Section 303(d) of the Clean Water Act for phosphorus-related impairments for aquatic life and aesthetic quality use. Participants include WWTPs, private and non-profit entities, planning agencies, municipalities, and other government agencies. A complete list of participants is located on the FRSG's website.

Algae bloom on the Fox River in 2012; Photo Credit: Karen Clementi

The main goal of the FRSG is to address aquatic life and water quality impairments in the Fox River, particularly related to dissolved oxygen (DO), algae, and total phosphorus. The algae levels in the Fox River are a major concern as the river serves as a drinking water source for 300,000 people. Algal blooms have caused taste and odor problems for drinking water suppliers in the past, and the potential for a toxic algal bloom caused by cyanobacterial toxins is an ever-present concern.

The FRSG developed a Fox River Implementation Plan (2015 FRIP) in 2015 and submitted it to Illinois EPA (FRSG, 2015). As there were concerns with inadequacies with the modeling performed for the 2015 FRIP, this plan update (2022 FRIP) is based on improved modeling and provides a roadmap and proposed watershed improvement projects to address impairments in the study area (Section 1.2). The impairments include nuisance algae, low DO, large diel DO swings, and high phosphorus concentrations.

Table 2 identifies the reaches of the mainstem Fox River that are listed as impaired, including the designated uses and the cause of impairments. **Figure 4** identifies the reaches of the mainstem Fox River that are on the updated Section 303(d) list in the FRIP Study Area due to phosphorus-related impairments (Illinois EPA, 2022).

The 2022 FRIP update is required as a special condition in the National Pollution Discharge Elimination System (NPDES) permits for the major municipal WWTPs in the watershed with a required completion date of December 31, 2022. The special condition language indicates that the WWTPs are to work with the FRSG to "determine the most cost-effective means to address the DO and nuisance algae impairments in the Fox River to the extent feasible." The FRSG adopted a multi-year and multi-phased project approach for developing the FRIP (Section 1.3.5). The original 2015 FRIP (FRSG, 2015) was based on a computer model that had several issues including the counterintuitive result that dam removal would not improve water quality (described in detail in Section 3.1.2). Hence, the 2015 FRIP did not include a recommendation for dam removal. Due to the modeling issues, Illinois EPA updated the NPDES special conditions for the study area WWTPs. The major WWTPs were required to reduce TP effluent to one milligram per liter or mg/L (annual average) by 2022 and 0.5 mg/L (12-month rolling geometric mean) by 2030 as part of the NPDES special conditions. The special conditions also required the permittees to work with the FRSG to collect additional data, improve the model, and submit an updated FRIP. The FRSG has continued several studies to collect additional data since 2015 (Section 1.3.6). The FRSG also engaged Geosyntec Consultants, Inc. (Geosyntec) in December 2018 to address the modeling issues and update the FRIP. The current document (2022 FRIP) supersedes the 2015 FRIP.

The MS4 communities have obtained coverage for urban stormwater discharges under Illinois' General NPDES Permit ILR40. Special condition C of the permit requires permittees to provide a schedule for meeting wasteload allocations in total maximum daily loads (TMDLs) or watershed management plans. As phosphorus is present in urban runoff, the FRIP serves as the watershed management plan for these communities.

Table 2: Fox River Mainstem Impaired Reaches and Causes (Illinois EPA, 2022)

Segment	Length	Downstream River Mile	Upstream River Mile	Cause of Impairment by Designated Use				
				Aquatic Life	Aesthetic Quality	Fish Consumption	Primary Contact	Public and Food Processing Water Supply
IL_DT-22	7.86	89.84	97.70	Algae, CauseUnk, FlowMod, Sed/Silt, StreamAlt	F	Aldrin, Dieldrin, Endrin, Heptachlor, Hg, Mirex, PCBs, Toxaphene	FC	
IL_DT-06	8.06	81.78	89.84	Algae, CauseUnk, FlowMod, StreamAlt	F	Hg, PCBs	F	
IL_DT-20	7.23	74.55	81.78	**DO**, FlowMod, StreamAlt	X	Hg, PCBs	X	
IL_DT-18	5.90	68.65	74.55	CauseUnk, **DO,** FlowMod, HCB, N, Sed/Silt, StreamAlt, TSS	X	Aldrin, Dieldrin, Endrin, Heptachlor, Hg, Mirex, PCBs, Toxaphene	FC	F
IL_DT-09	8.15	60.50	68.65	F	F	Aldrin, Dieldrin, Endrin, Heptachlor, Hg, Mirex, PCBs, Toxaphene	FC	
IL_DT-58	3.76	56.74	60.50	**DO**, FlowMod, StreamAlt	X	Hg, PCBs	FC	
IL_DT-69	4.51	52.23	56.74	F	F	Aldrin, Dieldrin, Endrin, Heptachlor, Hg, Mirex, PCBs, Toxaphene	FC	
IL_DT-38	10.83	41.40	52.23	**Algae**, FlowMod, StreamAlt, **TP**, TSS	F	Aldrin, Dieldrin, Endrin, Heptachlor, Hg, Mirex, PCBs, Toxaphene	FC	F
IL_DT-03	7.37	34.03	41.40	F	**Algae, TP**	Aldrin, Dieldrin, Endrin, Heptachlor, Hg, Mirex, PCBs, Toxaphene	FC	
IL_DT-11	5.00	29.03	34.03	Aldrin, **Algae**, FlowMod, pH, Sed/Silt, **TP**, TSS	**Algae, TP**	Hg, PCBs	FC	
IL_DT-41	11.01	18.02	29.03	F	**Algae, TP**	Hg, PCBs	X	
IL_DT-02	11.00	7.02	18.02	F	X	Hg, PCBs	X	
IL_DT-36	2.63	4.39	7.02	**Algae**, CauseUnk, pH	**Algae, TP**	Aldrin, Dieldrin, Endrin, Heptachlor, Hg, Mirex, PCBs, Toxaphene	X	
IL_DT-46	3.71	0.68	4.39	F	F	Aldrin, Dieldrin, Endrin, Heptachlor, Hg, Mirex, PCBs, Toxaphene	X	
IL_DT-01	3.23	-2.55	0.68	**Algae**, CauseUnk, FlowMod, Sed/Silt, StreamAlt, TSS	**Algae, TP**	Hg, PCBs	FC	

Notes:

CauseUnk - Cause Unknown; DO - Dissolved Oxygen; F - Fluoride; FC - Fecal Coliform; FlowMod - Flow Regime Modification; HCB - Hexachlorobenzne
Hg – Mercury; N - Nitrogen; PCBs - Polychlorinated Biphenyls; Sed/Silt - Sedimentation/Siltation; StreamAlt - Alteration in Stream-side or littoral vegetative covers;
TP - Total Phosphorus; TSS - Total Suspended Solids; X - Not Assessed

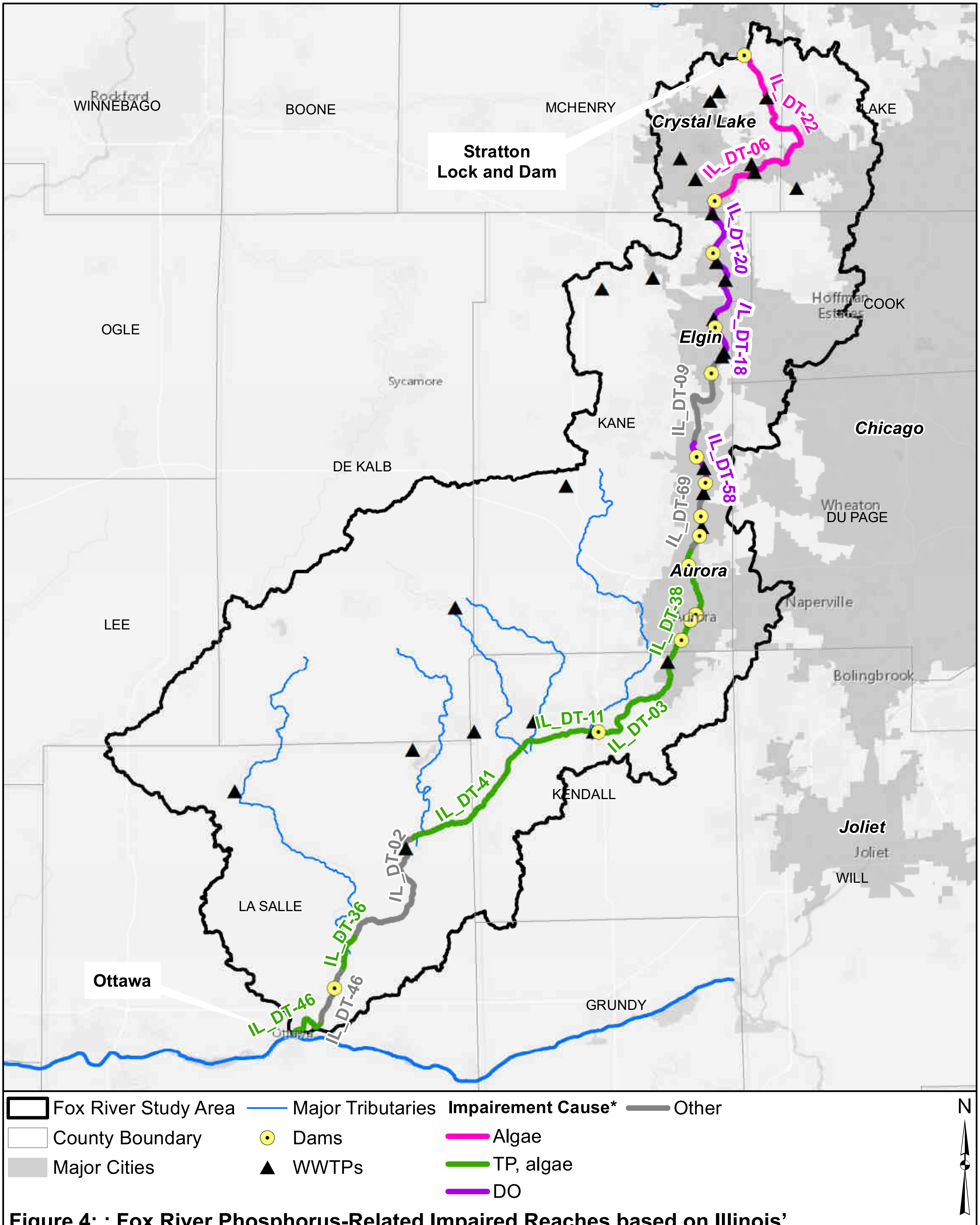


Figure 4: : Fox River Phosphorus-Related Impaired Reaches based on Illinois' Integrated Water Quality Report

*IEPA 303(d) Streams (2022)

1.3 Water Quality Studies and Management Plans

There have been extensive water quality studies and management plans for the Fox River and its tributaries within the study area. Summaries of relevant studies and management plans are provided below.

1.3.1 Illinois State Water Survey Studies

The Illinois State Water Survey (ISWS) has conducted water quality surveys for Illinois streams, including the Fox River, since the late 19th Century (Harmeson and Larson, 1969; Harmeson et al., 1973). These surveys serve as good reference points for changing water quality conditions in the Fox River over time. Data on nutrient concentrations collected between 1956 and 1971 showed an apparent decrease in phosphate concentrations at the Algonquin station from 1960 to 1961 and 1966 to 1971. Results also showed higher phosphate concentrations at the Batavia station than the Algonquin (located on the upstream end of the study area) and Dayton (located on the downstream end of the study area) stations. ISWS recently conducted a trend analysis of water quality data in the FRIP Study Area, which is described in Section 2.4.

1.3.2 Fox River Fish Passage Feasibility Study

Santucci and Gephard (2003) assessed the impact of low head dams on fish and macroinvertebrate populations, aquatic habitat, and water quality in the Fox River between McHenry and Dayton, IL. The study included sampling of fish, macroinvertebrates, and aquatic habitat from July to September 2000 at 40 stations. Continuous and discrete water quality monitoring was conducted at 11 free-flowing and 11 impounded station stations from August to September 2001. The study also assessed the quality of habitat in the impounded and non-impounded reaches. Finally, the study provided recommendations for removal and modification for each of the low head dams.

Results showed dams have an adverse impact on the aquatic life, habitat, and water quality in the Fox River. The non-impounded reaches of the river had a higher quantity and quality of fish (average Index of Biotic Integrity or IBI score of 31), as compared to the impounded reaches created by the dams (IBI scores of less than 31). The mean Macroinvertebrate Condition Index scores (MCI; a multi-metric index developed for the Fox River) for stations in non-impounded reaches was almost double the scores for the impounded reaches. The non-impounded reaches were determined to have good quality habitat based on Qualitative Habitat Evaluation Index (QHEI) and Stream Habitat Assessment Procedure (SHAP), while the impounded reaches were found to have several degraded habitats. The stations in impounded reaches had higher fluctuations of DO with DO ranging from 2.5 to >20 mg/L, as compared to non-impounded reaches stations (with DO ranging from 5 to 10 mg/L). The study concluded that dam removal is the most cost-effective option to address the adverse impacts associated with low-head dams on the Fox River.

1.3.3 Northeastern Illinois Planning Commission Studies

The Northeastern Illinois Planning Commission (NIPC) developed the Areawide Water Quality Management Plan under Section 208 of the Clean Water Act in 1979 (NIPC, 1979). This plan was subsequently submitted to Illinois EPA for adoption. The plan included detailed analyses and recommendations for the Fox River watershed in McHenry, Lake, and Kane counties. NIPC worked collaboratively with agencies such as Illinois EPA, the ISWS, the Illinois Natural History Survey (INHS), and the Metropolitan Water Reclamation District of Greater Chicago to collect data and evaluate water quality, sediment quality, and aquatic life conditions in the river. The study process included:

- Collecting diurnal water quality samples for 19 parameters at seven stations within the Fox River basin for 13 months (April 1976 to April 1977). This data was used to calibrate a continuous simulation water quality model, described below.

- Measurement of sediment oxygen demand (SOD) at 30 stations to estimate oxygen consumption by benthic organisms. In general, results showed that most of the Fox River is classified as slightly degraded to moderately polluted. Two stations (river miles or RMs 50.4 and 48.1) were classified as heavily polluted, and six (RMs 74.7, 58.8, 54.2, 46.8, 44.9, and 36.8) were classified as polluted (Butts et al. 1978a).

- A dam aeration-reaeration study for 14 dams along the Fox River (Butts et al. 1978b). Results showed algal blooms above the dams due to the low velocities and nutrient-enriched conditions. In addition, DO measurements upstream and downstream of the dams confirmed extreme variations in diurnal DO levels, generally lower DO levels in dam pools in violation of water quality standards, and a “deaeration” phenomenon where algal-induced high DO concentrations were rapidly lowered as water passed over the dam crest through a reaeration zone. NIPC concluded that dams generally have a negative impact on Fox River water quality conditions.

In addition to the above, NIPC calibrated and applied a computer model to evaluate the existing and year 2000 forecasted future water quality conditions of the Fox River. The existing conditions simulation results showed that the major pollutant contributors are the upstream boundary (water coming from Wisconsin), WWTPs, and urban and agricultural runoff. Furthermore, the model showed violations of the DO criterion in several reaches within the Fox River and its tributaries. Low mainstem DO concentrations were attributed to biochemical oxygen demand (BOD) loadings from municipal WWTPs, oxygen depletion in dam pools due to elevated algal concentrations and exacerbated low DO during low flows due to the river’s limited ability to assimilate pollutants. Low DO concentrations in the tributaries were attributed to nonpoint source loadings during wet weather conditions.

1.3.4 Upper Fox River TMDL

The upstream load to the FRIP Study Area includes loading from the Fox River watershed upstream of Stratton Dam, with a drainage area of 1,250 square miles in Wisconsin and Illinois. Although located upstream of the FRIP Study Area, this area is relevant since upstream nutrient loading impacts the water quality in the FRIP Study Area. The portion of the Fox River watershed in Wisconsin has no formal TMDL or completed watershed-wide analysis. The portion upstream of Stratton Dam in Illinois includes the Chain O'Lakes, a series of 15 lakes connected by the Fox River, which has been identified as being impaired for phosphorus (Illinois EPA, 2022). The Illinois EPA has developed two TMDLs for this portion of the Fox River. The total phosphorus (TP) targets for the lakes in both of these TMDLs is 0.05 mg/L, the Illinois General Use Water Quality Standard for lakes (35 Ill. Adm. Code 302.205). TMDLs were not developed for other impairments (i.e., total suspended solids and sediment/siltation) due to the lack of numerical water quality standards.

The Upper Fox River/Chain O' Lakes TMDL focused on the impairments in the Chain O' Lakes watershed in Illinois (CDM Smith, 2020a). The Upper Fox River/Flint Creek Watershed TMDL addresses impairments in 14 impaired waterbody segments within the Upper Fox River downstream of the Chain O'Lakes (CDM Smith, 2020b). The Fox Waterway Agency (FWA) is currently in the process of completing a watershed-based plan for this area, with an anticipated completion date of 2024. Once the plan is complete and approved by Illinois EPA, the FWA will be able to pursue funding for implementation projects. The TMDL impairments were addressed through a load reduction target and implementation strategies. Results of these TMDLs and the watershed-based plan could provide the basis for future reductions in the upstream load.

1.3.5 2015 Fox River Implementation Plan

The FRSG developed the 2015 FRIP through a multi-year and multi-phased approach from 2003 to 2015. Each phase is summarized below.

Phase 1: The first phase involved the review of water quality studies to identify water quality problems, possible causes, data gaps, and appropriate watershed and water quality models (McConkey et al., 2004). A water quality database was also developed.

Phase 2: The second phase involved the collection of water quality data. FRSG has collected monthly water quality data on the Fox River and major tributaries since April 2002 at 14 locations. The ISWS monitored conditions during storm events for the FRSG for two water years during 2009-2011. The FRSG and ISWS also conducted intensive low flow monitoring in 2012, including continuous and discrete water quality monitoring.

Phase 3: The third phase involved the development of watershed loading and receiving water models for the study area to evaluate the impacts of phosphorus load reductions on improving DO and reducing nuisance algae. The ISWS developed two types of models for the FRIP Study Area: Hydrological Simulation Program – FORTRAN (HSPF) watershed models for the mainstem and tributaries and a QUAL2K receiving water quality model for the mainstem (Bartosova, 2013a). The ISWS provided detailed documentation on the HSPF models in a series of reports (Bartosova 2007a, 2007b, 2007c, 2011, 2013a, 2013b).

While the ISWS QUAL2K model served as a good tool for water quality evaluation, the model did not accurately predict SOD and could not assess the impact of nonpoint source load reductions. As a result, FRSG tasked LimnoTech with updating and recalibrating the QUAL2K model using the low flow data collected in 2012. However, the recalibrated model did not accurately predict the diurnal fluctuations in DO and provided counter-intuitive results on the impacts of dam removals on Fox River water quality.

Phase 4: The final phase involved applying both models developed under Phase 3 to evaluate and identify watershed management actions that reduce phosphorus loads in the Fox River. The findings and a summary of the QUAL2K model limitations were presented in the final 2015 FRIP report and submitted to the Illinois EPA for review.

The FRSG and its members have undertaken several actions since the submission of the 2015 FRIP. This includes data monitoring (Section 1.3.6), water quality trend analysis (Section 2.4), modeling updates (Section 3.1), and WWTP upgrades (Section 2.2).

1.3.6 Studies Performed Since the 2015 FRIP Submittal

The FRSG has conducted several studies since the 2015 FRIP submittal. The data collected during the studies were utilized for the modeling updates described in Section 3.2. The studies are listed below, and are described in detail in *Appendix A: Studies Conducted Post 2015 FRIP*.

- United States Geological Survey Sonde Studies
- FRSG Monthly Monitoring
- FRSG 2016 Low-Flow Intensive Monitoring
- FMWRD Monthly Monitoring and Sondes
- Carpentersville Dam Pre-removal Studies
- Fox River Fish Tissue Contamination Data Analysis
- Public Opinion Surveys on Dam Removal (two conducted)

The FRSG has supported the following studies since 2015:

- US Army Corps of Engineers (USACE) Fox River Connectivity & Habitat Study
- Watershed Based Plan Development for Mill Creek and Indian Creek subwatersheds

The next section of the FRIP describes the status of water quality in the Fox River including the water quality standards, nutrient sources in the watershed, and a water quality trends analysis.

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SECTION 2

WATER QUALITY STATUS

2.1 Water Quality Standards

The current FRIP retains the focus on DO and nuisance algae impairments, but also includes recommendations for addressing other impairments such as sedimentation/siltation and fecal coliform. A brief summary of water quality standards in the Fox River is provided below.

2.1.1 DO and Nuisance Algae

The standards for DO and nuisance algae are described in Illinois Administrative Code (Ill. Adm. Code or IAC) rules for water quality standards (35 Ill. Adm. Code 302 and 35 Ill. Adm. Code 303).

The DO standard is dependent on the time of the year. It includes three components: (1) an instantaneous criterion, (2) a daily mean averaged over seven days, and (3) a daily mean averaged over 30 days. The segment of the Fox River in the FRIP Study Area from RM 30.4 (Illinois EPA assessment unit IL DT-38, Mill Creek Batavia to Waubonsee Creek Oswego) to RM 50.8 (Illinois EPA assessment unit IL DT-03, Waubonsee Creek Oswego to Blackberry Creek Yorkville) must meet more stringent DO criteria as defined in Section 302.206 (c) of the state water quality standards. This enhanced criterion is due to the presence of fish species that require higher levels of DO compared to the requirements for general use waters. The DO criteria for general use waters are defined in Section 302.206 (b). **Table 3** presents the DO standards for the mainstem Fox River reaches in the FRIP Study Area.

There is no numeric standard for nuisance algae in Illinois. The provisions of Section 302.203 are a narrative description for the offensive condition in streams that is applicable to mainstem Fox River reaches: "*Waters of the State shall be free from sludge or bottom deposits, floating debris, visible oil, odor, plant or algal growth, color or turbidity of other than natural origin"*. The Illinois EPA uses a visual assessment by a trained biologist to determine whether a stream complies with these provisions. The biologist documents the visual results assessment in a field form along with the offensive condition such as excessive plant or algal growth.

The FRSG determined an appropriate numeric threshold for nuisance algae (measured as water column sestonic chlorophyll-a) based on a review of documented visual assessments of the Fox River reaches. Illinois EPA had conducted 346 visual assessments for 14 reaches of the mainstem Fox River from May 2012 to February 2020 as part of the agency's intensive basin survey program. A total of 47 assessments were conducted when the flow in the Fox River was below target low flow thresholds. FRSG has defined the target low flow thresholds in the Fox River as 523 cubic feet per second (cfs) and 360 cfs for the United States Geologic Survey (USGS) Montgomery and Algonquin gages, respectively. The chlorophyll-a levels in the Fox River ranged from 16 to 292 micrograms per liter (µg/l) for the 47 assessments made under flow conditions lower than the target thresholds.

Ilinois EPA reported an offensive condition for eight out of the 47 visual assessments. For the 39 assessments where an offensive condition was not reported, the chlorophyll-a levels ranged from 16 to 271 µg/L with an average of 149 µg/L. The chlorophyll-a levels for the remaining eight assessments, which did report an offensive condition, ranged from 154 to 292 µg/L. Based on this analysis, FRSG selected the value of 149 µg/L for sestonic chlorophyll-a as a metric to indicate when the Fox River is not likely to be listed as impaired by Illinois EPA staff for offensive conditions due to algae. This metric is for the purposes of management scenario evaluation only, and it should not be considered as a water quality standard.

Table 3: Dissolved Oxygen Water Quality Standards for the Mainstem Fox River

	Stratton Dam to Illinois River, except RM 30.4 to 50.8		RM 30.4 to 50.8	
	March through July	August through February	March through July	August through February
Instantaneous (mg/L)	5.0	3.5	5.0	4.0
Daily mean averaged over seven days (mg/L)	6.0	4.0	6.25	4.5
Daily mean averaged over 30 days (mg/L)	N/A	5.5	N/A	6.0

2.1.2 Total Phosphorus

The Illinois EPA 303 (d) list identifies TP as a cause of impairment for several of Fox River reaches, but there is no numeric or narrative water quality standard for TP in rivers and streams in Illinois.

From 2015 to 2018, a Nutrient Science Advisory Committee consisting of science experts met and developed recommendations for water quality standards for non-wadeable streams and rivers and wadeable streams for Illinois' southern and northern ecosystems. They recommended TP, total nitrogen, benthic chlorophyll-a, and water column chlorophyll-a standards. (Illinois NSAC, 2018). The recommended TP criterion for non-wadeable streams in a northern Illinois ecosystem like the Fox River was 113 µg/L. The Illinois EPA has not acted on the NSAC recommendations.

2.1.3 Fecal Coliform

The fecal coliform standard is defined in IAC Section 302.209 as "*During the months May through October, based on a minimum of five samples taken over not more than a 30 day period, fecal coliform (STORET number 31616) shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10% of the samples during any 30 day period exceed 400 per 100 ml in protected waters.*" Protected waters are defined as supporting or having the physical characteristics to support primary contact recreation; they can also be defined as flowing through or being adjacent to parks or residential areas.

2.1.4 Sedimentation/Siltation, Sludge and Bottom Sediment

There is no numeric standard for sedimentation/siltation, sludge and bottom sediment in Illinois. The provisions of IAC Section 302.203 are a narrative description for the offensive condition in streams that is described in Section 2.1.1.

2.1.5 Other Fox River Impairments

Several reaches of the Fox River are listed as impaired for fish consumption, aquatic life, and aesthetic quality due to toxic chemical constituents. The standards for these constituents are specified in IAC Section 302.208 and presented in **Table 4** below. An assessment of impairments using recent data should be conducted to determine if these impairments still exist or if additional impairments are present.

Table 4: Chemical Constituent Standards for the Mainstem Fox River

Constituent	Acute Criterion	Chronic Criterion	Human Health Criterion
Aldrin (ng/L)	~3	-	-
Dieldrin (µg/L)	0.24	~0.056	-
Endrin (ng/L)	160	33	-
Heptachlor (ng/L)	520	3.8	-
Mercury – Total (ng/L)	2.6	1.3	0.012
Mirex (ng/L)	-	1	-
Fluoride (µg/L)	$e^{A+Bln(H)}$, where A = 6.7319 and B = 0.5394	$e^{A+Bln(H)}$, but shall not exceed 4.0 mg/L, where A = 6.0445 and B = 0.5394	-
Hexachlorobenzene (ng/L)	-	-	-
Polychlorinated Biphenyls (ng/L)	-	-	-
pH	6.5	9.0	-
Toxaphene (ng/L)	~730	~0.2	-

Notes:
µg/L- microgram per liter
ng/L- Nanogram per liter

2.3 Nutrient Sources in the Fox River Watershed

The main nutrient sources in the Fox River include point source loading from major WWTPs, loadings from areas upstream of Stratton Dam, and nonpoint source loading from surface runoff. Nonpoint sources can be grouped into three major categories:

- Agriculture (mainly cropped land, primarily used to grow corn and soybeans, and pastureland)
- Urban (developed and open space in urban areas)
- Other (forest, rural grassland, surface water, and wetlands)

The distribution of these land uses within the FRIP Study Area is shown in **Figure 2**.

The ISWS evaluated TP contributions from the main nutrient sources from 1990 to 2011 based on HSPF modeling results and measured data (ISWS, 2014). WWTPs were the largest TP load contributor during this period, with 53 percent of the total load in the FRIP Study Area. Agricultural sources were the second largest contributor with 26 percent, while the upstream boundary contributed nine percent of the total TP load. Finally, urban runoff contributed six percent of the total TP load in the study area.

As a part of the current FRIP update, Geosyntec updated the HSPF models for 2012 to 2016 to reflect the existing conditions and hydrology in the watershed more accurately. Geosyntec performed a similar analysis as the ISWS study using more recent data from 2012 to 2016. In addition to the relative contribution of different nutrient sources, Geosyntec also evaluated the projected TP load reduction from WWTPs to reflect future TP effluent limits of 1.0 mg/L and 0.5 mg/L. The results of this analysis are described in *Appendix B: Current Loading Sources in Watershed* and are briefly summarized below.

Total annual and average annual TP loads were calculated for the entire FRIP Study Area as well as for the upper Fox River and lower Fox River watershed portions of the study area. The Upper FRIP Study Area is the watershed between Stratton Dam and the confluence of Fox River and Ferson Creek. The Lower FRIP Study Area is the watershed between the confluence of Fox River and Ferson Creek to the confluence of Fox River and the Illinois River **(Figure 2)**.

Figure 5 provides the annual average percentage contribution of TP from different sources for the Upper, Lower, and entire FRIP Study Area watersheds from 2012 to 2016. The total simulated annual average TP load for the entire study area from 2012 to 2016 is 1.9 million pounds (lbs). Approximately 42 percent of this load is from agricultural sources, while 37 percent comes from WWTPs. The loading from non-major WWTPs and other NPDES discharges constitutes a smaller portion of the TP loading into the Fox River. Urban runoff accounts for four percent of the TP load. Most urban loading comes from the Poplar Creek, Brewster Creek, Jelkes Creek, Norton Creek, Mill Creek, and Indian Creek (Aurora) subwatersheds. The upstream contributions account for 11 percent of the average annual TP load from 2012 to 2016.

The Upper FRIP Study Area accounted for about 351,000 lbs of TP load with the WWTPs comprising about 77 percent of this load. The TP load generated in the Lower FRIP Study Area was about 1.3 million lbs, with agriculture comprising 58 percent of this load.

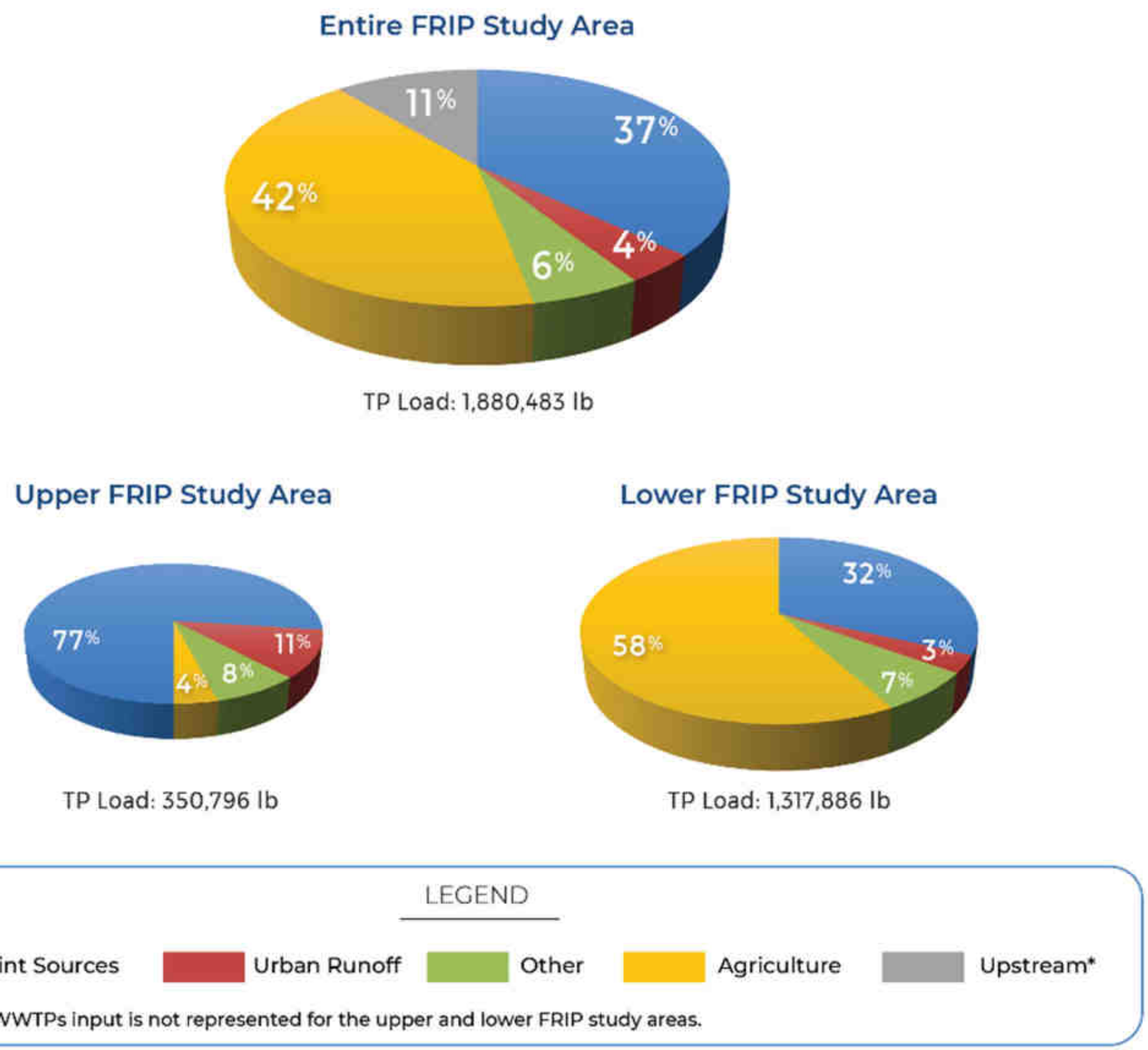


Figure 5: Annual Average Sources of Total Phosphorus Load (2012-2016)

Figure 6 compares the contribution of different TP sources based on the 2012-2016 annual average and 2012-2016 estimated annual average with the projected TP load for meeting WWTP effluent limits of 1 mg/L and 0.5 mg/L, respectively. The estimated load for agriculture, other and urban runoff was not updated for the projected load under this analysis. Further refinement of the HSPF model or use of alternative models could improve these estimates. Results are presented for the entire FRIP Study Area and the Upper Fox and Lower Fox portions of the study area. These results show that the relative contribution of WWTPs to total TP load has decreased by almost 19 percent in recent years (2012-2016) compared to the 1991-2011 period. Projected load reductions based on anticipated WWTP upgrades to meet TP effluents limits of 1 mg/L and 0.5 mg/L will further reduce point source contributions by 57 percent and 79 percent, respectively, from the long-term annual average for the 2012-2016 period. It is likely that agriculture will remain the largest source of nutrient loading to the Lower Fox portion of the study area and the Fox River Study Area.

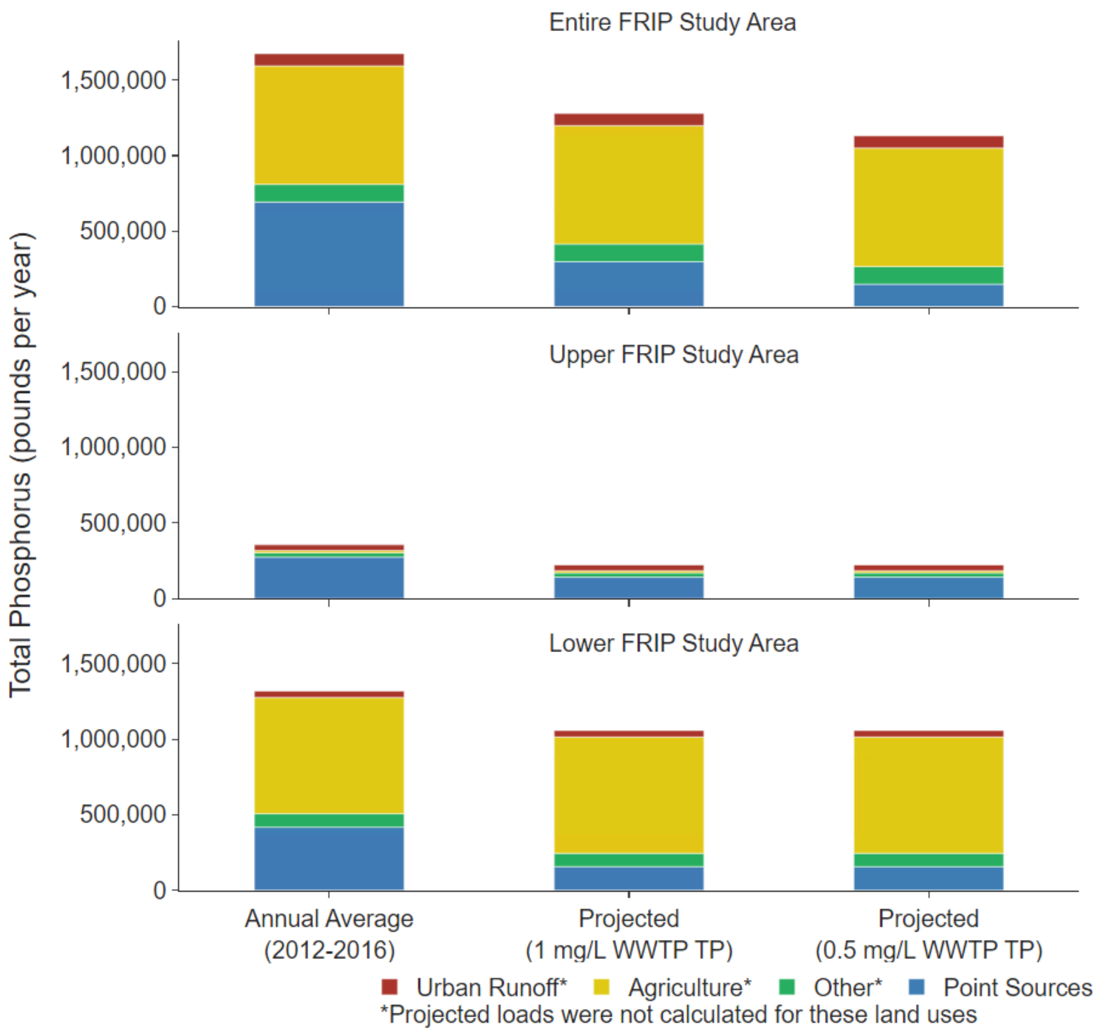


Figure 6: Estimated Quantity of Total Phosphorus (TP) Load 2012-2016 Annual Average, Projected TP Corresponding to 1.0 mg/L and 0.5 mg/L TP Effluent Limits.

WWTP loading data obtained from Illinois EPA shows that the phosphorus loading from WWTPs has reduced by 46 percent since 2017 (**Figure 7**). This reduction is due to major upgrades at several of the major WWTPs in the FRIP Study Area.

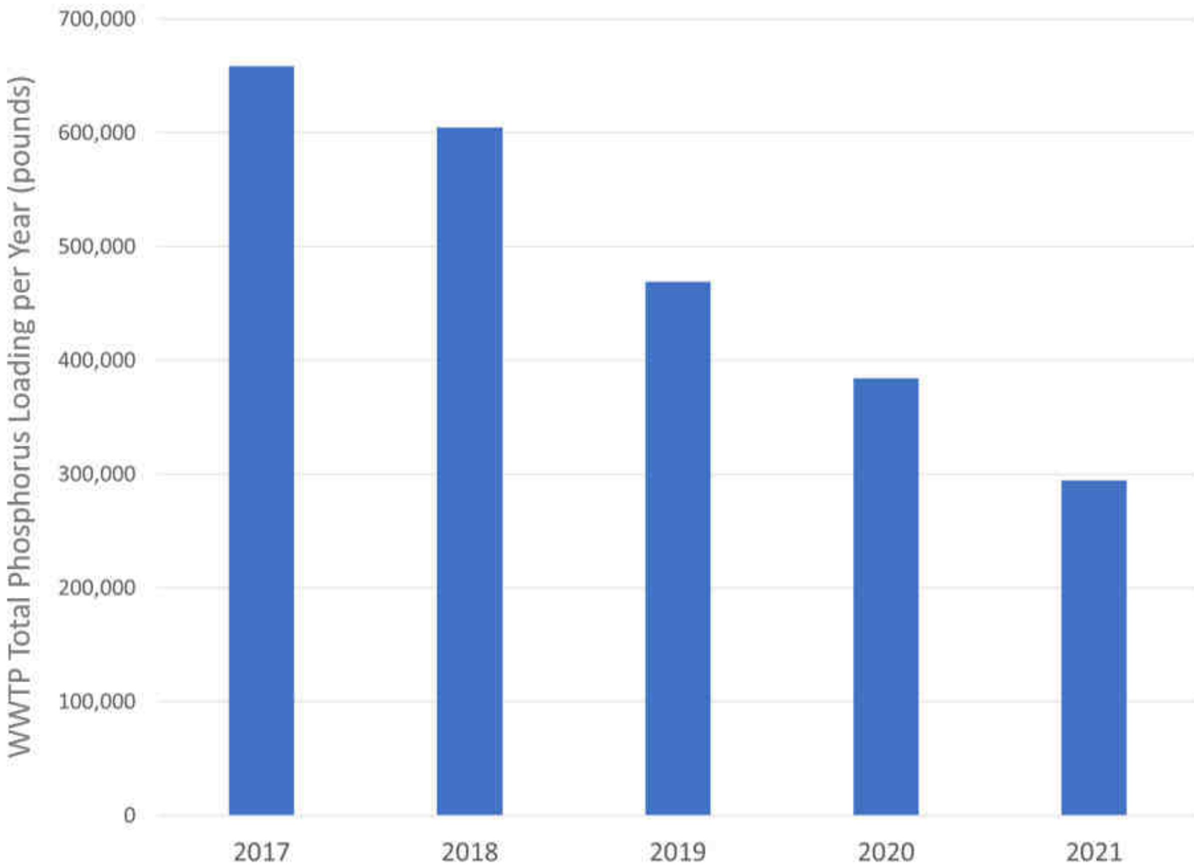


Figure 7: Estimated Total Phosphorus Loading from Major WWTPs from 2017 to 2021 based on the Data Provided by Illinois EPA

This analysis shows that diverse management scenarios are necessary to target the different TP load contributors to the mainstem Fox River and its tributaries. Agricultural best management practices (BMPs) and other conservation measures focused on the Lower Fox River watershed would help to substantially reduce loads to this portion of the Fox River. Implementing urban BMPs in tributary subwatersheds with relatively high TP loads from urban nonpoint sources would also improve water quality in creeks.

2.5 Water Quality Trend Analysis

The FRSG engaged the ISWS to conduct a water quality trend analysis for the FRIP Study Area. This study evaluated nutrient and nutrient-related data collected between 1997 and 2016 on the Fox River mainstem and its tributaries (Getahun et al., 2019, *Appendix C: Illinois State Water Survey Water Quality Trends Analysis Report*). The trend analysis for TP and chlorophyll-a is summarized below.

2.5.1 Total Phosphorus

The ISWS conducted an annual and seasonal TP trend analysis for seven mainstem and ten tributary stations in the FRIP Study Area (**Figure 8a**). The annual TP trend analysis for the mainstem Fox River stations showed a decreasing trend overall in median TP concentrations from 1997 to 2016, except at the two most upstream stations. The most upstream station in the FRIP Study Area, Fox River at Burtons Bridge, showed an estimated increase of 1.6 percent per year (0.002 mg/L per year) in median TP. The trend analysis indicated no change in TP concentrations at the next upstream station at Algonquin Road. At the remaining five downstream mainstem stations, trend analysis indicated a decreasing trend in median TP concentrations, reductions ranging from 1.4 percent per year at the South Elgin station to 4.9 percent per year at Yorkville, the most downstream monitoring station. The seasonal TP trend analysis largely correlated with the annual TP trend analysis and showed either a decreasing or no seasonal TP change at all mainstem stations except Fox River at Burtons Bridge. The increasing trend at the most upstream station may have been caused by higher TP loading into the Fox River between Fox Chain O' Lakes and Burtons Bridge.

The analysis also indicated a decreasing or no trend in annual TP concentrations for all tributary stations except at the mouth of Poplar Creek. The increased concentrations at the mouth of Poplar Creek could be attributed to the impact of urbanization in the Poplar Creek watershed.

The ISWS also conducted a flow normalized flux analysis at one mainstem and two tributary stations, where concurrent flow and water quality data are available. The flow normalized flux analysis at the mainstem Montgomery station showed a 21 percent decrease in annual TP flux between 2006 and 2016. This reduced TP flux could be attributed to reduced TP loading from the WWTPs downstream of Stratton Dam. The flow normalized flux analysis for Poplar Creek at its mouth in Elgin and Blackberry Creek at Route 47 estimated an increase of 51 percent and 43 percent in annual TP flux, respectfully.

The TP trend analysis and the normalized flux analysis indicate that TP loading to the Fox River mainstem has decreased over recent years, while it has increased in specific tributaries such as Poplar Creek and Blackberry Creek. These findings highlight the potential need for local stormwater controls in specific tributary subwatersheds.

2.5.2 Chlorophyll-a

The annual chlorophyll-a trend analysis showed a consistent annual decrease at all seven mainstem stations, with reductions ranging from 1.7 percent per year at South Elgin to 3.4 percent per year at Oakwood Hills **(Figure 8b)**. However, there were no changes in chlorophyll-a concentrations at tributary stations. The seasonal trend analysis showed a decreasing trend in chlorophyll-a in the spring and fall at most monitored mainstem and tributary stations. However, no trend was detected in winter or summer at most stations.

A flow normalized flux analysis for the mainstem Montgomery station indicated a decrease of 10 percent from 2006 to 2016. A similar analysis could not be conducted for the two tributary stations on Poplar Creek and Blackberry Creek since the concurrent flow and chlorophyll-a data was not available.

The results of chlorophyll-a trend analysis are in line with TP trends analysis results which indicate water quality improvement on the mainstem Fox River in recent years.

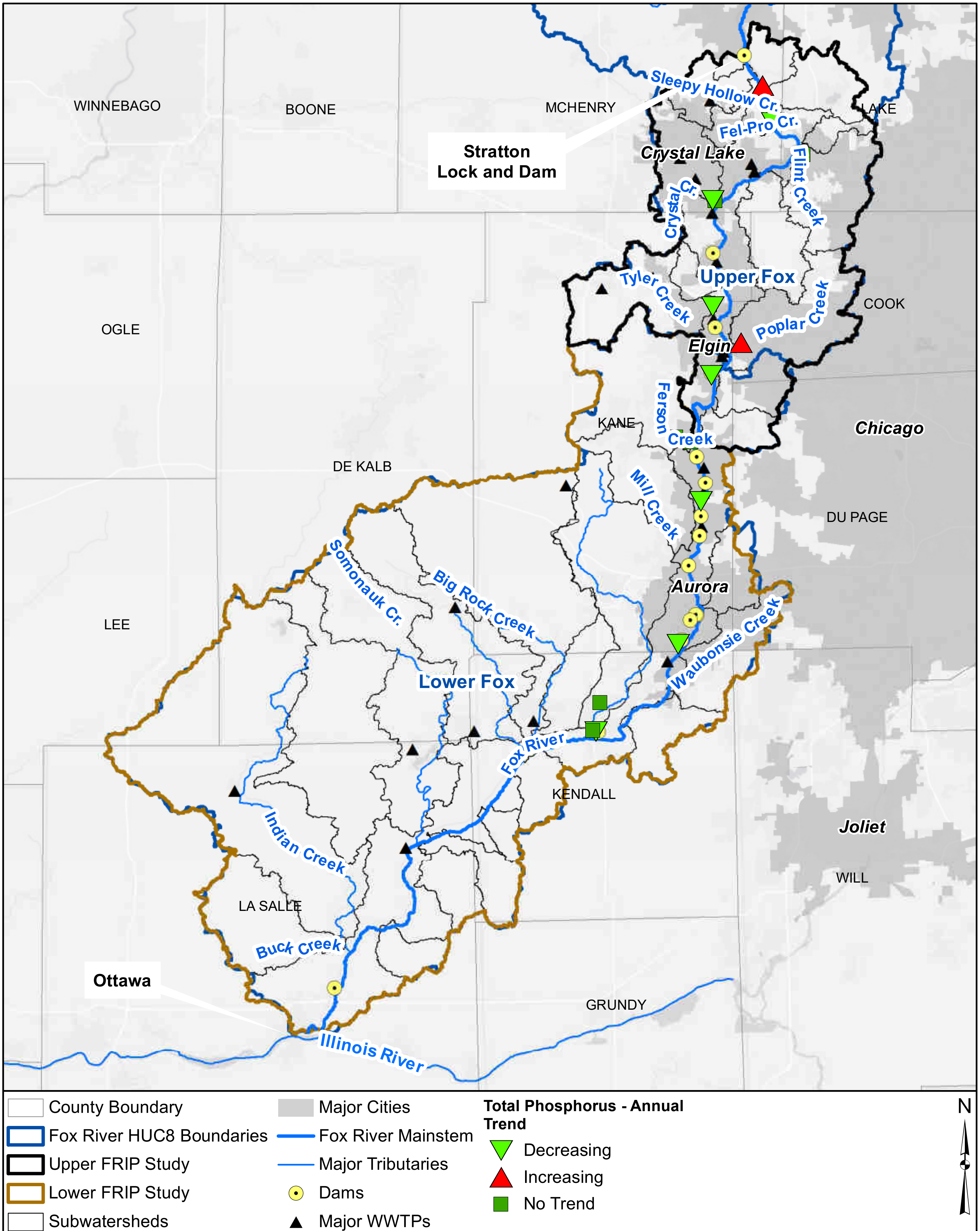


Figure 8a: 1997-2016 Annual Trends of Total Phosphorus in the Fox River Watershed

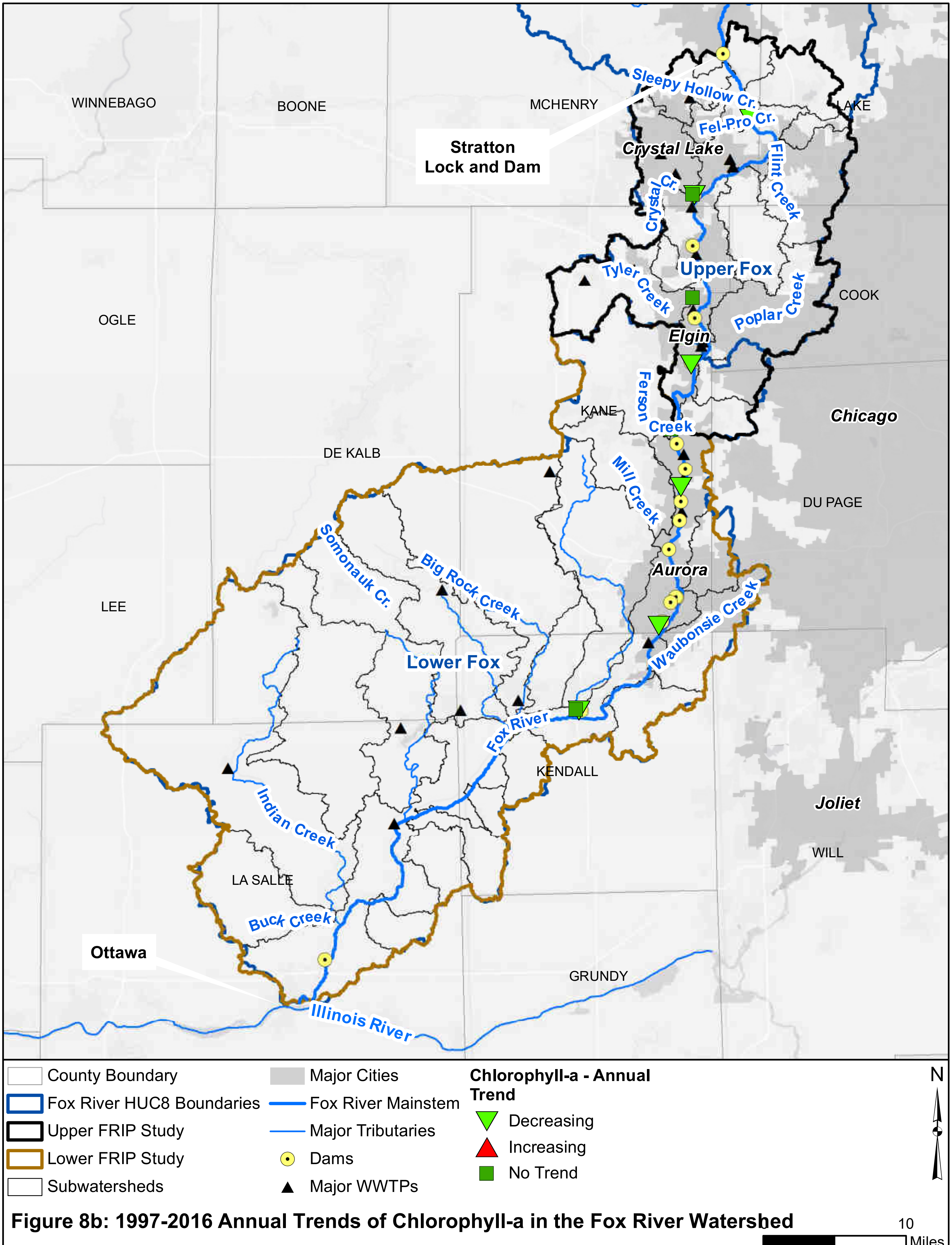


Figure 8b: 1997-2016 Annual Trends of Chlorophyll-a in the Fox River Watershed

SECTION 3

MODELING TOOLS AND MANAGEMENT ACTIONS

This section describes the modeling tools and their application for the evaluation of watershed-based management actions to eliminate low DO and nuisance algae impairments in the mainstem Fox River within the FRIP Study Area.

3.1 Modeling Tools

The FRSG developed a linked numerical modeling framework under Phase 3 of the 2015 FRIP (**Figure 9**). The framework consists of two components: 1) a watershed model and 2) an instream model that includes hydraulic and water quality components. The current FRIP update addresses limitations with the original modeling approach. The enhancements made to the models are summarized below and described in detail in *Appendix D: Water Quality Model Update*.

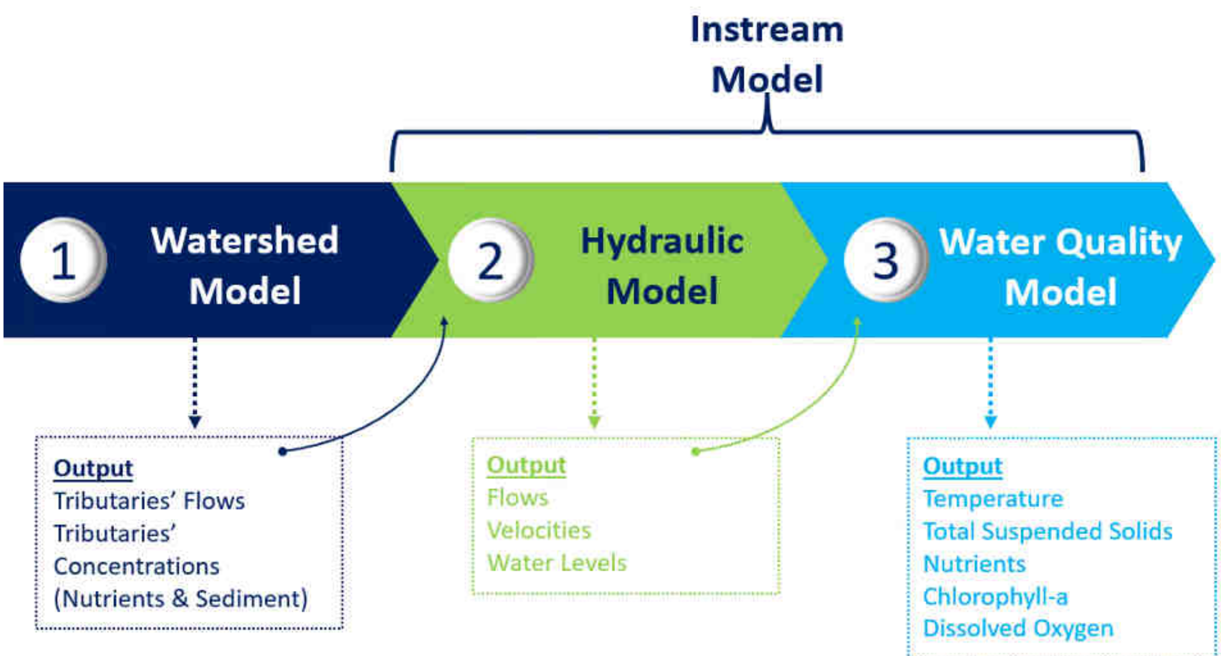


Figure 9: Model Framework

3.1.1 Watershed Model

The ISWS developed the watershed model for the FRIP Study Area using the Hydrological Simulation Program – Fortran platform (HSPF, Bicknell et al., 2001). The ISWS HSPF model simulated the period of January 1990 to September 2011 and is not reflective of current loadings from different sources in the watershed. Geosyntec updated the HSPF model for the period of October 2011 to December 2016 to represent more current tributary loadings into the mainstem Fox River. The HSPF model simulated flows as well as nutrient and sediment loads to input into the instream model for the mainstem Fox River.

3.1.2 Instream Model

ISWS developed the original instream model for the Fox River mainstem to simulate river hydraulics and water quality. The instream model was developed using the QUAL2k framework (Chapra et al., 2008). LimnoTech recalibrated the QUAL2k model for the 2015 FRIP (2015 FRIP Model) using the data collected by the FRSG during low flow conditions in June 2012 (LimnoTech, 2014).

The 2015 FRIP Model had several issues which limited its ability to be used for evaluating watershed management actions. There were two major issues with the model:

1. **Inability to Predict Diel Variation in Dissolved Oxygen:** The 2015 FRIP Model was poorly calibrated for diel DO swings. The model significantly overpredicted the daily minimum DO and underpredicted the daily maximum DO as compared to the measured data. The inability of the 2015 FRIP Model to predict diel DO variation limited its utility for making watershed management decisions.

2. **Inaccurate Representation of Dams and Impoundments:** The dam removal scenarios conducted using the 2015 FRIP Model indicated that dam removals decreased DO concentrations in the impounded reaches of the river. These results are contrary to what has been reported in the literature (Stanley and Doyle, 2002). They are also contrary to observations of DO concentrations in the non-impounded versus impounded reaches of the Fox River. This further limited the model's utility as a tool for informing dam removal decisions.

Consequently, one of the major tasks the FRSG and Illinois EPA agreed on was improved modeling to simulate the actual conditions of the Fox River. This requirement was identified in WWTP NPDES permits for completion by August 31, 2019. Geosyntec worked with the FRSG Modeling Subcommittee to address the 2015 FRIP modeling issues, described in more detail below.

Model Platform

Geosyntec updated the 2015 FRIP Model to a dynamic version of QUAL2k, QUAL2kw (Pelletier et. al, 2005). QUAL2k is a steady-state model which assumes constant flow and water quality input. QUAL2kw can perform continuous simulations of flow and water quality which accounts for varying conditions, including nonpoint source loads and environmental conditions. Furthermore, Illinois EPA recognizes that nutrient impacts vary over time and conditions can be averaged over a "growing season" for algae. This update provided a better tool for the FRSG to inform management decisions concerning water quality over the growing season from May to October.

Model Inputs and Parameters

Geosyntec updated several model inputs and parameters, which are summarized below.

Dissolved Oxygen Reaeration Rate: The 2015 FRIP Model used constant reaeration rates in sections (reaches) of the river ranging from 0.02 to 0.8 per day (day^{1}) downstream of the Algonquin dam. This results in reaeration rates not dependent on simulated depths and velocities. The constant rates were surmised to be related to the 2015 Model output that indicated DO could decrease with dam removal. Geosyntec updated the model so that the DO reaeration rates are calculated internally by the model as a function of depth and velocity. This update helped address the lack of DO response to changing river hydraulics in the 2015 FRIP Model.

Upstream Boundary Conditions: The 2015 FRIP Model used constant flow and water quality inputs at the upstream boundary based on average monthly values. The dynamic QUAL2kw requires time-varying inputs of flow and water quality at the upstream boundary. The upstream boundary was updated based on measured flow and water quality data collected just downstream of Stratton Dam. This change is particularly relevant when looking at low flow conditions.

Channel Characteristics: The channel characteristics for river reaches, such as cross-section information, benthic algae coverage, and specified SOD rates, were also updated based on more recent data collected by the FRSG and other agencies. See *Appendix D: Fox River Water Quality Model Update* for additional details.

Tributary Inputs: The time series of HSPF-simulated flow and water quality concentrations were used as inputs for the tributaries and mainstem direct drainage areas into the QUAL2kw model.

Model Calibration

The QUAL2kw model was calibrated to the available flow and water quality data (nutrients, sestonic chlorophyll-a, and DO) for two time periods: June 1 to July 31, 2012, and August 1 to September 30, 2016. These time periods were chosen because of data availability for the different water quality constituents. The data used was from the FRSG monthly monitoring, FRSG low-flow intensive monitoring, Fox Metro Water Reclamation District monitoring, and Illinois EPA ambient water quality monitoring programs.

The calibrated model predictions for flow, temperature, phosphorus, and chlorophyll-a are in reasonably close agreement with measured data. A detailed description of the results is provided in *Appendix D: Fox River Water Quality Model Update*. The calibrated model simulates the observed diurnal variations in DO at different locations in the Fox River and sufficiently captures the minimum DO levels in most reaches of the river. **Figure 10** compares the range of simulated and measured DO concentrations along the length of the river for June 25-29, 2012. **Figure 11** shows the timeseries comparison of simulated and observed DO concentrations at Fox River-Sullivan Bridge, Aurora. While no modeling effort will ever completely mimic real-world data, the simulated results shown in both figures provided significantly better results than the 2015 FRIP

Model. The calibrated model's ability to capture measured minimum DO levels and DO diurnal swings were critical parameters to demonstrate that the FRSG could utilize it for identifying appropriate management actions for reducing nuisance algae and improving dissolved oxygen levels in the river. This was a critical juncture in the FRSG efforts because it allows FRSG to have confidence in recommended actions.

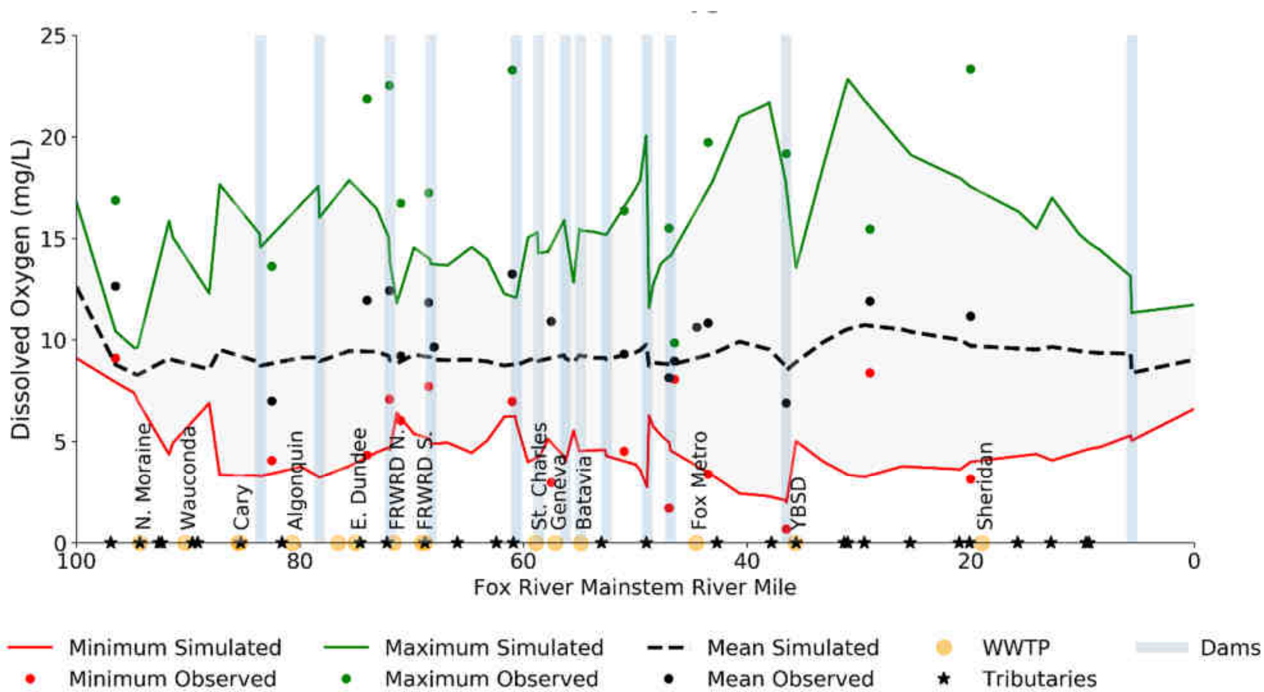


Figure 10: Dissolved Oxygen Concentration Longitudinal Plot for June 25-29, 2012.

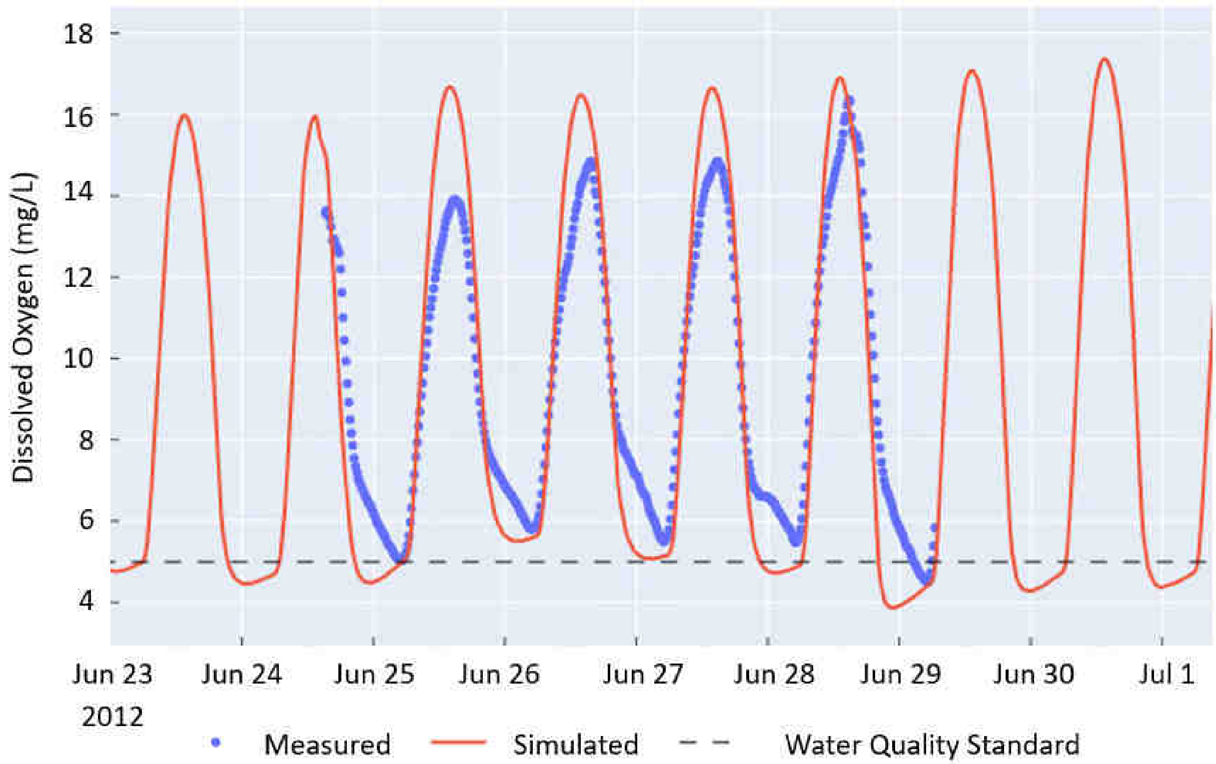


Figure 11: Comparison of Simulated and Measured Dissolved Oxygen Concentrations at Fox River – Sullivan Bridge for June 25-30, 2016

3.2 Management Action Options

Following model calibration, Geosyntec evaluated the following management actions to improve water quality in the mainstem Fox River. The management actions are briefly described below.

3.2.1 Upstream Total Phosphorus Load Reduction

The upstream load to the FRIP Study Area includes loading from the Fox River watershed upstream of Stratton Dam, with a drainage area of 1,250 square miles. The portion of the Fox River watershed in Wisconsin has no formal TMDL or completed watershed-wide analysis, however a TMDL has been initiated. The portion upstream of Stratton Dam in Illinois includes the Chain O'Lakes, a series of 15 lakes connected by the Fox River, which has been identified as impaired for phosphorus (CDM Smith, 2020a). The TP target for the Chain O' Lakes is 0.05 mg/L, which is the Illinois General Use Water Quality Standard for lakes. The upstream load constitutes approximately 11 percent of the annual average TP load into the Fox River from 2012 to 2016 **(Figure 5).**

The impact of upstream load reduction was simulated by running the instream model for scenarios with a reduction of 50 percent and 75 percent in upstream TP concentration. The reduction in upstream TP was simulated by proportionally reducing the upstream boundary concentration for organic phosphorus, inorganic phosphorus, and internal phosphorus within sestonic algae (algae suspended in the water column). The upstream boundary sestonic chlorophyll-a values for the baseline scenario ranged from 46 to 235 µg/L over the growing season. For the 50 percent reduction scenario, the upstream sestonic chlorophyll-a boundary ranged from 23 to 117 µg/L. For the scenario with a 75 percent upstream load reduction, the TP concentration was capped at 50 µg/L or 0.05 mg/L, which corresponds to the TP target for the Chain O' Lakes. Whether and/or when such load reductions can be realized is unknown at this time. The Implementation Plan in Section 4 of this report will address monitoring upstream TP loading to the study area.

3.2.2 Tributary Total Phosphorus Load Reduction

There are 31 tributaries draining an area of approximately 1,150 square miles to the Fox River mainstem within the FRIP Study Area. About 255 sq. miles drain directly to the Fox River mainstem. The majority of nonpoint source TP load in the Upper FRIP Study Area comes from urban runoff, while agriculture is the most significant contributor in the Lower FRIP Study Area.[1] The relative contribution of tributaries to the total TP loading along most of the length of the Fox River mainstem is less than five percent. The one exception is downstream of the confluence of Indian Creek South around RM 43 in LaSalle County where it represents approximately five percent of the total TP load.

The instream model was run for scenarios with 50 percent and 75 percent reductions in tributary loads to simulate the impact of tributary load reductions on the Fox River mainstem.

[1] It is worth noting that most of impaired reaches in Lower FRIP are located in the urban areas

3.2.3 WWTP Total Phosphorus Load Reduction

The loading from WWTPs constituted about 37 percent of the annual average TP loading to the mainstem Fox River in the FRIP Study Area from 2012 to 2016. From 2017 onwards, the yearly WWTP loads have reduced by more than 50 percent (**Figure 7**). The NPDES permits for major (>1 MGD) WWTPs in the FRIP Study Area require that the facilities meet TP effluent limits of 1.0 mg/L rolling annual average (12-month rolling average, calculated monthly) by 2022-2023 and 0.5 mg/L (12-month rolling geometric mean, calculated monthly) by 2030. If enhanced biological phosphorus removal technology is combined with supplemental chemical treatment and advanced effluent filtration, it is generally believed that a limit of 0.1 mg/L represents limit-of-technology.[2] The progress made by individual WWTPs towards meeting the targets of 1.0 mg/L and 0.5 mg/L is detailed in *Appendix G: WWTP Upgrades Progress.*

Newly Constructed Facilities for Enhanced Phosphorus Treatment at Fox Metro South Plant, Photo Credit: Fox Metro Water Reclamation District

WWTP load reduction scenarios were conducted by setting TP effluent concentrations to 1.0 mg/L, 0.5 mg/L, and 0.1 mg/L in the instream model for the mainstem WWTPs and in the watershed model for the tributary major WWTPs.

[2] High-Efficiency Nutrient Removal and Recovery for Achieving Low Regulatory Limits.US EPA Office of Research and Development. EPA Contract Number EPD17007

3.2.4 Dam Removal

The ten dams on the Fox River between Carpentersville and Yorkville are classified as "run of the river" dams, which means that they are simply a weir structure built across the width of the river for the purpose of raising the water level upstream. These low head dams impound 67 percent of river length from RM 81.71 to RM 36.06. These dams are in close proximity of each other with impoundment lengths ranging from 0.5 to 6.3 miles. The impact of these dams on the Fox River water quality is discussed below.

Fox River at Kimball St. Dam; Photo Credit: Art Malm

The volume of water in the dam impoundments results in increased sestonic algae mass in the impounded reaches, which causes DO depletion in these areas. The slow water velocities behind the dam also cause the accumulation of silt and organics, materials that settle behind the dams to form benthic detritus. Together, the benthic detritus and benthic algae act to remove oxygen from the river. This deoxygenation effect is especially apparent on the river bottom behind the dams, where only pollution-tolerant species of fish such as carp and a few macroinvertebrates such as midge flies can thrive. The accumulated sediment behind the dam also provides poor habitat for broader macroinvertebrate types, mussels, and fish, all important components of the river's food web.

The series of dams also creates shallow and wide non-impounded reaches upstream of each dam (**Figure 12**). These reaches provide suitable conditions of more light availability and slow-moving velocities for benthic algae growth. The growth of benthic algae results in DO depletion in these reaches.

For the FRSG, the primary objective of dam removal is to eliminate the conditions causing DO and nuisance algae impairments in the mainstem Fox River. An additional objective for the dam removal is to improve the aquatic habitat for fish, benthic macroinvertebrates, and mussels. While the FRSG's focus is on meeting Clean Water Act requirements for the Fox River to support its designated uses and water quality standards, other very important benefits of dam removal include the elimination of drowning hazards associated with spillways and improved navigability for paddling.

The impact of dam removal on river hydraulics and water quality was simulated in the instream model. This was done by removing dam structures in the model and specifying reach characteristics such as cross-section, SOD, and benthic algae coverage similar to the Fox River reaches that are not impacted by dams.

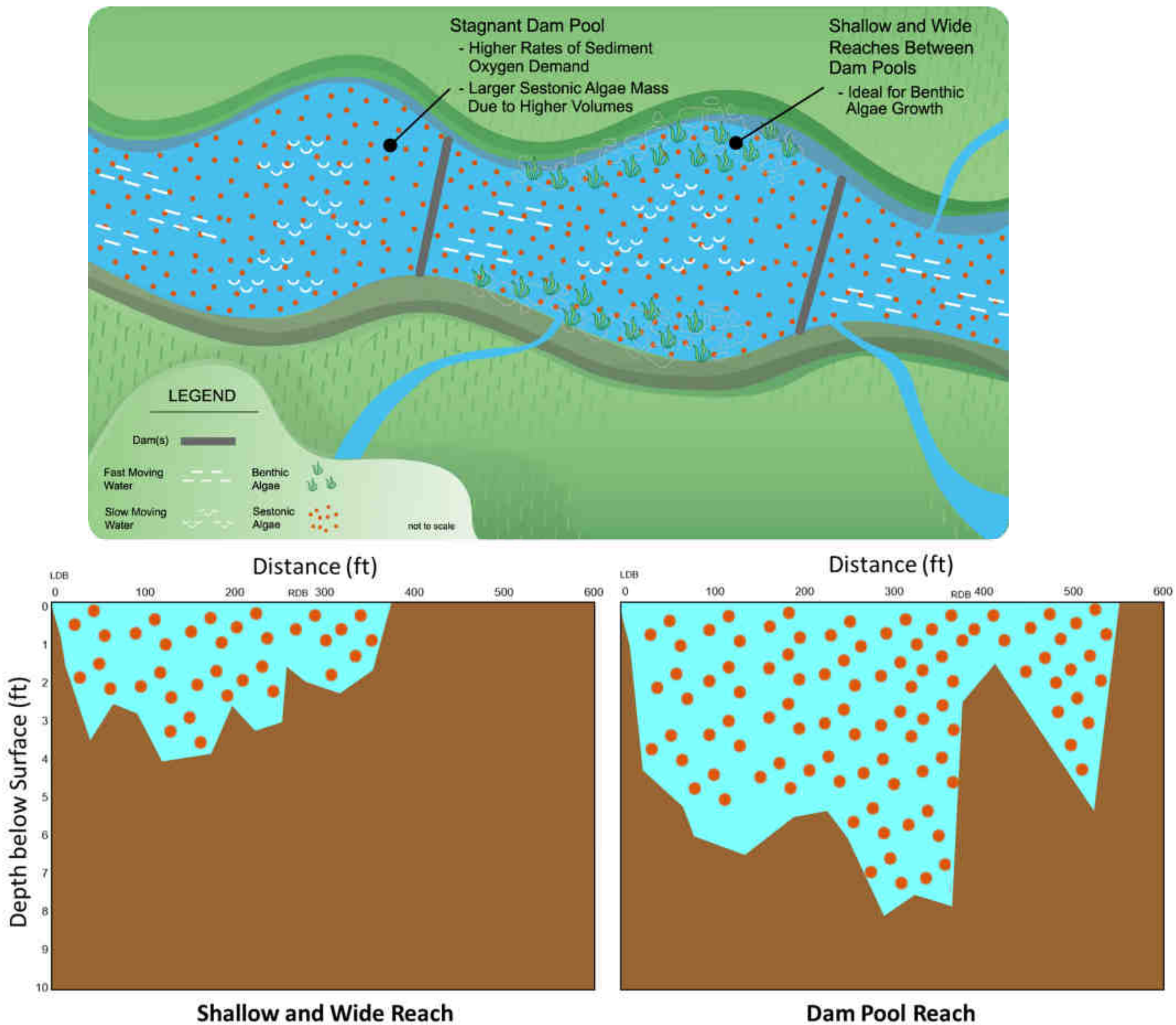


Figure 12: Impact of Dams on Fox River Mainstem Water Quality

3.2.5 Combined Management Actions

The management actions were combined into both short- and long-term scenarios to evaluate the impacts of combined actions on Fox River water quality. A total of 15 combined scenarios were simulated. Two stages of combined management actions were simulated. The first stage of scenarios included combined actions that could be implemented pre 2032 (e.g., 0.5 mg/L effluent TP limit, removal of three dams, and 50 percent upstream TP load reduction). The second stage, long-term scenarios, focused on management actions that could be implemented post 2032 (e.g., 0.1 mg/L effluent TP limit, all dams removed, 75 percent upstream TP load reductions, and 50 percent nonpoint source TP load reductions).

3.3 Evaluation of Management Actions

The updated watershed and instream models were used to evaluate the watershed management actions and combined scenarios. The modeling results and key findings are summarized below and described in detail in *Appendix E: Fox River Watershed Management Scenarios*.

Key Finding 1: Reduction of WWTP TP below 0.5 mg/L will not substantially improve water quality in the Fox River under the present dammed river conditions.

The DO impairment in the Fox River is caused by the photosynthetic activity of sestonic algae (suspended in the water column) and benthic algae (attached to the river bottom) and the contribution of SOD due to the accumulation of dead and dying organic materials generally referred to as detritus. The total simulated mass of DO removed for each reach by each DO sink is included in *Attachment 3 of Appendix E: Fox River Watershed Management Scenarios*. Modeling results of reducing WWTP TP concentrations to 0.5 mg/L and 0.1 mg/L are presented in **Figure 13**. The reduction of WWTP TP concentrations to 0.5 mg/L results in the reduction of sestonic algae below the nuisance impact threshold value of 149 µg/L identified for use in the FRIP in the middle and lower reaches of the Fox River (**Figure 13f)**. However, the sestonic chlorophyll-a levels in the upper reaches of the Fox River are determined by upstream loading and hence are not impacted by WWTP TP load reduction (**Figure 13d)**. The benthic algae also decreased in the middle reaches because of the increased phosphorus limitation factor[3] with about a one-third reduction in instream TP from the baseline scenario. For the lower reaches, the benthic algae increased compared to the baseline scenario because of increased light availability due to reductions in sestonic chlorophyll-a (**Figure 13f)**. As a result, the minimum DO concentration increases for the middle reaches and decreases for the lower reaches with the reduction in WWTP TP loading (**Figure 13a)**.

[3] Nutrient limitation factor ranges from 0 to 1. It is dependent on the algae biomass and instream nutrient concentrations. A factor of 1 implies no nutrient factor limitation

As **Figure 13** shows, a further reduction of WWTP TP concentrations from 0.5 mg/L to 0.1 mg/L has a limited incremental impact on sestonic and benthic chlorophyll-a levels, and hence provides limited additional water quality benefits under the current dammed scenario.

Phosphorus removal feasibility studies conducted by the WWTPs in the FRIP Study Area show that a large amount of additional capital infrastructure investment and expensive chemical treatment would be required to reduce WWTP TP concentrations from 0.5 mg/L to 0.1 mg/L. For example, the phosphorus feasibility study conducted for the Fox River Water Reclamation District's WWTPs estimated that an additional investment of approximately $94 million would be required to go from TP effluent limits of 1 mg/L to 0.1 mg/L, with a net present worth cost of over $90 million (Black and Veatch, 2015). Fox Metro Water Reclamation District would require an additional investment of approximately $95 million to reduce effluent levels from 1 mg/L to 0.1 mg/L TP effluent (Deuchler, 2016a). These investments would not likely improve water quality given the river's current conditions and are therefore not recommended in this FRIP update.

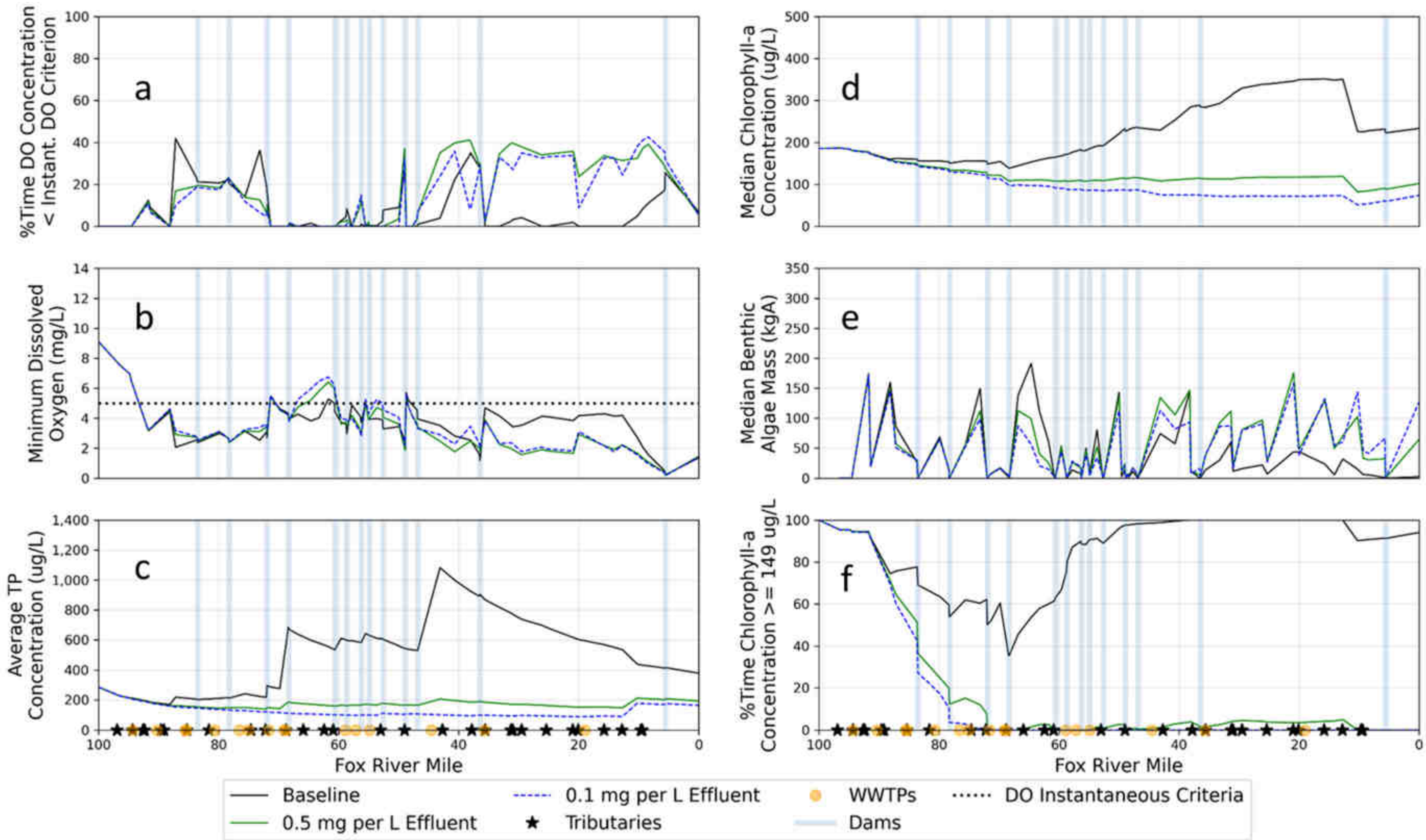


Figure 13: Comparison of Model Results for the Baseline Scenario (black solid line), a Scenario with WWTP Effluent Discharge at 0.5 mg/L Total Phosphorus (red dashed line) and a Scenario with WWTP Effluent Discharge at 0.1 mg/L Total Phosphorus (green dashed line)

Key Finding 2: Dam removal is required to address low DO issues

Model simulations were run to assess the impact of dams on the DO impairments in the mainstem Fox River. **Figure 14** shows the comparison of results for the baseline scenario (black solid line); a scenario with the Carpentersville and North Aurora dams removed (red dashed line); and a scenario with ten dams removed from the Carpentersville to Yorkville dams (green dashed line). The results show that removing a single dam will significantly reduce benthic algae in reaches just upstream and downstream (tailwater) of the dam (**Figure 14e)**. As a result, the DO concentrations would improve in these reaches. For the scenario with ten dams removed, the model shows substantial decreases in benthic algae from Carpentersville to Yorkville due to rapidly flowing waters, which do not provide a suitable habitat for the growth of benthic algae. As a result, the simulated minimum DO increases (**Figure 14a)**, and the percentage of time DO is below the instantaneous DO standard decreases with the dam removals (**Figure 14b)**. The results indicate that dam removal is required to address the low DO issues in the Fox River.

Key Finding 3: Upstream TP load reduction is required to address nuisance algae conditions in the Fox River reaches upstream of the Algonquin Dam.

The mainstem upstream of the Algonquin Dam is largely dominated by loading from upstream of the Stratton Dam. The modeling results show that reducing upstream TP and chlorophyll-a loading would address nuisance algae conditions in this reach. The reduction in upstream loading has a minimal impact downstream of the Algonquin dam due to WWTP loadings and the presence of dams (**Figure 15**).

Key Finding 4: Tributary TP load reduction would have minimal impact on mainstem water quality under current conditions, relative to the WWTPs and upstream sources.

The modeling results for the watershed management scenarios show that reducing the tributary TP loadings have a minimal impact on mainstem water quality relative to the WWTPs and upstream sources, except for reaches downstream of Indian Creek South around RM 43 (**Figure 16**). This is because tributary loading (including WWTP loads to tributaries) constitutes a smaller proportion of the modeled TP loads to the Fox River under low flow conditions. However, note that TP and sediment loadings from urban runoff does contribute significantly to water quality impacts in many Fox River tributaries (see Figures 5 and 7 in *Appendix B – Current Loading Sources in the Watershed*).

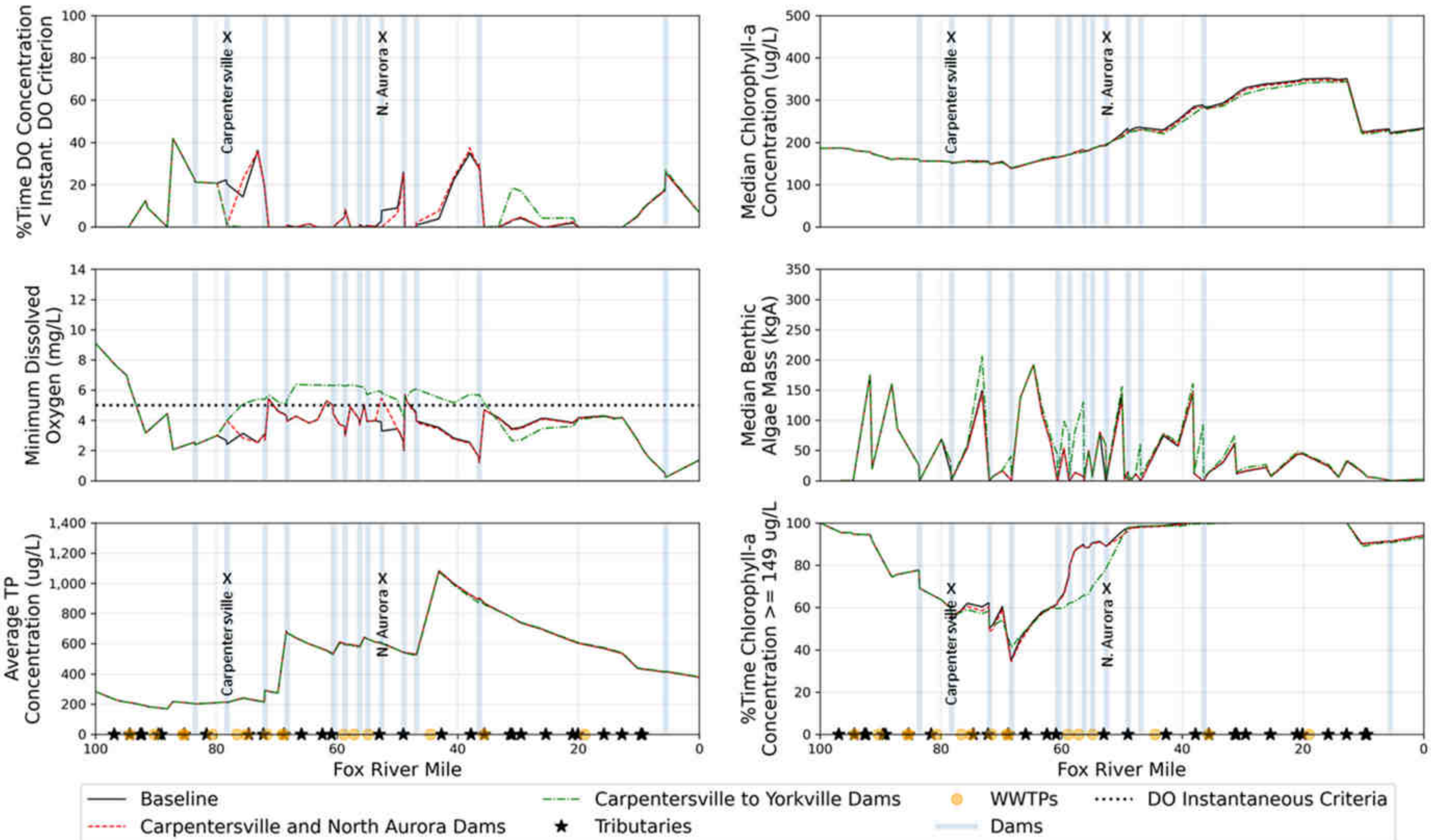


Figure 14: Comparison of Model Results for the Baseline Scenario, Carpentersville and North Aurora Dam Removals, and Ten Dam Removals from Carpentersville to YorkvilleDams; 'X' indicates locations of Carpentersville and North Aurora Dams

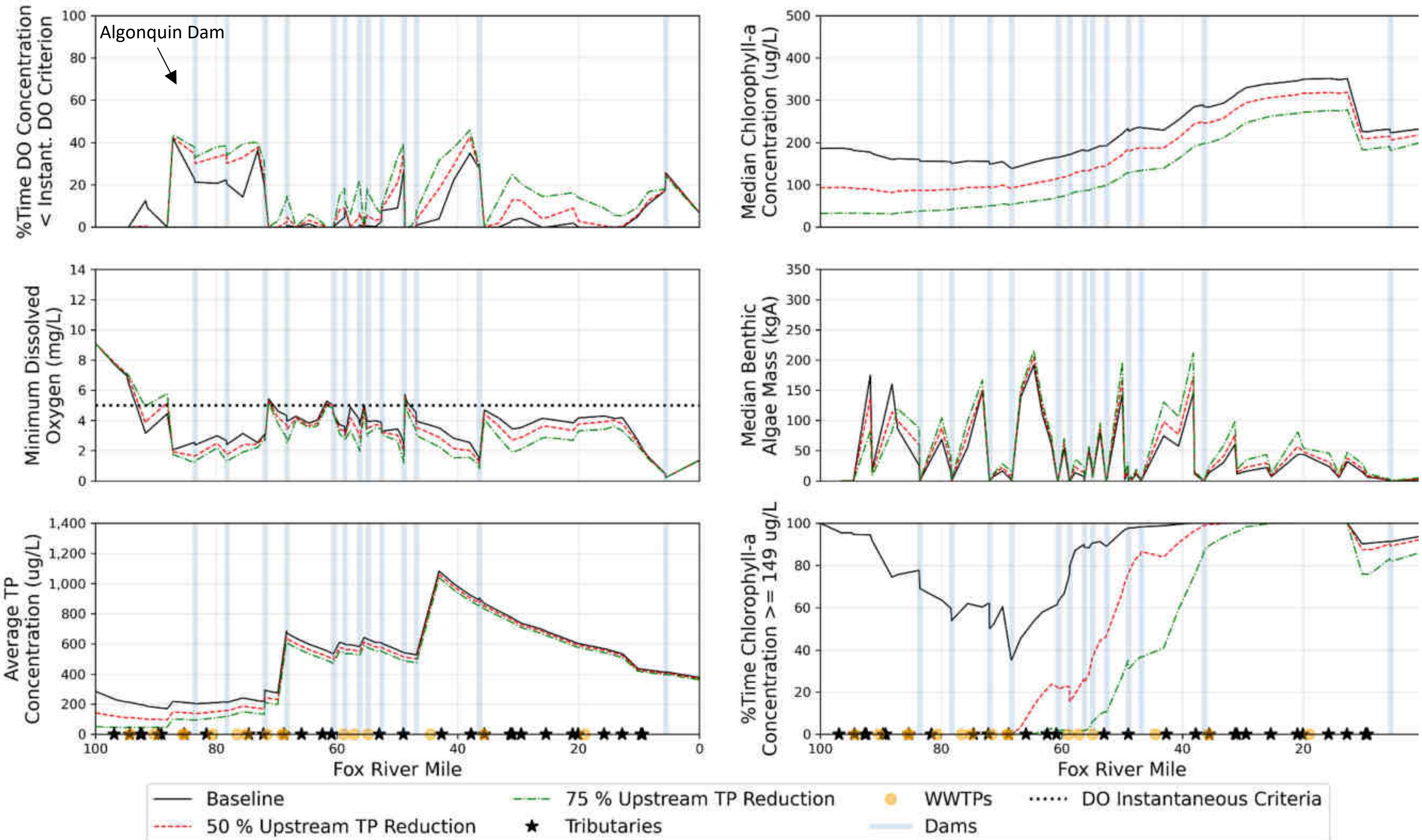


Figure 15: Comparison of Model Results for the Baseline Scenario (black solid line), a Scenario with 50% Reduction in Upstream Phosphorous Load (red dashed line), and a Scenario with 75% Reduction in Upstream Phosphorus Load (green dashed line)

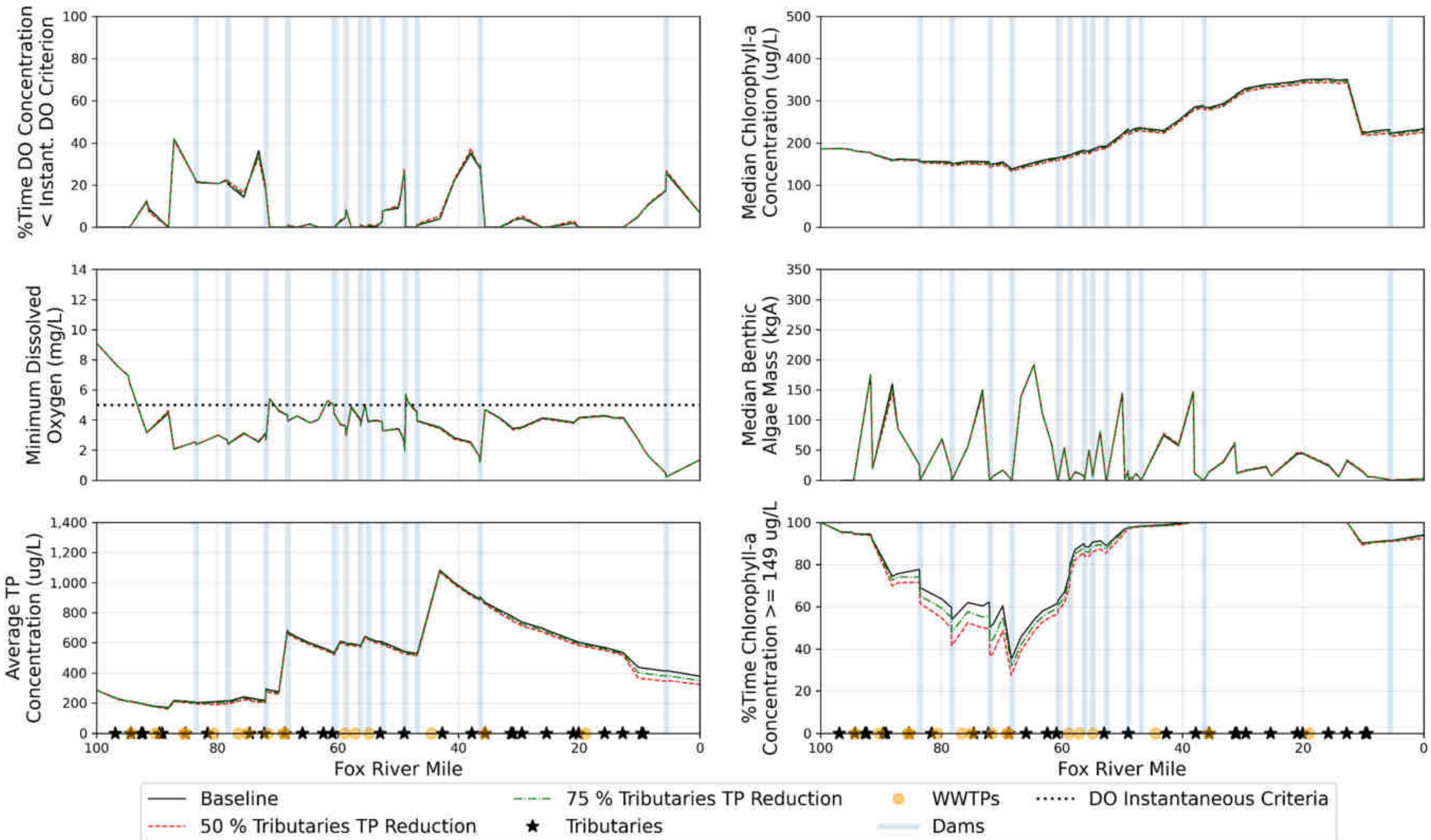
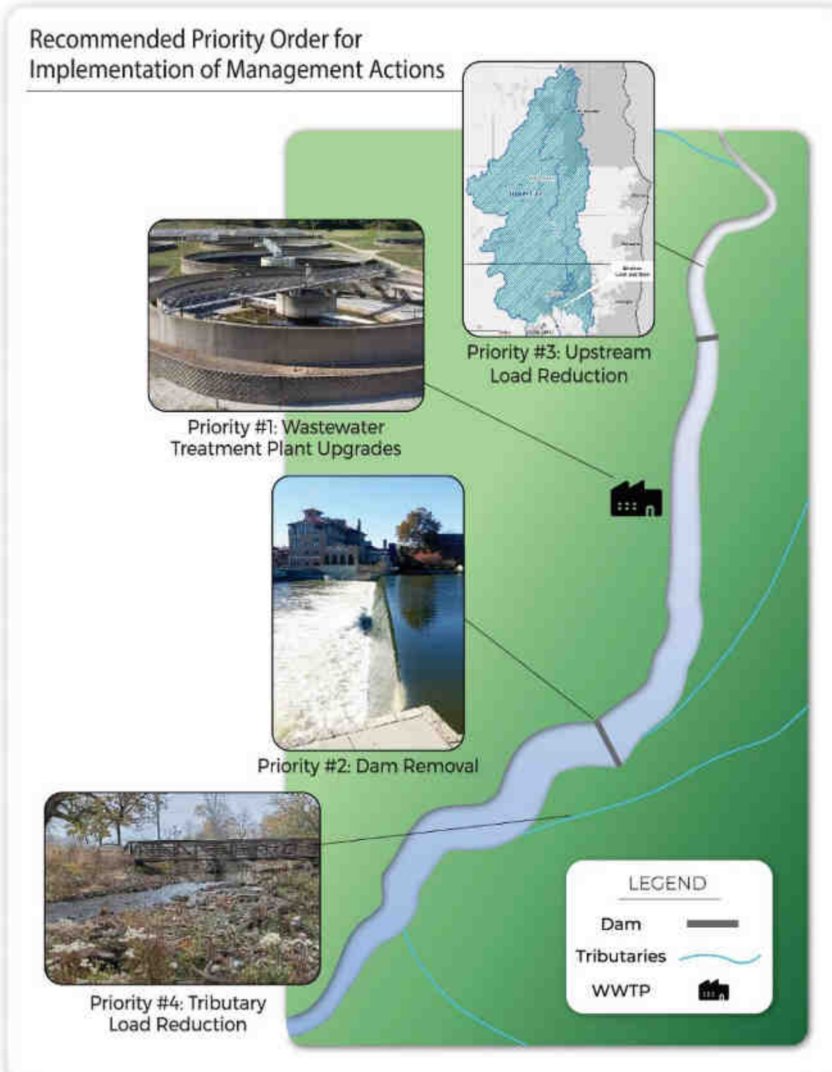


Figure 16: Comparison of Model Results for the Baseline Scenario (black solid line), Scenario with 50 percent Reduction in Tributary Total Phosphorus load (red dashed line) and Scenario with 75 percent Reduction in Tributary Total Phosphorus load (green dashed line

3.4 Recommended Priority Order for Implementation of Management Actions

The following priority order for implementation is recommended based on the results of watershed management scenarios.



1. WWTP TP Removal Upgrades – This priority is well underway. Most WWTPs are already or soon to be in compliance with the 1.0 mg/L TP limit in their NPDES permits. These upgrades represent significant capital investments by the communities along the Fox River to improve water quality. Most WWTPs are already planning for and optimizing treatment systems to meet the 2030 0.5 mg/L TP limit.

2. Dam Removal – This priority, while potentially having a huge impact on water quality, includes significantly different stakeholders, processes for completion, and funding complexities. The USACE Fox River Connectivity & Habitat Study is a key component in engaging stakeholders, developing cost estimates, determining impacts to adjacent landowners, and substantiating the flood reduction, economic, and aquatic habitat benefits of dam removals. These items are essential to moving forward with dam removal projects. The study is expected to be completed in December 2023.

3. Upstream TP Load Reduction – The Fox River segment upstream of the FRIP Study Area in Illinois has two TMDLs. The Wisconsin portion of the Fox River also contributes to the upstream loading into the FRIP Study Area but does not have a TMDL or watershed-based plan. The stakeholders for the upstream load reductions include the FWA, WWTPs discharging to the Fox River upstream of Stratton Dam, Illinois EPA, Wisconsin DNR, Southeastern Wisconsin Regional Planning Commission (SEWRPC), and Southeastern Wisconsin Fox River Commission (SEWFRC).

4. Tributary TP Load Reduction - The tributary load reduction can be achieved through the implementation of watershed-based plans for each subwatershed (discussed in Section 4.2). A summary of completed watershed-based plans is provided in Table 5. The majority of tributary load comes from the agriculture dominated Indian Creek South tributary. The implementation of traditional agricultural practices such as cover crops, grassed waterways, riparian buffers, and filter strips, and innovative practices such as iron sand filters and agricultural runoff treatment systems (ARTS) can be used to reduce tributary loads.

An implementation plan and schedule for the above management actions and actions to address other impairments is described in Section 4.

SECTION 4

IMPLEMENTATION PLANNING AND SCHEDULE

The work completed for the current FRIP focused on identifying management actions to eliminate DO and nuisance algae impairments. Future work would continue these efforts and also expand to studying other impairments or issues such as fecal coliform, sedimentation, and hydromodification. This section presents the recommended management actions for addressing impairments in the FRIP Study Area. Recommended actions fall under the following categories:

1. Administrative actions
2. Actions to address DO and nuisance algae impairments
3. Actions to address other impairments
4. Monitoring and modeling studies

In addition to recommended actions, this section also discusses the FRSG's role in implementation.

The recommended actions include shorter-term actions that can be implemented prior to 2032 and longer-term priorities for post-2032 implementation. An implementation schedule with realistic milestones has been developed to allow the FRSG and other watershed stakeholders to pursue and utilize funds from public and private sources more effectively. Error! Reference source not found. summarizes the pre- and post-2032 recommended actions along with key stakeholders and potential funding sources. The recommended actions are also described in detail below, along with potential funding sources.

Table 5: FRIP Recommended Action Items

Category	Subcategory (if applicable)	Pre-2032	Post-2032	Key Stakeholders	Funding Sources
Administrative		Work with US Army Corps of Engineers (USACE) to complete Fox River Habitat Connectivity Study by December 2023	Continue to work with USACE and Illinois Department of Natural Resources (DNR) on dam removals	• USACE • Illinois DNR • Illinois EPA • FRSG	• Water Resources and Development Act, Section 206 Funding (WRDA Section 206) • Illinois DNR • FRSG (In-kind contributions)
		Update existing 10-year long-term funding plan for FRSG after completion of Fox River Connectivity & Habitat Study		• FRSG • FRSG members	• FRSG Dues
		Continue to develop educational materials to inform decision makers and the public about benefits of dam removals		• FRSG • FRSG members • Local communities	• FRSG Dues
		Petition Illinois EPA to delist the PCB impairments for the Fox River based on more recently collected data		• FRSG • Illinois EPA	• FRSG Dues
Actions to Address Low Dissolved Oxygen (DO) and Nuisance Algae Impairments	Dam Removal and Riparian Restoration	Work towards removal of dams identified in the Fox River Connectivity & Habitat Study Promote removal of North Aurora, Carpentersville, and North Batavia dams and stabilization of communities' shorelines in dam removal locations Develop education materials for the public about the benefits of dam removal	Continue working towards removal of dams identified in the Fox River Connectivity & Habitat Study Promote stabilization of MS4 communities' shorelines in dam removal relocation	• FRSG • USACE • Illinois DNR • Kane County Forest Preserve District (Carpentersville) • City of Batavia (North Batavia) • Local MS4s	• WRDA Section 206 Funding • Illinois DNR • FRSG (In-kind contribution) • Local dam owners • Local communities • National Culvert Removal, Replacement, and Restoration Grant Program

Category	Subcategory (if applicable)	Pre-2032	Post-2032	Key Stakeholders	Funding Sources
Actions to Address Low Dissolved Oxygen (DO) and Nuisance Algae Impairments	Major Wastewater Treatment Plant (WWTP) Upgrades	Meet a 0.5 mg/L total phosphorus effluent limit (12-month rolling geometric mean, calculated monthly) by January 1, 2030		• Major WWTPs • Illinois EPA • FRSG	• WWTP capital budgets • Illinois EPA State Revolving Fund Loans • User rates
	Explore partnership opportunities with stakeholders upstream of Stratton Dam in Illinois and Wisconsin	Continue to explore opportunities to work with stakeholders upstream of Stratton Dam in Illinois and Wisconsin		• FRSG • WWTPs upstream of Stratton Dam • Illinois EPA • Wisconsin DNR • Southeastern Wisconsin Regional Planning Commission • Southeastern Wisconsin Fox River Commission	• Explore partnership opportunities with stakeholders upstream of Stratton Dam in Illinois and Wisconsin
Actions to Address Other Impairments		Support state of the art watershed management practices		• Chicago Metropolitan Agency for Planning • FRSG • Local communities • Counties	• Illinois EPA Section 319

Category	Subcategory (if applicable)	Pre-2032	Post-2032	Key Stakeholders	Funding Sources
Actions to Address Other Impairments	Urban Tributary Subwatersheds	Promote retrofitting of existing facilities with best management practices (BMPs) Advocate for watershed-friendly development and redevelopment Encourage stream and wetland restoration projects Develop educational materials on watershed-friendly practices	Advocate for the review and revision of local development and redevelopment ordinances to promote watershed-friendly practices Continue developing educational materials on watershed-friendly practices	• CMAP • FRSG • Local communities • Counties	• CMAP Local Technical Assistance program, • Illinois EPA Section 319 and 604(b) • Public Private Partnerships
	Agriculture Tributary Subwatersheds	Explore and build on opportunities to partner with agriculture communities on the application of traditional practices (cover crops, grassed waterways, riparian buffers, and filter strips) and innovative practices such as iron sand filters and agricultural runoff treatment systems		• Illinois Farm Bureau • County farm bureaus • Local forest preserve districts • Local Soil and Water Conservation Districts • Local farmers • FRSG • Local communities, if applicable	• Agricultural Conservation Easement Program • Conservation Reserve Program • Conservation Stewardship Program • Environmental Quality Incentives Program • Wetland Program Development Grants • Regional Conservation Partnership Program • Illinois Research & Education Council

Category	Subcategory (if applicable)	Pre-2032	Post-2032	Key Stakeholders	Funding Sources
Monitoring and Modeling Studies	Instream Low Flow Monitoring Studies	Collect continuous and discrete water quality data on the mainstem Fox River over a month during targeted low flows		• FRSG	• FRSG Dues
	Bathymetry Studies	Collect bathymetry data in the mainstem reaches upstream of the Algonquin dam and downstream of Yorkville, if needed after USACE study completed		• FRSG	• FRSG Dues
	Pre- and Post-Dam Removal Studies	Conduct water quality monitoring and biological data (fish by IDNR, macroinvertebrates by Illinois EPA, mussels by INHS) pre- and post-removal of the Carpentersville dam	Conduct water quality monitoring pre- and post-removal of selected dams	• FRSG • Illinois DNR Fisheries • Illinois EPA • Illinois Natural History Survey	• FRSG Dues
	Modeling Updates	Consider model based on additional data collected during instream low flow monitoring, bathymetry, and Carpentersville dam pre- and post-monitoring studies		• FRSG	• FRSG Dues
	MS4 Spreadsheet Tool Update	Update the MS4 spreadsheet tool to document load reduction through the implementation of BMPs watershed-wide		• FRSG	• FRSG Dues
	Continuous Data Collection	Continue to fund the collection of continuous chlorophyll-a and other water quality parameters upstream of USGS 05549500 (Stratton Dam)		• FRSG	• FRSG Dues

<table>
<tr><th>Category</th><th>Subcategory (if applicable)</th><th>Pre-2032</th><th>Post-2032</th><th>Key Stakeholders</th><th>Funding Sources</th></tr>
<tr><td rowspan="3">Monitoring and Modeling Studies</td><td>Water Quality Monitoring Database and Trend Analysis Update</td><td>Continue to update the FoxDB database</td><td>Conduct an update of FoxDB database every ten years;
Update the water quality trend analysis to incorporate recently collected data</td><td>• Illinois State Water Survey
• FRSG</td><td>• FRSG Dues</td></tr>
<tr><td>Microbial Source Tracking (MST) Studies</td><td>Consider doing a Microbial Source Tracking (MST) study to determine sources of high fecal coliform levels in tributary subwatersheds</td><td>Consider conducting MST studies in other tributary subwatersheds with high fecal coliform levels</td><td>• FRSG</td><td>• Illinois EPA Section 319 and 604(b) with a local match from FRSG</td></tr>
<tr><td>Other Studies</td><td colspan="2">Improve subwatershed flow measurement locations

Identify erosive hot spots on the Fox River mainstem and tributaries

Conduct studies to better understand sources of phosphorus that are currently attributed to nonpoint sources to better target nonpoint source controls</td><td>• FRSG</td><td>• FRSG Dues</td></tr>
</table>

4.1 Administrative Actions

Several of the recommended actions in **Error! Reference source not found.** are administrative. These actions, to be undertaken primarily by the FRSG, include:

- Work with the USACE and Illinois DNR to complete the Fox River Connectivity & Habitat Connectivity Study by December 2023
- Continue to develop educational materials to inform the decision makers and public about benefits of dam removal
- Petition Illinois EPA to delist the toxic impairments for the Fox River based on recently collected data
- Develop a long-term funding plan for the FRSG for implementation projects and update the plan after the completion of the Fox River Connectivity & Habitat Study
- Continue to work with USACE and Illinois DNR on the removal of the remaining dams post-2032

Funding Sources

The administrative actions can be primarily funded through dues collected by the FRSG and in-kind contributions from members. The FRSG currently uses dues to fund a number of activities, including essential studies and programs deemed necessary to operate on a day-to-day basis. As FRSG's role evolves over time, the dues structure may be revisited and repurposed through mutual membership agreements to support additional capacities, including project development and implementation. The FRSG has long-term (10 year) funding plan in place which will be updated after the Fox River Connectivity & Habitat Study is completed in December 2023.

4.2 Actions for Eliminating DO and Nuisance Algae Impairments

The recommended actions for eliminating low DO and nuisance algae impairments in the mainstem Fox River include dam removal and associated riparian restoration, WWTP upgrades, and upstream load reductions. To improve the likelihood that recommendations are implemented on a timely basis, factors related to stakeholder engagement, evaluating the success of actions, and obstacles to implementation must be considered. These are discussed below.

4.2.1 Dam Removal and Riparian Restoration

Overview

The removal of ten low head dams in the study area is the most important recommendation of the FRIP. The objectives of dam removal on the Fox River (described in **Section 3.2.4**) are best achieved by eliminating the artificial impoundments and returning the upstream river reaches to something resembling the free-flowing pool and riffle system that existed prior to dam construction. Associated sediment removal or attenuation will also greatly reduce SOD and associated adverse impacts on benthic macroinvertebrates and fish spawning. *Appendix F1: Dam Removal Implementation* describes recommended dam removal design considerations.

As dams are removed, there are associated needs and opportunities to improve river riparian conditions. Water levels upstream of each dam will drop substantially, re-exposing hundreds of acres of riparian land. These riparian landscapes will be important targets for revegetation and restoration. The objectives for river channel restoration and riparian revegetation include shoreline shading, bank stabilization, and enhancing habitat for aquatic organisms. Shoreline shading is a critical consideration of the FRIP to help limit benthic algae growth in shallow water zones after dam removal. Bank stabilization is important to help limit inputs of sediment, including particulate phosphorus, from bank erosion. Enhancing habitat would also help restore and sustain aquatic life, which is a designated use for the Fox River. *Appendix F2: River Channel Restoration and Riparian Revegetation* describes recommended river channel restoration and riparian revegetation actions in detail.

Stakeholder Engagement

The stakeholders for dam removal include the dam owners, surrounding communities, FRSG, Illinois DNR, and the USACE.

The dams that are likely to be removed pre-2032 include the Carpentersville, North Batavia, and North Aurora dams. The dam owners are currently working with Illinois DNR on dam removal plans. These were the dam removals modeled in the short-term dam removal option evaluated by the FRSG. The plans for these individual dams are as follows:

- The Forest Preserve District of Kane County owns the Carpentersville Dam and is currently working on the design and permitting for its removal. The removal of the Carpentersville dam is anticipated to be completed by the end of 2023.

- The City of Batavia, which owns the North Batavia Dam, is currently undertaking a feasibility study to evaluate options for removing this dam while preserving the Depot Pond. Alternatives for North Batavia Dam range from full dam removal to modifications to create riffles and canoe/kayak runs.

- Illinois DNR owns the North Aurora dam and has committed to studying, supporting, and providing funding assistance for dam removal. This work is contingent on support from local governments. Initial studies considering the feasibility of different options for the modification and removal of the North Aurora Dam are underway.

In addition to state and local agencies, the USACE is a critical stakeholder in the effort to remove dams and restore habitat in the Fox River. The USACE recently restarted the Fox River Connectivity & Habitat Study, which focuses on removal of the ten dams from Montgomery on the downstream end to Algonquin on the upstream end. The feasibility phase of the study includes hydraulic modeling, ecological and cost assessments, project design, riparian and real estate matters, and public engagement. The study will gauge the feasibility of project alternatives including removal of all or a portion of the 10 dams and a no action plan. The subsequent implementation phase (anticipated to begin in 2024-2025), would involve Project Partnership Agreements with the State of Illinois and local dam owners. Dam removal projects would become eligible for removal under Section 519 following approval of the USACE feasibility study. The USACE will lead the dam removals recommended in the final feasibility study and provide 65 percent of the capital costs. The timing of individual dam removals will be impacted by results of the USACE study and support for dam removal from individual stakeholders.

Important stakeholders for river channel restoration and riparian revegetation recommendations include municipalities, park districts, forest preserve districts, and private landowners. Of these, municipalities are perhaps the most critical with regard to their role and capacity to implement demonstration projects, integrate BMPs into capital improvement plans, and establish landscaping and zoning requirements for riparian zones.

Evaluating Success

The FRSG conducted pre-dam removal water quality monitoring of the Carpentersville dam pool and upstream areas in 2021 and will conduct post-removal monitoring at the same locations. The data collected includes nutrients, chlorophyll-a (sestonic and benthic), and SOD. The data will be used to assess the impact of dam removal on water quality and verify critical modeling assumptions regarding the effect of dams on DO, chlorophyll-a, benthic algae, SOD, and other related factors. Illinois DNR fisheries biologists conducted fish surveys above and below the dam and Illinois EPA biologists monitored macroinvertebrates. The FRSG also contracted the Illinois Natural History Survey to conduct a mussel survey before the dam is removed. Mussel field surveys were conducted in summer of 2021 at three sites – one impact site at the Carpentersville dam location, one reference site upstream of the dam near Algonquin, and one reference site downstream of the dam near West Dundee.

The FRSG will adopt a similar approach for monitoring and assessing the water quality effects of subsequent selected dam removal projects.

Addressing Obstacles to Implementation

Despite overwhelming evidence that dam removal will benefit water quality and aquatic habitat, as well as reduce safety hazards, there is reluctance or opposition to dam removal in some communities. Concerns are related to the loss of historical structures, reduction of powerboat usage upstream of dams, and a perception that the river will dry up or expose mudflats. There are also several examples where dam removal projects have broad support from communities and river users, such as the Brewster Creek dam removal in 2003, South Batavia dam removal in 2006, Blackberry Creek dam in 2013 and other projects on the DuPage and Des Plaines rivers. Beyond northeastern Illinois, dam removal on formerly industrial rivers like the Milwaukee and Huron

(Michigan) rivers has been embraced by communities because of the recreational and economic benefits. It will be vital for the FRSG, the Forest Preserve District of Kane County, Friends of the Fox River, The Conservation Foundation, and other stakeholders to highlight and share the positive outcomes of early dam removal projects, notably Carpentersville. The FRSG is currently hosting public meetings and conducting surveys to understand public perceptions of dam removals. Developing and sharing educational materials highlighting the benefits of dam removals will help address community concerns and build support for projects.

Former South Batavia Dam Site; Courtesy: Art Malm, FRSG Board

Historically, in some areas, there has also been a utilitarian perspective of the Fox River and using it primarily for waste disposal and power generation and situating buildings with their backs to the river. However, there is now growing awareness and support for the river's aesthetic value and ecological and recreational potential, such as the Fox River Corridor plans for upper river areas and the recent riverfront planning initiatives in Batavia and St. Charles. In addition, the Fox River Water Trail initiative (https://fabulousfoxwatertrail.org/), which is working toward establishing the entire Fox River as a designated National Water Trail, will raise awareness and increase support for the river as a recreational resource.

Funding Sources

USACE is anticipated to play a substantial role in implementing and funding dam removal projects after the completion of the Fox River Connectivity & Habitat Study. This study is funded under Section 519 of the Water Resources and Development Act (WRDA). Congress provided authority for Illinois River Basin Restoration in Section 519 of WRDA 2000. Additional authority was provided in Section 5071 of WRDA 2007. Authority was granted in Sections (b) & (c) of Section 519 of the Water Resources Development Act 2000 (as amended; WRDA 2007) to complete a comprehensive plan and identify, evaluate, and implement critical restoration projects in the Illinois River Basin.

The USACE will provide 65 percent of the funding for approved projects. The remaining 35 percent local match can include in-kind and direct dollar contributions. It is anticipated that Illinois DNR will be the principal funding partner for approved projects. Local governments and the FRSG (primarily through in-kind activities) may also serve in significant funding roles.

Illinois DNR has also expressed support for funding Fox River dam removal projects. This support is conditioned on community and political support for removal projects. The Illinois DNR is the local cost-share partner with the USACE in its ongoing feasibility study of potential dam removal projects, with the FRSG providing the Illinois DNR with the remaining 35% cost-share funding needed to complete the study through Joint Funding Agreement. The Illinois DNR will also be a significant source of direct and in-kind funding to meet the required 35 percent non-federal match in the implementation phase.

4.2.2 WWTP Upgrades

Overview

All major (>1 million gallons per day) municipal WWTPs within the FRIP Study Area are in the process of upgrading facilities to meet TP effluent limits. The technologies being utilized to meet these targets include biological phosphorus removal, chemical dosing, and others. A detailed description of these technologies is included in the phosphorus optimization feasibility reports submitted to Illinois EPA by all major WWTPs.

The NPDES permits for the 24 major WWTPs require that facilities meet TP effluent limits of 1.0 mg/L (12-month rolling average, calculated monthly) by 2022. These WWTPs must also meet a 0.5 mg/L effluent limit (12-month rolling geometric mean, calculated monthly) by January 1, 2030. A summary of progress made by WWTPs in reducing TP is in *Appendix G: WWTP Upgrades Progress.*

Stakeholder Engagement

WWTPs may need to consider rate increases to help cover the cost of required upgrades. It will be important to communicate information about needed upgrades, potential rate increases, and other actions WWTPs are taking to their customers. The FRSG can work with WWTPs on communicating the benefits of facility upgrades as well as the overall FRIP to elected officials, businesses, and residents in the communities they serve to raise public awareness and support.

Evaluating Success

The success of WWTP upgrades will be measured by reported TP effluent data complying with the TP targets. Several WWTPs are already meeting or planning to meet this target within the next few years.

Addressing Obstacles to Implementation

The major WWTPs in the Fox River watershed have already budgeted for facility upgrades to meet the TP effluent limits. If rate increases are required, the WWTPs will need to communicate the regulatory requirements necessitating increases to address customer concerns. The Fox River is also an important aesthetic amenity, a recreational resource, a commercial waterway for businesses and residents, and a drinking water source. Raising awareness about efforts to address river health, the impact of impairments, and other actions that the FRSG is undertaking can help alleviate community concerns and increase understanding of rate increases.

Funding Sources

The WWTP capital budgets would account for the facility upgrades required to achieve compliance targets. Additional sources of funding may include Illinois EPA State Revolving Fund Loans and increase in user rates.

4.2.3 Upstream Load Reduction

Overview

Modeling results indicate that the elimination of low DO and nuisance impairments in the upper reaches of the Fox River would require upstream load reductions. The upstream segment of the river in Illinois is part of the Upper Fox River/Chain O' Lakes and Fox River/Flint Creek TMDLs. The Wisconsin portion of the Fox River also contributes to upstream loading in the FRIP Study Area.

Stakeholder Engagement

Key stakeholders for upstream load reduction actions include the FWA, major WWTPs discharging to Fox River upstream of Stratton Dam, Illinois EPA, Wisconsin DNR, the SEWRPC), and the SEWFRC.

Illinois EPA completed TMDLs for the Fox River upstream of Stratton in 2020 (CDM Smith, 2020a and CDM Smith 2020b). The FRSG should track the TMDL implementation processes by collaborating with Illinois EPA.

The FWA is also in the process of completing a watershed plan for this area, with an anticipated completion date of 2024. Once the plan is complete and approved by Illinois EPA, the FWA will be able to pursue funding for implementation projects. FRSG can work with the FWA to target a 75 percent reduction in upstream loading by 2042. The FWA has performed extensive outreach to engage stakeholders, starting in 2018, with local WWTPs, MS4 communities, non-governmental organizations, and business entities tied to waterfront endeavors. Since the initial outreach efforts, both the City of Woodstock and the Northwest Regional Water Reclamation Facility (NWRWRF – Fox Lake) have received NARP Special Conditions within their NPDES permits. These WWTPs should play an integral role in the development of that plan. This portion of the watershed also receives phosphorus inputs from agriculture, and outreach should be focused on this community if it has not already been engaged.

The FRSG will track the efforts currently underway in Wisconsin to address impairments in the Fox River through continued participation in the annual Fox River Summit, which is an annual gathering of organizations, municipalities, citizens, and stakeholders from across the Fox River Watershed. The SEWFRC has an established stakeholder group with representatives from MS4 communities, local sanitary districts, and local lake management districts. Furthermore, the State of Wisconsin has an active water quality trading program focused primarily on phosphorus reduction. The degree to which that program has been successful in the Wisconsin Fox River watershed is unknown. It is recommended that Illinois EPA engage with Wisconsin DNR to reduce the upstream loading from the Fox River watershed in Wisconsin.

Evaluating Success

The completion, approval, and implementation of the Fox Chain O' Lakes upstream watershed plan would provide the basis for evaluating success, particularly as projects are implemented. Additionally, the USGS recently installed a water quality monitoring station on the Fox River at the Illinois-Wisconsin border as part of their pilot Next Generation Water Observation System (NGWOS). The data from this station should be used to track the progress of load reduction efforts in Wisconsin. FRSG has also engaged USGS to install a continuous water quality monitoring sonde at Stratton dam (USGS 05549500 Fox River near McHenry, IL). The gage has recorded continuous measurements of DO, total algae, and turbidity starting in October 2018. The USGS also collects monthly discrete samples, which are analyzed for nutrients, including TP. This data could be used to evaluate the impact of upstream load reductions. FRSG will continue to fund the collection of data at the Stratton Dam by the USGS.

Addressing Obstacles to Implementation

The ability of the FWA to successfully complete the plan and begin execution of identified implementation projects is a new and expanding role for the agency. It should be brought to the attention of the upstream WWTPs with NARP special conditions that the watershed plan, while initially non-regulatory in its creation, will need the support and financial backing of key stakeholders to help in initiating projects. To this end, FRSG can encourage the City of Woodstock, NWRWRF, and other stakeholders to play a proactive role in watershed plan implementation. This would encourage other stakeholders to undertake implementation projects and support the initiatives of the plan.

Funding Sources

Potential funding sources include Illinois EPA Section 319 funding, the Regional Conservation Partnership Program (RCPP), and Lake County Stormwater Management Commission (SMC). The SMC funding is limited to Fox River communities in the Lake County portion of the watershed.

4.3 Actions to Address Other Impairments

Other impairments in the FRIP Study Area include sedimentation/siltation, habitat degradation hydromodification, high levels of fecal coliform bacteria, and several other contaminants. The development of recommendations to address fecal coliform levels will require additional monitoring studies, which are discussed in Section 4.4.8. Sedimentation, habit degradation, and hydromodification can be addressed by reducing the impact of stormwater runoff and other nonpoint sources in urban and agricultural tributary watersheds.

Recommended actions to reduce stormwater and other nonpoint source impacts on the Fox River mainstem and tributary watersheds are described in the numerous Illinois EPA approved nine-element watershed-based plans developed by local governments and other stakeholders.

Table 6 lists completed watershed-based plans in the FRIP Study Area. FRSG should collaborate with CMAP and other stakeholders to update watershed-based plans that are more than ten years old. The specific recommendations for urban and agricultural tributary subwatersheds are further discussed below.

Table 6: Watershed-based Plans in Fox River Tributary Watersheds

Watershed	Completion Date/Status
Tyler Creek	2008
Ferson-Otter Creek	2011
Blackberry Creek	2011
Silver & Sleepy Hollow Creeks	2011
Jelkes Creek-Fox River	2012
Spring Creek	2012 (being updated)
Woods Creek	2013
9 Lakes (Cotton-Mutton Creek, Slocum Lake Drain, Tower Lake Drain)	2014
Poplar Creek	2018
Flint Creek	2018
Mill Creek	2019
Little Rock Creek	Completed, awaiting approval
Crystal Creek	Completed, awaiting approval
Indian Creek (Aurora)	Ongoing

4.3.1 State of the Art Urban Watershed Management Recommended Actions

The FRSG will encourage state of the art urban watershed management practices by organizing special webinars on recommendations to support the long-term health and water quality goals for the Fox River. Topics would include, but are not limited to:

- Promoting the review and revision of local development and redevelopment ordinances to advance watershed-friendly practices (see *Appendix F3: Ordinance Update Recommendations)*
- Implementing stream and wetland restoration projects, including an evaluation of tributary dam removals
- Retrofitting existing developed landscapes and stormwater facilities with green infrastructure practices
- Incorporating green infrastructure designs into future public infrastructure projects.

The FRSG will promote the recommendations briefly discussed below.

Ordinance Updates

Adopting improved standards for regulating development and stormwater runoff will help reduce phosphorus as well as other pollutant loadings from urban sources and provide co-benefits such as stabilized hydrology and reduced flooding and streambank erosion. Improved standards will also be important for addressing the expected adverse effects of future development in the Fox River watershed. In addition to mitigating the impacts of new development, updated ordinances also target redevelopment in areas built prior to the adoption of modern stormwater and development ordinances. More specific recommendations for updating development ordinances are provided in *Appendix F3: Ordinance Update Recommendations*. The recommended approach includes a detailed ordinance checklist that local governments can use to review and update their stormwater, zoning, subdivision, and landscaping codes.

Stream and Wetland Restoration Projects

The various adopted tributary watershed plans identify opportunities to restore stream channels, riparian areas, and wetlands as well as online impoundments. To the Such restorations can reduce streambank erosion (a significant contributor of phosphorus) and stabilize downstream hydrology.

Retrofitting Existing Infrastructure and Incorporating Green Infrastructure

There are opportunities for local governments and other public agencies to continue to retrofit areas that were developed prior to requirements for modern stormwater best management practices. Retrofits should focus on green infrastructure practices such as naturalized detention basins, bio-infiltration, and permeable paving that provide both water quality and hydrologic benefits. Fox River communities such as Algonquin, Elgin, and Aurora have already implemented a number of demonstration projects that address identified problems and provide highly visible local examples for private developers and landowners to emulate. One notable retrofitting

Permeable parking lot at FRWRD headquarters. Photography: DLA Architects, Ltd. / Alexander Romanovsky opportunity is public infrastructure – e.g., roads and parking lots – owned by municipalities, townships, and the county. As public infrastructure ages, there will be opportunities to incorporate green infrastructure into replacement or rehabilitation projects.

Stakeholder Engagement

Municipalities and counties are the key stakeholders in recommended actions related to reviewing and improving ordinances. Countywide stormwater entities (particularly in McHenry, Kane, and Kendall Counties) should also review county ordinances for opportunities to improve provisions that address water quality, hydrology, and aquatic habitat.

The primary stakeholders for implementing restoration and retrofit projects are municipalities, counties, townships, park districts, school districts, and other public entities. Municipalities likely have the greatest opportunities for identifying and implementing green infrastructure retrofit projects. These projects can target existing facilities and parking lots for police and fire stations, public works buildings, and roads.

Addressing Obstacles to Implementation

There has been some historical resistance to utilizing green infrastructure in urban drainage, parking lot, roadway, and landscape design, due to perceived concerns about cost effectiveness, aesthetics, and reliability. However, these practices are becoming more widely accepted and supported by local planners and engineers, developers, and the public. Notably, numerous studies have shown that the long-term expense of green infrastructure, when factoring in maintenance, replacement, and other life cycle costs, is generally less than conventional infrastructure. In addition, some of the recommended conservation design approaches provide developers with greater flexibility in site design, allowing them to creatively tailor projects to evolving consumer markets.

Funding Sources

There are several funding and technical assistance sources that can support local governments and landowners in the implementation of the above actions. CMAP's Local Technical Assistance (LTA) program has been used to support local governments and watershed groups in reviewing and updating local development ordinances. The LTA program provides access to public policy experts from CMAP staff or outside contractors. Local watershed groups and municipalities have already used the LTA program to review ordinances in the Ferson-Otter Creek and Silver & Sleepy Hollow Creeks watersheds.

Illinois EPA has funding programs available for the planning and implementation of urban BMPs including green infrastructure, stream restoration, wetland restoration, and other water quality improvement projects. These include Section 319, Section 604 (b) and Green Infrastructure Grant Opportunities (GIGO) programs. A particular opportunity is for the FRSG to partner with CMAP in applying for Section 319 funds to perform ordinance reviews and revisions. Details about these programs are available on the Illinois EPA website.

Another innovative funding source for programmatic implementation or retrofit of green infrastructure is Public Private Partnerships (P3s). A P3 is an agreement between one or more public and private sector entities to accomplish goals more efficiently than what can be accomplished individually. This involves a private entity developing or maintaining stormwater infrastructure on behalf of public partners. The P3 shares the risk and cost so that no one organization has to bear the full burden. This cooperation helps to drive innovation and build strong long-term relationships. For example, the Milwaukee Metropolitan Sewerage District (MMSD) is currently implementing green infrastructure to reduce overflows into Lake Michigan through a P3 program. P3s are an alternative funding option that the FRSG and its members could explore to expand green infrastructure in the FRIP Study Area.

4.3.2 State of the Art Agricultural Watershed Management Recommended Actions

Agriculture is the dominant land use in the lower portion of the FRIP Study Area and in major portions of tributary sub-watersheds throughout the study area. Collaborating with agricultural stakeholders will be of primary importance in addressing sedimentation/siltation impairments in the mainstem and tributaries and reducing phosphorus loadings downstream. Recommended practices to reduce agricultural loading include traditional practices such as cover crops, grassed waterways, riparian buffers, and filter strips, and innovative practices such as iron sand filters and agricultural runoff treatment systems (ARTS).

The FRSG may explore opportunities for engaging the agricultural community on the application of these recommended practices. This could be done through the Illinois Farm Bureau, county farm bureaus, and Soil and Water Conservation Districts. Innovative technologies (iron sand filters, ARTS, etc.) can be merged with traditional practices (cover crop, no-till, etc.). The FRSG could work with the agriculture community to identify farm practitioners for pilot demonstration projects. After the initial projects, the FRSG could further investigate opportunities for placement and strategic alliances with the agricultural community to shore up marginal lands, switching them from limited agricultural returns to areas of beneficial nutrient capture, while investigating the means to programmatically fund design and construction of the needed facilities to reduce agricultural loading. The above strategy would tie in well with the goals of the Illinois Nutrient Loss Reduction Strategy (IEPA, IDOA, and University of Illinois Extension 2015).

Potential funding sources agriculture-related implementation practices include the Agricultural Conservation Easement Program (ACEP), Conservation Reserve Program (CRP), Conservation Stewardship Program, Environmental Quality Incentives Program (EQIP), Wetland Program Development Grants, and the RCPP.

4.4 Monitoring and Modeling Studies

The FRSG will undertake the following monitoring and modeling studies to track the progress of implemented actions and enable adaptive management discussed in Section 5.

4.4.1 Monthly Monitoring Effort

The FRSG will continue to undertake monthly monitoring grab samples at seven mainstem and seven tributary stations. These samples will be analyzed for temperature, DO, pH, conductivity, nutrients, sestonic chlorophyll-a, fecal coliform, chloride and turbidity

4.4.2 Instream Low Flow Monitoring Studies

The FRSG will consider conducting low flow monitoring studies approximately every ten years, if low flow conditions arise, to track the progress of implemented management actions. The FRSG defines the low target flows as approximately 523 cfs at the USGS 05551540 Fox River at Montgomery and approximately 360 cfs at the USGS 05550000 Fox River at Algonquin. Low flow studies should collect continuous data, discrete water column data, benthic algae, and SOD in the mainstem Fox River over a period of one month. The recommended locations and data to be collected at each location are provided in **Table 7**. The 2016 Quality Assurance Project Plan developed by FRSG (FRSG, 2016) should be updated prior to the next low flow monitoring study.

Continuous Data

Water quality sondes should be used to collect DO, pH, temperature, and specific conductivity at recommended locations in **Table 7**. The procedures for the collection of continuous data are documented in the Quality Assurance Project Plan for the 2016 FRSG low flow monitoring study (Deuchler, 2016b).

Discrete Water Column Data

Discrete water quality samples should be collected at recommended locations in **Table 7**. The samples should be analyzed for the following parameters: TP, Dissolved Reactive Phosphorus, Ammonia, Nitrate-Nitrogen, sestonic chlorophyll-a, DO, pH, and temperature. The procedures for the collection of discrete water column data are documented in Quality Assurance Project Plan for the 2016 FRSG low flow monitoring study.

Benthic Algae

Benthic algae should be measured at recommended locations in Table 5. The benthic algae should be reported by the laboratory in units of mass per unit area[4] in milligrams per square meter.

Sediment Oxygen Demand

SOD should be measured at four dam pool locations.

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[4] Previous FRSG low flow monitoring studies reported benthic algae in units of ug/L, which is not the correct measurement unit for benthic algae.

Table 7: Recommended Sampling locations for Instream Low Flow Monitoring Studies

Site ID; Location	RM	Type	Continuous	Discrete	Benthic Algae	SOD	Notes
USGS Gage 0554950; Downstream of Stratton Dam	97.7	Run					Data already being collected by USGS
Burtons Bridge	96.5	Run		X	X		2012 Low Flow Study Site
Site #870; Kimball St.	72.0	Pool	X	X		X	2012 Low Flow Study Site
Site# 869.5; National Street	74.0	Run	X	X	X		2012 Low Flow Study Site
Site# 850; St. Charles Pool	61.0	Pool	X	X		X	2012 Low Flow Study Site
Site# 840; Fabyan Forest Preserve	57.5	Run	X	X	X		2012 Low Flow Study Site
Site# 832; Sullivan Bridge	51.0	Run	X	X	X	X	2012 and 2016 Low Flow Study Site
Site# 825; Ashland Ave	47.0	Pool	X	X		X	2012 Low Flow Study Site
Site# 53; Route 30	46.0	Run	X*	X	X		FMWRD DO Sonde location
Site# 807; Yorkville Dam	43.0	Pool	X	X		X	2012 Low Flow Study
Site# 810; Orchard Road	41.5	Run	X	X	X		2016 Flow Study Site
Site# 800; Sheridan Road	20.5	Run	X*	X	X		2012 Low Flow Study Site

4.4.3 Bathymetry Studies

The model developed for the current FRIP includes very minimal bathymetry data for reaches downstream of Yorkville dam (RM 50). The FRSG may consider the collection of bathymetry data in this reach, if required after the completion of Fox River Connectivity & Habitat Study by USACE.

4.4.4 Dam Removal Studies

The FRSG will collect water quality data for selected pre- and post-dam removals. The parameters for data collection are described under low flow monitoring studies. This data will be used to assess the impact of dam removal on water quality and verify critical modeling assumptions regarding the effect of dams on DO, chlorophyll-a, benthic algae, SOD, and other related factors.

4.4.5 Modeling Updates

The FRSG will work with CMAP on update of the HSPF watershed models for the tributary using the recent land use and topography information. Kane County recently developed a hydro-conditioned Digital Elevation Model with the stream, storm sewer, and other drainage lines burned into the ground topography. This dataset (or similar ones) can be utilized for updating the HSPF models. The updated models would be used to support watershed-based plans for the subwatersheds.

The instream model QUAL2kw model developed as part of the current FRIP can also be updated with additional data to inform corrective actions for adaptive management described in Section 5.

4.4.6 MS4 Spreadsheet Tool Update

The 2015 FRIP included the development of an MS4 spreadsheet tool to calculate phosphorus load reductions resulting from BMPs implemented in the tributary watersheds. The following updates should be made to the MS4 spreadsheet tool:

- Updated estimated unit area loadings for phosphorus based on the HSPF model outputs for the period of 2012 to 2016
- Development of a web-based platform for the load calculations
- Incorporation of load reduction calculations for total nitrogen and TSS
- Incorporation of reporting features that auto generate an annual report on proposed and completed projects for submittal to regulatory agencies

The FRSG and member communities can use this tool in several ways to support planning, implementation, and reporting requirements for FRIP projects including:

1. Documenting annual load reductions from completed projects for annual reports to Illinois EPA.
2. Assessing how new and individual site development opportunities can alter nonpoint source loading.
3. Assessing how a community could allocate resources to offset development and reduce community aggregate loading or loads in a specific area (industrial park, near river area, etc.).

To maximize the benefits of such a tool, the FRSG will need to coordinate with member communities to collect and maintain sufficient data and information for landscape-based improvement and development projects.

4.4.7 Water Quality Monitoring Database and Trend Analysis Update

The ISWS maintains the FoxDB database, which is the repository for water quality data collected in the FRIP Study Area. The FRSG recently initiated a new project with the ISWS to update the

FoxDB with more current data and update the 2020 water quality trends analysis report (Getahun et al., 2019, **Appendix B)**. The project is expected to be completed in May 2023. The FRSG will continue to update the FoxDB database and the water quality trends analysis every ten years based on the additional data collection.

4.4.8 Microbial Source Tracking Studies

The FRSG conducts monthly monitoring for fecal coliform in the mainstem Fox River and major tributaries. High fecal coliform levels in the range of 1,000 to 10,000 counts per 100 milliliter have been reported from 2012 to 2020 in Fox River tributaries such as Indian Creek (Aurora) and Mill Creek (Geosyntec, 2022). These tributaries are also listed as being impaired for fecal coliform by Illinois EPA.

The FRSG is considering undertaking a pilot microbial source tracking (MST) study to determine the source(s) of high fecal coliform levels in a select tributary. This pilot study will seek to answer the following two study questions:

- Are human waste sources contributing fecal coliform to the tributary during dry weather?
- Are non-human waste sources, including dogs and geese, contributing fecal coliform to the tributary during dry weather?

The pilot MST study is a recommendation in the Indian Creek watershed-based plan, making the project eligible for Illinois EPA Section 319 funding (CMAP, 2022a). FRSG could apply for Section 319 funding to conduct the pilot study.

4.4.9 Phosphorus Sources Evaluation

To better understand the nonpoint sources of phosphorus in the Fox River, a study looking at naturally occurring phosphorus in groundwater, urban runoff, and agricultural/undeveloped land should be performed. This evaluation could inform the potential lower limit of phosphorus in the Fox River as well as projections of runoff loads as future development occurs.

4.4.10 Other Studies

The following additional studies should be considered by the FRSG to assess the impact of nonpoint sources on tributary water quality:

- Installation of additional flow gages in the tributaries
- Identification of erosive hot spots on the Fox River mainstem using field surveys and desktop analysis

4.5 Role of FRSG in FRIP Implementation

The FRSG should continue its role in guiding the region "towards a cleaner, safer, and more beautiful Fox River" with the FRIP. Specific actions are listed below.

4.5.1 Pre-2032

The Pre-2032 implementation actions to be undertaken by the FRSG are:

- Continue to undertake monthly monitoring grab sampling
- Fund water quality monitoring and mussel studies post-removal of the Carpentersville dam
- Fund and coordinate work with USACE and Illinois DNR to complete the Fox River Habitat & Connectivity Study and with communities to develop dam removal implementation plans (the study is estimated to be complete in December 2023)
- Develop education materials for the general public about the benefits of dam removal
- Explore opportunities to collaborate with agencies upstream of Stratton Dam such as FWA, WWTPs, and Fox River Wisconsin watershed partners on efforts to reduce phosphorus and algae levels that enter the Fox River study area
- Conduct special webinar(s) to promote state of the art watershed management practices
- Continue to maintain the water quality gage at Stratton Dam and track the progress of reducing upstream phosphorus and algae

Additional actions may include:

- Conduct MST in a pilot subwatershed to determine the cause of high fecal coliform levels in some of the Fox River tributaries
- Petition Illinois EPA to delist the Fox River segment for PCB impairments based on recent data
- Promote tracking and supporting the implementation of recommendations for state of the art watershed management practices
- Advocate for the adoption of development ordinances that include provisions to safeguard overall watershed water quality and minimize runoff

4.5.2 Post-2032 Recommended Actions

The Post-2032 implementation actions to be undertaken by the FRSG are expected to be:

- Support the USACE and Illinois DNR to remove the remaining dams on the Fox River identified in the final Fox River Connectivity & Habitat Study
- Conduct water quality monitoring studies pre- and post-removal of selected dams, including water quality and mussel studies
- Advocate for adoption of development ordinances that include provisions to safeguard overall watershed water quality and minimize runoff

SECTION 5

ADAPTIVE MANAGEMENT WATER QUALITY

The 2022 FRIP provides a roadmap for addressing water quality and related issues in the mainstem Fox River within the FRIP Study Area. The path forward for the FRIP must be flexible and adaptable to address these issues. This section outlines an adaptive management framework to reasonably accommodate potential challenges, including outcomes due to external inputs such as severe weather and extended drought.

Adaptive management is intended to be an iterative process that involves continual monitoring to assess the performance of management actions and enable responsiveness to potential challenges. According to the National Research Council (NRC, 2004), adaptive management "promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood."

Adaptive management should include a protocol that can account for needed changes as information becomes available, environmental and land use conditions change, or the policy environment changes. An adaptive management protocol for the FRIP is described below. The FRSG will report on adaptive management activities in annual reports submitted to the Illinois EPA.

5.1 Adaptive Management Protocol

The adaptive management protocol for the FRIP is based on a fixed recurring time period for assessing outcomes and future actions. The recommended fixed schedule is ten years after the approval of the 2022 FRIP and every ten years thereafter.

A recurring 10-year fixed schedule supports a planning and decision-making process to account for trends that need to be considered for the next 10-year endpoint. The review and assessment should consider cumulative changes resulting from project implementation, land use changes, regulatorily driven change, and the anticipated 10-year water quality outcomes. Documentation of significant management actions for watershed-based changes is essential to provide a historical record that can be reviewed if conditions change and additional corrective actions are needed.

5.1.1 Project Implementation

The two major areas warranting review and documentation are WWTP upgrades and dam removal.

WWTP upgrades: Several WWTPs have already upgraded their facilities to meet the TP effluent annual geometric mean target limit of 0.5 mg/L, whereas others are anticipated to be on schedule to meet this target limit by January 2030. This is a vital element of the FRIP, and the river's response in 10 years will be an important benchmark. Documentation of this process should be largely supported by FRSG monthly monitoring of the river and the WWTP monitoring requirements in NPDES permits.

Dam removals: While dams are situated locally throughout the FRIP Study Area, there are enough structures to have a cumulative impact on the river's water quality. Monitoring and documenting the impacts of dam removal should be used to evaluate river recovery within the adaptive management process. The removal of the Carpentersville, North Batavia, and North Aurora dams are anticipated to be completed by 2032. Targeted studies for selected dam removals will help inform adaptive management efforts.

The documentation of load reductions from WWTP upgrades and changes in water quality from WWTP upgrades and dam removals is important as it will help validate anticipated water quality outcomes. Projects may change from what was modeled due to increased costs or previously unknown local field conditions. If so, additional data may need to be collected and the models may need to be updated to reflect these changes for developing future corrective actions for adaptive management.

5.1.2 Regulatory Changes

As the FRSG continues to gather, review, and monitor activities as part of ongoing collaboration efforts, new data and insights will become evident. The FRSG should endeavor to stay ahead of permitting cycles for WWTPs and MS4s by periodically reviewing data that may impact the regulatory decision-making process or determine if draft permit conditions are practical to achieve.

WWTP NPDES permits: WWTPs should use the data and water quality outcomes within the FRIP Study Area as a tool to proactively impact the draft and final NPDES permit language. Rather than wait for regulatory authorities to dictate policy for individual NPDES permits, the FRSG should proactively explore and advocate for watershed-based approaches with supporting data.

MS4 permits: Each draft permit brings changes from previous versions, which may or may not be anticipated. The FRSG can use data and information collected through ongoing efforts to support suggested changes to draft permit conditions or as evidence against the need for specific draft permit conditions. The FRSG can help identify proactive management alternatives, such as targeted, cost-effective stormwater management at the local level. These alternatives can then be considered when Illinois EPA assesses the need for changes to MS4 permits in the FRSG Study Area.

5.1.3 Land Use Changes

The impact of changing land use should be considered in developing adaptive management strategies. The FRIP Study Area is anticipated to experience substantial growth and development by 2050 (CMAP, 2022b). Notably, Kane and McHenry Counties are projected to have an increase of more than 400,000 people.

A USGS study of the Fox River and Des Plaines River watersheds documents how continual urbanization can degrade water quality and aquatic life over time (Fitzpatrick et al., 2005). An important factor of urbanization is the change to the landscape and the increase in associated impervious cover. The anthropogenic modifications were shown to have adverse impacts on flow regimes, biological communities, and pollutant loads. Notably, indices representing benthic algal, macroinvertebrate, and fish biological communities declined rapidly as urban land cover increased from 10 to 30 percent or more.

These observations, as well as observations that existing urban tributaries to the Fox River are not currently meeting aquatic life use standards, raise concerns about the likelihood of the mainstem Fox River meeting designated use standards in the future, even with full implementation of recommended dam removals and WWTP upgrades. Therefore, it is important that the FRSG have an effective adaptive management strategy to address detrimental watershed level impacts and protect the Fox River for its designated uses including aquatic life, as a source of drinking water, and as a safe, recreational resource.

This requires a collaborative effort to implement and track recommended state of the art watershed management measures into the future. Section 4 identifies recommended art practices to address existing water quality and hydrologic impairments caused by stormwater and nonpoint sources. These include revising stormwater and development ordinances as well as retrofitting existing landscapes and BMPs to reduce existing impairments. FRSG should continue to collaborate with watershed stakeholders and advocates to encourage the implementation of watershed measures and track their implementation on a periodic basis.

SECTION 6

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