NUTRIENT ASSESSMENT REDUCTION PLAN FOR THE NORTH BRANCH CHICAGO RIVER WATERSHED

Prepared for

North Branch Chicago River Watershed Workgroup

500 W Winchester Road, Suite 201
Libertyville, IL

Prepared by

Geosyntec Consultants, Inc.
1420 Kensington Road, Suite 103
Oak Brook, Illinois 60523

Project MOW5618

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ACRONYMS AND ABBREVIATIONS

%	percent
µg/L	micrograms per liter
BMP	Berst Management Practice
DO	dissolved oxygen
FPDCC	Forest Preserve District of Cook County
IDNR	Illinois Department of Natural Resources
Illinois EPA	Illinois Environmental Protection Agency
mg/L	milligrams per liter
mm	millimeters
MS4	Municipal Separate Storm Sewer System
NARP	Nutrient Assessment Reduction Plan
NBCR	North Branch Chicago River
NBWW	North Branch Chicago River Watershed Workgroup
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
SMC	Stormwater Management Commission
SWMM	Storm Water Management Model
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
WASP	Water Quality Analysis Simulation Program
WBP	watershed-based plan
WRF	Wastewater Reclamation Facility
WWTP	Wastewater Treatment Plant

1. INTRODUCTION

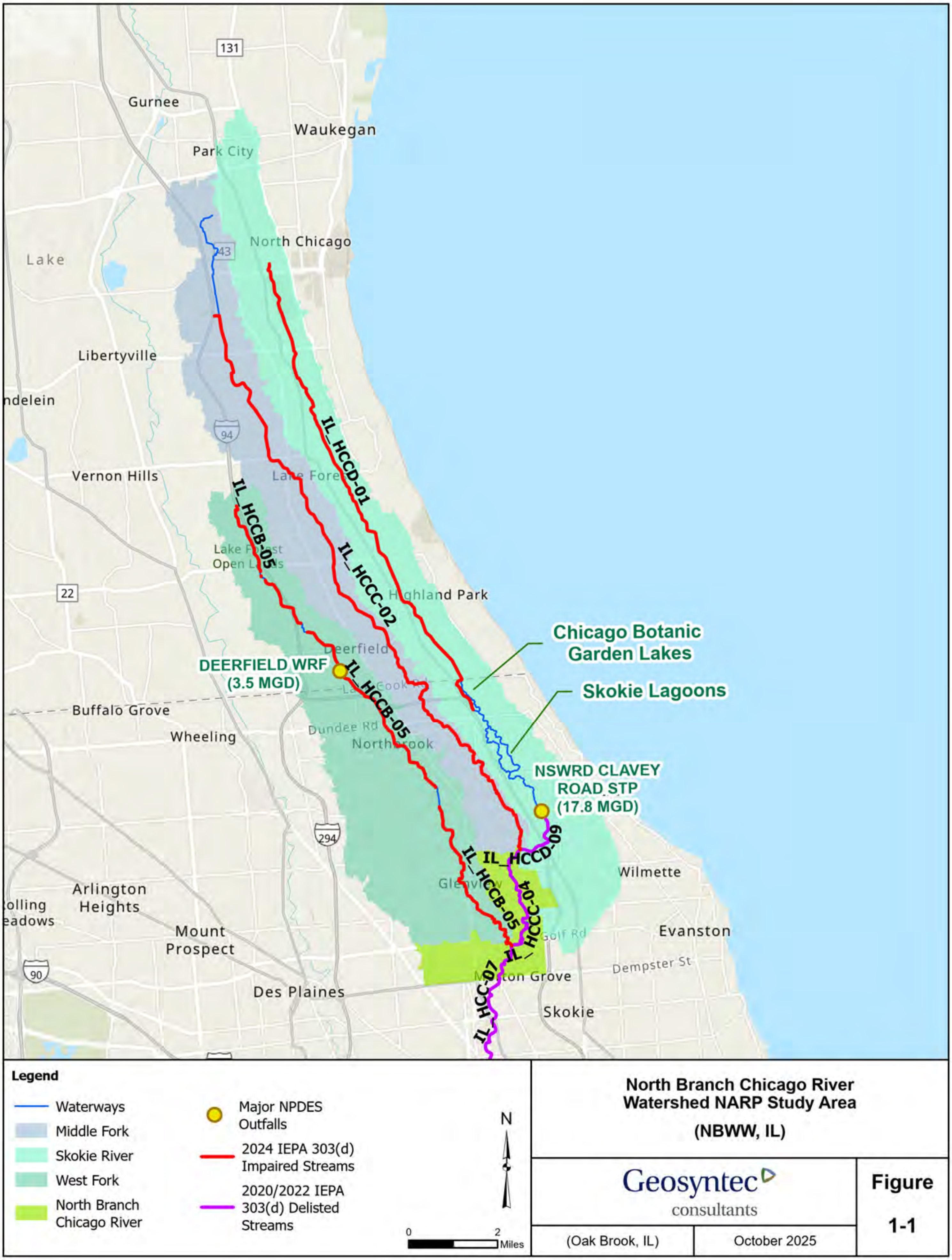
The North Branch Chicago River Watershed Workgroup (NBWW) has worked over the course of the past several years to responsibly study and understand how anthropogenic change may have impacted the North Branch Chicago River (NBCR). This report embodies the result of this work while addressing the Nutrient Assessment Reduction Plan (NARP) Special Conditions for the North Shore Water Reclamation District (NSWRD) Wastewater Reclamation Facility WRF and Deerfield WRF. Through this work and a better understanding of the key issues impacting the NBCR, appropriate efforts towards watershed recovery and surface water improvement consistent with the goals of the NBWW can be realized.

1.1 Study Area

The NBCR originates as far north as Gurnee, Illinois, and drains an area of 170 square miles through Lake and Cook Counties in northeastern Illinois (**Figure 1-1**). The NBCR is formed by three tributaries: West Fork, Middle Fork, and Skokie River. The Skokie River and Middle Fork are approximately 24 miles and 17 miles, respectively, long prior to the confluence, where they form the main stem NBCR. The West Fork is approximately 14 miles long prior to the confluence with the main stem NBCR in Morton Grove, Illinois. The river joins the North Shore Channel near Foster Avenue in Chicago, Illinois, and then flows south through Chicago before converging with the South Branch Chicago River.

The study area for the NBCR watershed NARP encompasses a 95-square-mile area bounded to the north by Illinois Route 132 in Waukegan, Illinois. The NARP Study Area (see shaded area in **Figure 1-1**) terminates at the intersection of Dempster Street with the NBCR in Morton Grove. The NARP Study Area has a warm continental climate with warm summers and cold winters. The polar jet stream creates low-pressure systems that bring clouds, wind, and precipitation. Impervious surfaces such as buildings, roads, parking lots, and industrial activities result in increased temperatures in the urban area. Lake Michigan moderates the temperatures in the winter and summer.

Land use in the Study Area is predominantly residential (36.3%); conservation and recreation open space (29.1%); and transportation, utility, or waste facilities (14.7%). The remaining area is commercial, institutional, industrial, and vacant lots, based on the 2015 Chicago Metropolitan Agency data (**Figure 1-2**). According to 2015 United States Census data, the population in the Study Area is 204,279. The population is anticipated to increase by 23% by 2050 (Lake County Stormwater Management Commission [SMC] 2021).



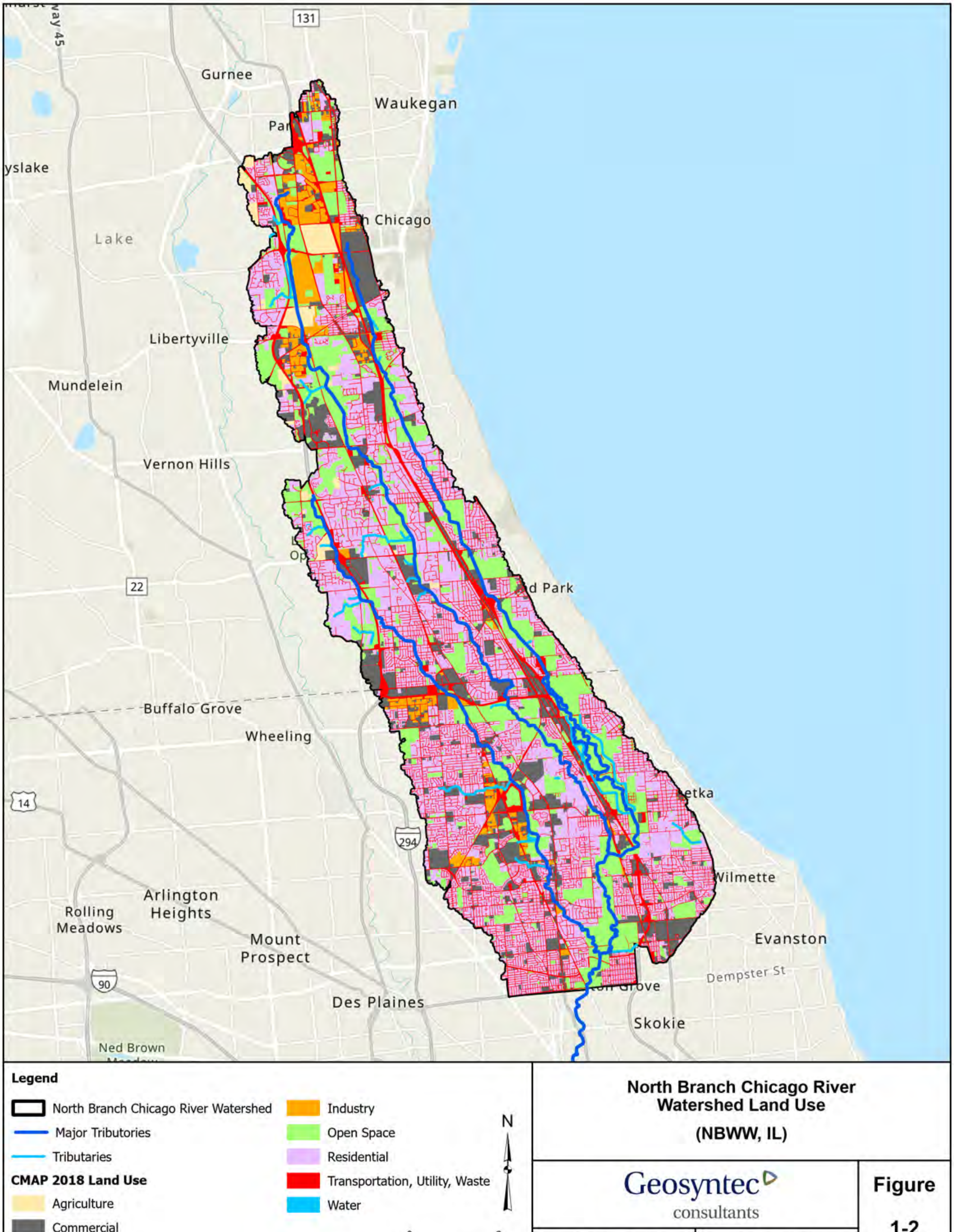
North Branch Chicago River Watershed NARP Study Area

(NBWW, IL)

Geosyntec consultants

(Oak Brook, IL) | October 2025

Figure 1-1



North Branch Chicago River Watershed Land Use

(NBWW, IL)

Geosyntec consultants

Figure 1-2

(Oak Brook, IL)

October 2025

1.2 Purpose of the NARP

The Illinois Environmental Protection Agency (EPA) has incorporated a special condition requirement to develop a NARP in many Illinois National Pollutant Discharge Elimination System (NPDES) permits for major wastewater treatment plants (WWTPs) with design average flow of greater than 1 million gallons per day. The NARP requirements apply to WWTPs discharging upstream of water bodies that are determined to have a phosphorus-related impairment[1] or to be at "risk of eutrophication."[2] The NPDES permit of Village of Deerfield Water Reclamation Facility (WRF) and North Shore Water Reclamation District Clavey Road WRF includes the following special condition to develop a NARP

The Permittee shall develop, or be a part of a watershed group that develops, a Nutrient Assessment Reduction Plan (NARP) that will meet the following requirements:

A. *The NARP shall be developed and submitted to the Agency by December 31, 2024. This requirement can be accomplished by the Permittee, by participating in an existing watershed group or by creating a new group. The NARP shall be supported by data and sound scientific rationale.*

B. *The Permittee shall cooperate with and work with other stakeholders in the watershed to determine the most cost-effective means to address the phosphorus-related impairment. If other stakeholders in the watershed will not cooperate in developing the NARP, the Permittee shall develop its own NARP for submittal to the Agency to comply with this condition.*

C. *In determining the target levels of various parameters necessary to address the phosphorus related impairment, the NARP shall either utilize the recommendations by the Nutrient Science Advisory Committee or develop its own watershed-specific target levels.*

D. *The NARP shall identify phosphorus input reductions by point source discharges and non-point source discharges in addition to other measures necessary to* remove phosphorus related impairments in the watershed*. The NARP may determine, based on an assessment of relevant data, that the watershed does not have an impairment related to phosphorus, in which case phosphorus input reductions or· other measures would not be necessary. Alternatively, the NARP could determine that phosphorus input reductions from point sources are not necessary, or that phosphorus input reductions from both point and nonpoint sources are necessary, or that phosphorus· input reductions are not necessary and that other measures, besides phosphorus input reductions, are necessary.*

E. *The NARP shall include a schedule for the implementation of the phosphorus input reductions by point sources, non-point sources and other measures necessary to remove*

[1] A water body with a phosphorus-related impairment means is listed by Illinois EPA as impaired because of the presence of dissolved oxygen or "offensive conditions" (e.g., algae or aquatic plant growth).
[2] A water body is determined to be at "risk at eutrophication" if the levels of sestonic chlorophyll, pH, and dissolved oxygen are above the thresholds set by Illinois Risk of Eutrophication Committee.

phosphorus related impairments. The NARP schedule shall be implemented as soon as possible and shall identify specific timelines applicable to the Permittee.

F. *The NARP can include ·provisions for water quality trading to address the phosphorus related impairments in the watershed. Phosphorus/Nutrient trading cannot result in violations of water quality standards or applicable antidegradation requirements.*

G. *The Permittee shall request modification of the permit within 90 days after the NARP has been completed to include necessary phosphorus input reductions identified within the NARP. The Agency will modify the NPDES permit, if necessary.*

H. *If the Permittee does not develop or assist in developing the NARP, and such a NARP is developed for the watershed, the Permittee will become subject to effluent limitations necessary to address the phosphorus related impairments. The Agency shall calculate these effluent limits by using the NARP and any applicable data. If no NARP has been developed, the effluent limits shall be determined for the Permittee· on a case-by-case basis, so as to ensure that the Permittee's discharge will not cause or contribute to violations of the dissolved oxygen or narrative water quality standards.*

In addition, the Municipal Separate Storm Sewer System (MS4) general permit Special Condition C (reproduced below) requires permittees to provide a schedule for meeting waste load allocations in total maximum daily loads (TMDLs) or watershed management plans:

If a TMDL allocation or watershed management plan is approved for any water body into which the permittee discharges, the permittee shall review the permittees SWMP to determine whether the TMDL or watershed management plan includes requirements for control of storm water discharges. If the permittee is not meeting the TMDL allocations, the permittee shall modify the permittees SWMP to implement the TMDL or watershed management plan within 12 (twelve) months of notification by the Agency of the TMDL or watershed management plan approval.

The purpose of the NARP is to identify phosphorus input reductions and other measures necessary to address phosphorus-related impairment. Illinois EPA recognizes that other measures (such as dam removal, stream restoration, riparian buffers, or constructed wetlands) may be needed to eliminate impairments. Therefore, Illinois EPA has encouraged WWTPs to develop NARPs on a watershed-wide basis with input from MS4s and other stakeholders.

1.3 Watershed Group

The North Branch Watershed Workgroup (NBWW) is a voluntary, dues-paying membership organization whose mission is to meet Illinois EPA requirements by making cost-effective improvements to water quality in the NBCR and its tributaries. The NBWW brings together a diverse coalition of stakeholders: members include communities, WWTPs, and park districts, non-profit organizations, environmental interest groups and other interested parties. A complete list of participants can be found on the NBWW website (www.nbwwil.org).

The NBWW decided to develop a NARP on a watershed-wide scale; giving multiple opportunities to all NBWW members and NBCR stakeholders to provide input, guidance and direction for the plan. The original NARP deadline submission was December 31, 2024. The NBWW requested a one-year extension for the NARP deadline because of the complexity involved in collecting data in Skokie Lagoon. The Illinois EPA approved the extension request.

There are two major WWTPs in the Study Area **(Figure 1-1**) with design flows ranging from 3.5 to 17.8 million gallons per day **(Table 1-1**). The NPDES permits for these WWTPs include the NARP special conditions because these WWTPs are located upstream of a reach that Illinois EPA has identified as impaired due to phosphorus (Illinois EPA 2024).

Table 1-1: Wastewater Treatment Plants in the Nutrient Assessment Reduction Plan Study Area

Wastewater Treatment Plants	Design Average Flow (MGD)	Receiving Water Body
Village of Deerfield WRF	3.5	West Fork
North Shore Water Reclamation District (NSWRD) Clavey Road WRF	17.8	Skokie River

MGD: million gallons per day
WRF: water reclamation facility

1.4 NARP Development Timeline

NBWW hired Geosyntec Consultants, Inc. (Geosyntec) to develop a work plan to identify the scope, schedule, and budget for subsequent work required to produce the NARP (Geosyntec 2021). The work plan was submitted by NBWW to Illinois EPA in 2021 to meet the special condition in the NPDES permit of WWTPs. NBWW did not receive any specific feedback on the work plan from Illinois EPA. The NPDES permit conditions required submission of NARP by December 2024. NBWW requested an extension of NARP deadline by NARP deadline to December 2025 for additional monitoring, which was subsequently approved by Illinois EPA.

NBWW engaged a project team, including Geosyntec as the prime consultant and the Illinois Institute of Technology, to develop the NARP. The project team collaborated with the NBWW Monitoring Committee and other stakeholders during the NARP's development. The process followed a multi-year timeline, starting with targeted data collection in 2022, then progressing to data analysis and the creation of watershed and instream models in 2023 and 2024, respectively. Simulations of watershed management scenarios were conducted in 2024 and 2025 and the NARP report, along with the implementation plan and schedule, was prepared in 2025. The timeline of NARP development is shown in **Figure 1-3**.

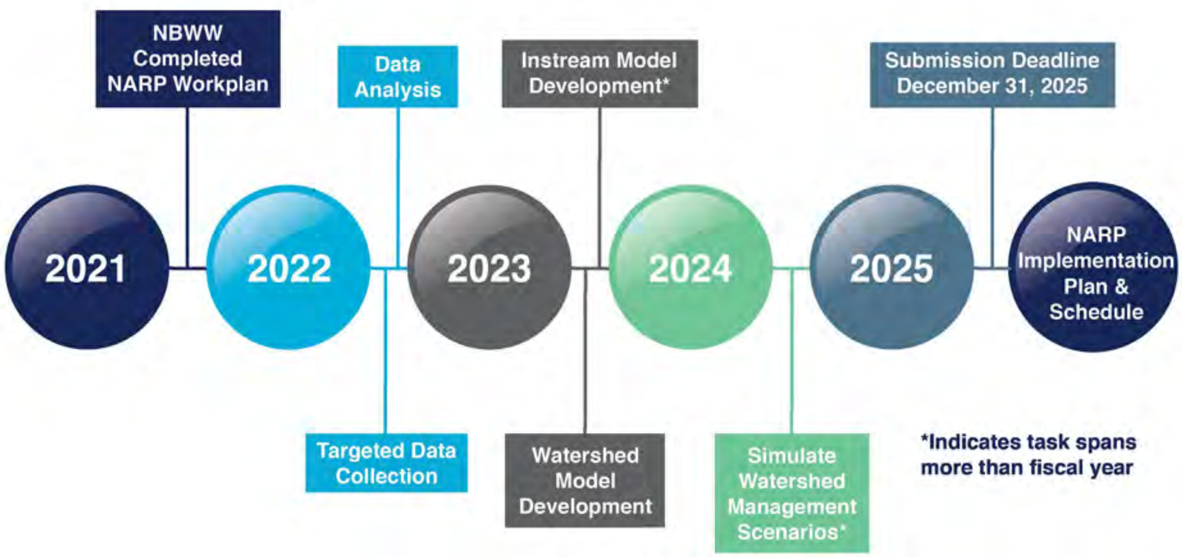


Figure 1-3: North Branch Watershed Workgroup Nutrient Assessment Reduction Plan Development Timeline

1.5 Report Organization

This report documents the work that the project team conducted to execute the work plan for the Study Area NARP (Geosyntec 2021).

Chapter 2 of the report provides an overview of water quality impairments, nutrient sources, and other factors impacting water quality and previous water quality studies. The NARP development process, which included data collection and analysis, modeling, and evaluating management scenarios, is described in **Chapter 3**. **Chapter 4** describes the recommended implementation plan and schedule to address phosphorus-related impairments.

2. WATER QUALITY STATUS

2.1 Phosphorus-Related Impairments

To fulfill the requirements of Section 303(d) of the federal Clean Water Act, every 2 years the Illinois EPA prepares a list of impaired waterbodies not meeting their intended uses (fishing, swimming, drinking water supply, etc.) and the criteria used as the basis of the impairment. The criteria can be numeric or nonnumeric (Section 303[d] List). The 2024 Section 303(d) listed reaches in the Study Area for phosphorus-related impairments are provided in **Table 2-1.**

Figure 1-1 shows the location of these impaired reaches. Segments of the NBCR (IL_HCC-07), Skokie River (IL_HCCD-09), and Middle Fork (IL_HCCC-04) were listed as impaired due to dissolved oxygen in the 2020/2022 Section 303(d) List (Illinois EPA 2020/2022) but were delisted in the 2024 Section 303(d) List. The delisting of these segments shows progress in the watershed toward improving water quality in the NBCR.

Table 2-1: Phosphorus-Related Impaired Reaches (Illinois EPA 2024)

Water Body	Segment	Length (miles)	Cause of Impairment by Designated Use	
			Aquatic Life	Aesthetic Quality
North Branch Chicago River	IL_HCC-07	11.9	Total Phosphorus (**TP**)*	F
Skokie River	IL_HCCD-01	13.47	**Total Phosphorus (TP), Dissolved Oxygen (DO)**	F
Skokie River	IL_HCCD-09	1.76	Total Phosphorus **(TP)**	F
Middle Fork	IL_HCCC-02	18.57	Cause Unk, Dissolved Oxygen **(DO)**	X
Middle Fork	IL_HCCC-04	3.51	Total Phosphorus (**TP**)	X
West Fork	IL_HCCB-05	14.48	Total Phosphorus (**TP**)	X

*Delisted for DO in 2024 Listing
Cause Unk: Cause Unknown
F: Fully Supporting
X: Not Assessed

2.2 Water Quality Goals and Load Reductions Target

The NBWW has identified within its bylaws the following mission:

The mission of the Workgroup is to bring together a diverse coalition of stakeholders to preserve and enhance water quality in the North Branch Chicago River and its tributaries.

These bylaws demonstrate that NBWW is willing to work with any and all stakeholders that desired to participate to address the water quality impairments identified by the Illinois EPA and develop a reasonable framework as part of this NARP to accomplish the implementation necessary to achieve this goal. The segments of NBCR and its tributaries where phosphorus-related impairments (dissolved oxygen [DO] and nuisance algae impairment) have been reported are identified in **Section 2.1**. A summary of water quality standards in the NBCR and its tributaries for DO, nuisance algae and nutrients are provided below.

2.2.1 Water Quality Standards

2.2.1.1 Dissolved Oxygen

Numeric criteria for DO are described in Illinois Administrative Code (IAC) rules for water quality standards (35 IAC 302). The DO criteria are dependent on the time of the year and include 3 components: (1) an instantaneous criterion, (2) a daily mean averaged over 7 days, and (3) a daily mean averaged over 30 days. **Table 2-2** presents the DO standards for reaches in the Study Area.

Table 2-2: Dissolved Oxygen Water Quality Measurements

DO Standard	March through July (mg/L)	August through February (mg/L)
Instantaneous	5.0	3.5
Daily mean averaged over seven days	6.0	4.0
Daily mean averaged over 30 days	N/A	5.5

mg/L: milligrams per liter

2.2.1.2 Nuisance Algae

There are no numeric standards for nuisance algae in Illinois. The provisions of IAC Section 302.203 are a narrative description for the offensive condition in streams that is applicable to the reaches in the Study Area: "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 conditions such as excessive plant or algal growth. For this study the Illinois risk of eutrophication threshold was used as water quality target, which is described in **Section 2.2.2.**

2.2.1.3 Nutrients

The Illinois EPA 303(d) list identifies total phosphorus (TP) as a cause of impairment for several of the NBCR and its tributaries' reaches associated with nuisance algae or plant growth. There are no numeric or narrative water quality criteria for TP in rivers and streams in Illinois. From 2015 to 2018, a Nutrient Science Advisory Committee (NSAC) met and developed recommendations for numeric nutrient criteria for non-wadable streams and rivers and wadable streams for Illinois's southern and northern ecosystems. During the development of instream nutrient criterion, the NSAC did not find stressor-causal relationship between TP and sestonic chlorophyll-a and macroinvertebrates or fish metrics The NSAC recommended criteria for TP, total nitrogen, benthic chlorophyll *a*, and water column chlorophyll *a* criteria based on a reference stream approach (Illinois NSAC, 2018). The recommended TP criterion for wadable streams in a northern Illinois ecosystem like the NBCR was 113 micrograms per liter (µg/L). The Illinois EPA has not acted on the NSAC recommendations. Hence, this recommended criterion was not used for the NARP.

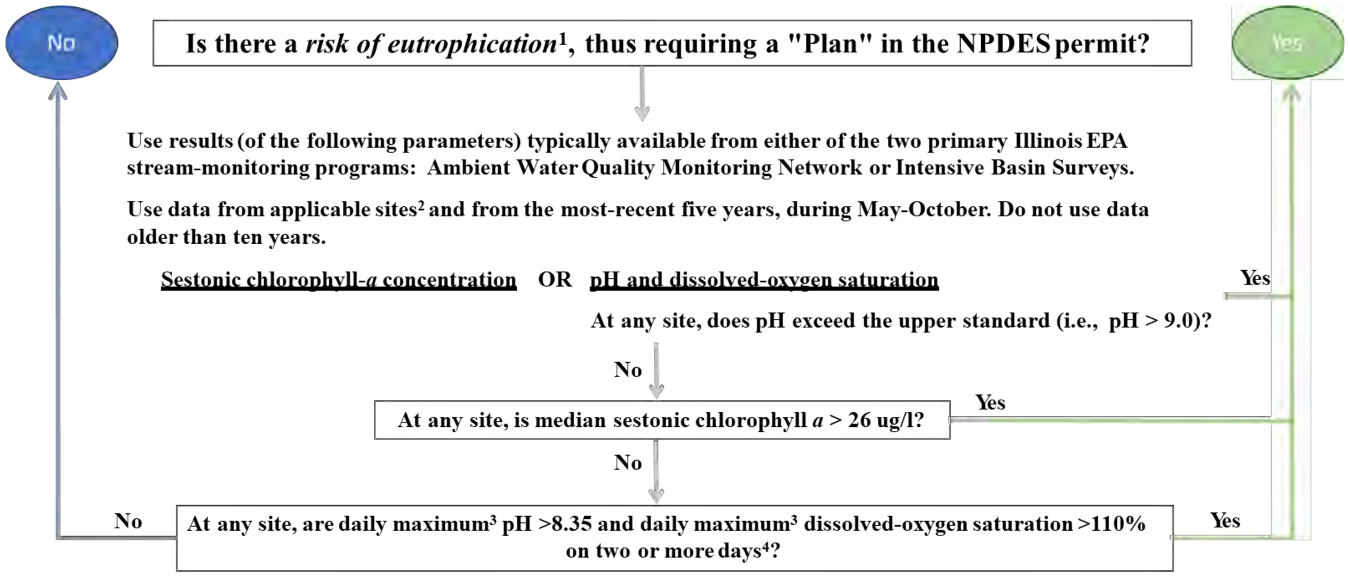
The NBWW NARP did not establish an instream phosphorus target and instead used the Illinois risk of eutrophication targets discussed below. Additional information regarding this decision is discussed in **Section 3.2.2** The NARP used these targets to identify the phosphorus input reductions needed. This approach is consistent with the methods used by Illinois EPA and the United States Environmental Protection Agency (US EPA) to develop a total maximum daily load (TMDL).

2.2.2 Risk of Eutrophication Thresholds

The Illinois EPA Risk of Eutrophication Committee developed a decision process to assess the "risk of eutrophication" by using numeric thresholds of chlorophyll *a*, pH, and DO saturation (**Figure 2-1**). The "risk of eutrophication" was defined as a reasonable suspicion that plant, algal, or cyanobacterial growth is causing or will cause a violation of the narrative criteria in Illinois' streams and rivers. The numeric thresholds for pH, chlorophyll *a*, and DO saturation levels were determined by analyzing the relationships between pH, chlorophyll *a*, and DO data at Illinois EPA stations located throughout the state. A stream or river is defined at risk of eutrophication if either of the following criteria are met:

1. pH exceeds a threshold of 9.0 SU
2. Median chlorophyll a greater than 26 ug/L
3. Daily maximum pH > 8.35 and daily maximum oxygen saturation >110% for two or more days

The thresholds for chlorophyll *a* and DO saturation were used as water quality targets for the development of the NARP.



[1] *Risk of eutrophication* means reasonable suspicion that plant, algal, or cyanobacterial growth is causing or will cause violation of a water-quality standard.

[2] To be determined, case by case.

[3] For one-per-day results, *daily maximum* is represented by the single result. For many-per-day (i.e., continuously monitored) results, *daily maximum* is the maximum result in a discrete 24-hour period.

[4] For many-per-day (i.e., continuously monitored) results, a *day* means a discrete 24-hour period.

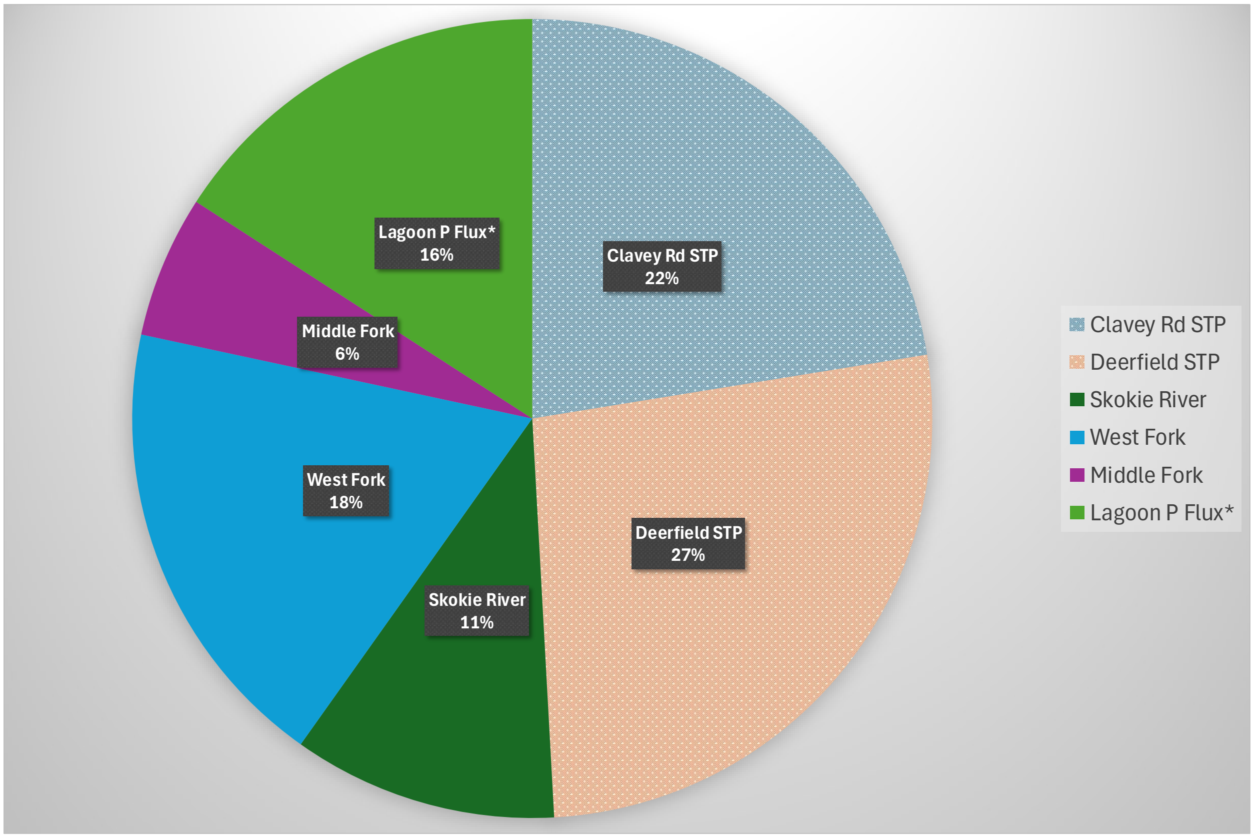
Figure 2-1: Illinois EPA Procedure for Determining Risk of Eutrophication

2.3 Nutrient Sources

The nutrient sources in the NARP Study Area include point-source loading from major WWTPs, and nonpoint-source loading from Skokie River, West Fork and Middle Fork subwatersheds. Nonpoint sources are classified into two main categories: MS4 areas, which include developed and open spaces in urban environments, and Other, comprising forest, rural grassland, surface water, and wetland. Legacy sediments in the Skokie Lagoons also contribute nutrients.

As part of NARP development, the project team developed watershed and instream models to quantify the TP loading, which are described in **Section 3**. *: P flux based on model calibration (see Page 9 of Appendix B for additional information)

Figure 2-2 provides the percentage contribution of TP from different sources for the NARP Study Area from July 28 to October 5, 2022. The total simulated TP load for the entire Study Area for this period is 11,605 pounds. Loading from the two WWTPS constitutes approximately 49% of total TP loading during this period. This loading was based on the measured flow and effluent data (see **Figure 3-10**). Nonpoint-source loading from West Fork, Skokie River, and Middle Fork contribute approximately 35% of the total TP. The legacy sediment in Skokie contributes approximately 16% of TP loading.



*: P flux based on model calibration (see Page 9 of Appendix B for additional information)

Figure 2-2: Contribution of Different Sources to Total Phosphorus Loading from July 28 to October 5, 2022

2.4 Water Quality Studies

There have been extensive water quality studies and management plans for the NBCR and its tributaries. Summaries of relevant studies and management plans are provided below.

2.4.1 North Branch River Watershed-Based Plan

The Lake County SMC developed a nine-element watershed-based plan (WBP) for the 95-square-mile NBCR watershed planning area (Lake County SMC 2021). The plan identified phosphorus, nitrogen, sediment, chloride, and fecal coliform as primary causes of impairments in streams and tributaries. The total pollutant load in the WBP was estimated at 115,013 pounds per year (lbs/year) for TP and 1,623,664 lbs/year for total nitrogen (TN), with point sources contributing approximately 54% of the TP load and 79% of the TN load[3]. Using watershed assessment tools and land use projections, the WBP estimated future increases in pollutant loads under unmanaged

[3] Loads for point source are calculated based on 2020 data while the non-point source loading was calculated using Northeastern Illinois Planning Commission (NIPC) excel based model which used event mean concentrations

development scenarios. Specifically, the modeling predicted significant rises in nutrient loads, including phosphorus, in areas with expanding impervious cover. To address these concerns, the WBP proposed numerous best management practices (BMPs), including green infrastructure retrofits (such as rain gardens, bioswales, native landscaping, micro detention basins) , streambank stabilization, wetland restoration, and stormwater detention upgrades. The plan also emphasized the importance of reducing point and nonpoint sources of phosphorus through improved septic systems, improved leaf litter collection, phosphorus reduction in effluent discharges, and decreased road salt application.

2.4.2 North Branch River Watershed Total Maximum Daily Load

The Illinois EPA established TMDLs for TP in three lakes within the NBCR watershed—Skokie Lagoons, Chicago Botanic Garden Lake, and Eagle Lake—to address exceedances of the lake phosphorus criterion of 0.05 milligrams per liter (mg/L) (Illinois EPA, 2020). Using the Simplified Lake Model (SLAM), Illinois EPA quantified both external loads (primarily from regulated stormwater runoff via MS4s) and internal loading (from sediment flux and bioturbation by benthic fish under anoxic conditions). The calculated TP reductions required to meet water quality standards ranged from 43% in Eagle Lake and Chicago Botanic Garden Lake to 86% in Skokie Lagoons. Load allocations, wasteload allocations, and a 10% explicit margin of safety were developed for each lake, and BMPs were recommended to target both watershed sources and internal lake processes.

Although several stream segments in the watershed were listed as impaired for DO under the General Use standard, Illinois EPA determined that these impairments were primarily due to low stream reaeration rates, rather than excessive oxygen demand from nutrient or organic pollutant loads. As a result, no DO-specific TMDLs were developed. Illinois EPA's analysis indicated that stream morphology and hydraulic conditions, especially in low-gradient, impounded reaches, were the dominant factors contributing to low DO levels. Consequently, these impairments were reevaluated in the *Illinois Integrated Water Quality Report and Section 303(d) List, 2024 Draft* (Illinois EPA, 2024) which led to delisting of several streams segments attributed to DO (see Section 2.1) While DO-specific reductions were not assigned in the TMDL, Illinois EPA noted that implementation of nutrient and sediment control measures are expected to yield ancillary benefits by mitigating algal growth and reducing biochemical oxygen demand, thereby improving DO levels in stream reaches.

2.4.3 Monitoring Studies

The NBWW and Illinois EPA have performed water quality monitoring in the Study Area, which is briefly described below.

2.4.3.1 NBWW Monitoring

The NBWW has undertaken a comprehensive monitoring program since 2018 to collect physical, chemical, and biological data in the mainstem NBCR and its tributaries. The goals of the monitoring program as stated in the NBWW monitoring strategy documents are as follows (NBWW 2024):

1. "Develop and implement a comprehensive monitoring program that will include chemical, physical, and biological components that will accurately identify the quality of stream and river ecosystems as well as stressors associated with non-attainment of water quality standards and designated uses. The NBWW monitoring program will establish baseline conditions and then measure progress towards meeting water quality standards."
2. "Provide a secondary benefit to NPDES permittees by meeting certain monitoring permit requirements, including monitoring requirements for upstream and downstream of Publicly Owned Treatment Works (POTWs) and Municipal Separate Storm Sewer Systems (MS4s)."

The comprehensive water quality monitoring that NBWW undertook from 2018 to 2021 leveraged a tiered site design, which allowed for more frequent monitoring of sites with greater flow and tributary area while still providing comprehensive coverage of the watershed. The 4-year monitoring program was conducted at 25 sites throughout the NBCR watershed within Lake County and Cook County. The location of monitoring stations is shown in **Figure 2-3**.

The components of monitoring included the following:

Biological and sediment chemistry monitoring. Biological assessments, including fish and macroinvertebrate sampling and habitat evaluations, began in 2018 at 11 sites on the Skokie River and were expanded in 2019 to 14 sites on the Middle Fork and West Fork. Biological data was also collected at 11 sites in 2020 and 2021. Sediment samples were concurrently collected and analyzed for metals and organics.

Water column chemistry monitoring. The water column chemistry data is collected six times from January through October. The monitoring strategy included three tiers of sampling. Tier 1 involved eight sites that were monitored four times a year for common water quality parameters such as nutrients and bacteria, and once annually under low flow conditions for metals and water organics. Tier 2 included 17 sites that were monitored four times a year for the most common water quality parameters, including nutrients and bacteria. Tier 3 consisted of two additional monitoring events per year at each bioassessment site, focusing on common water quality parameters like nutrients and bacteria, conducted concurrently with the bioassessment sampling period. Water column monitoring consisted of both continuous monitoring of DO, pH, temperature, and conductivity and grab sample collection for DO, DO saturation, ammonia, nitrogen, TP, organic carbon, total suspended solids (TSS), pH, conductivity, and chlorine. Sediment samples were analyzed for metals and organics. Water column chemistry monitoring data has been collected at Tier 1 and Tier 2 site. The data used for NARP development is described in **Section 3.1**.

Continuous DO monitoring. Datasondes were used in the NBCR watershed to record continuous water quality data for DO over periods of 3 to 5 consecutive days from 2018 to 2020. Seven datasondes were deployed in late summer each year under low-flow conditions. The location of the datasondes were concurrent with the biological sample locations for any given year. In 2018, datasondes were deployed along the Skokie River branch coinciding with biological monitoring activities. The following year, 2019, saw the deployment of datasondes in both the Middle Fork and West Fork. In 2020, these instruments were again deployed in the Skokie River and Middle Fork.

Benthic Periphyton Sampling. Periphyton sampling, focused on chlorophyll *a*, was conducted in summer low-flow periods in conjunction with DO and biological monitoring to assess nutrient effects on primary productivity. Benthic periphyton sampling began in 2018 on the Skokie River and began on the Middle Fork and West Fork in 2019. NBWW collected data as part of the NARP development which is described in **Section 3.1**.

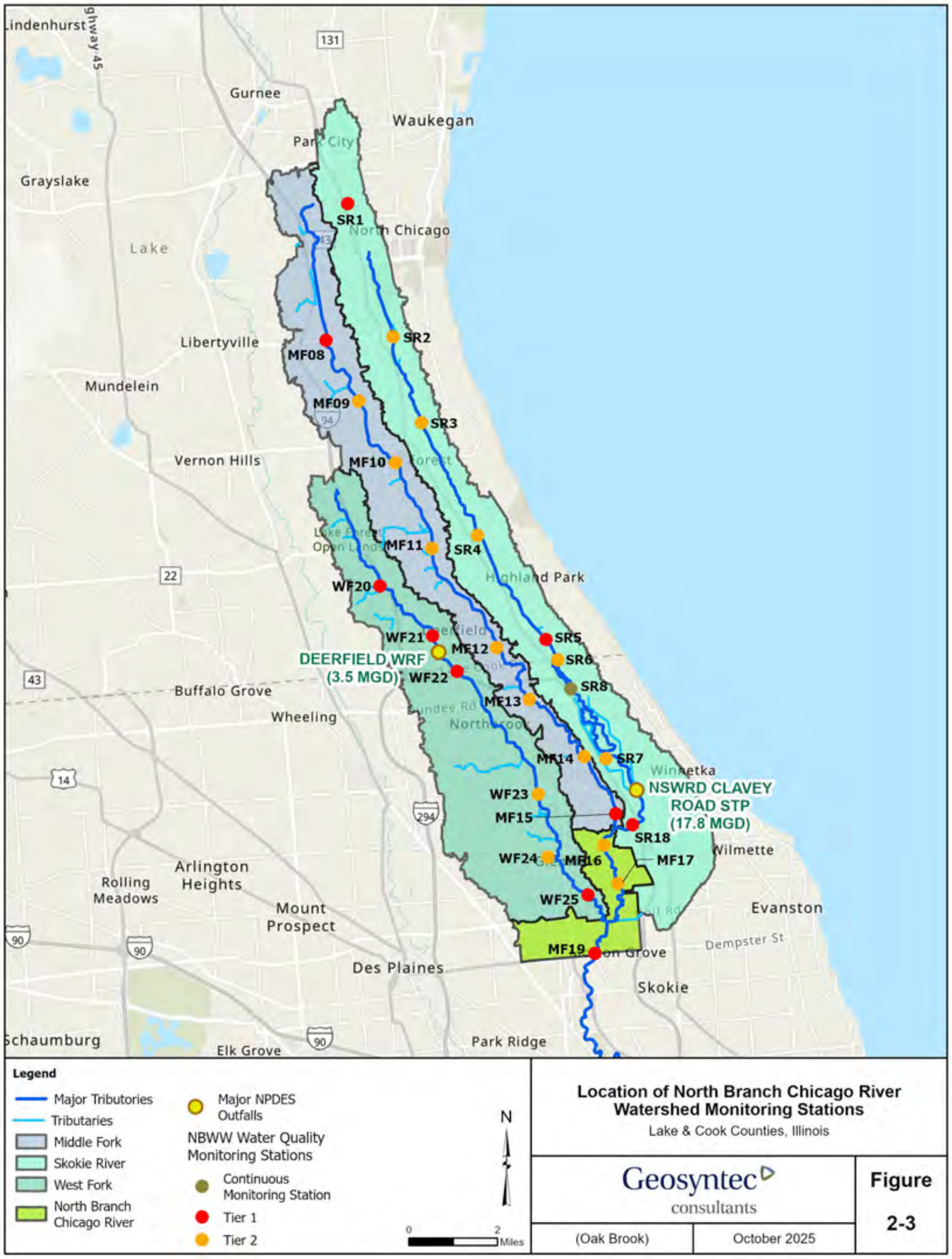


Figure 2-3: Locations of North Branch Watershed Workgroup Monitoring Stations

2.4.3.2 Illinois EPA Monitoring

Illinois EPA collected continuous and discrete water quality monitoring data in the watershed in 2011 and 2016 as part of its Intensive River Basin Survey program. Additional limited data was collected in the watershed as part of Illinois EPA's Ambient Water Quality Monitoring Network Program and Special Study programs from 2011 to 2020 (Illinois EPA 2025).

2.4.4 NBWW Water Quality Trend Analysis

NBWW commissioned Geosyntec to perform a water quality trend analysis using data from 2018 to 2023 (Geosyntec, 2025). Parameters relevant to the NARP that were assessed include TP, chlorophyll *a*, and DO. The report identified that Deerfield WRF and NSWRD Clavey Road WRF influence water quality by increasing DO concentrations and raising nutrient levels in West Fork and Skokie River, respectively. The Seasonal Kendall test was applied to evaluate trends in monitored parameters at each station over time. The Seasonal Kendall test assesses long-term data for monotonic trends (increasing or decreasing) with regular seasonal patterns. The analysis showed an increase in TP levels over time in West Fork at stations upstream of Deerfield WRF, potentially due to increased impacts from nonpoint sources. No significant trend was identified for TP at other stations in the three tributaries and NBCR, likely due to improvements at the Claye Road WRF prior to the monitoring period. Additionally, either no trend or a decreasing trend was observed for chlorophyll *a* and DO at all stations within the NBCR watershed.

3. NARP DEVELOPMENT PROCESS

3.1 Data Collection

NBWW conducted NARP-focused monitoring in 2022 to evaluate nutrient-related impairments in the NBCR Watershed. The monitoring included both continuous and discrete components at key sites across the West Fork, Middle Fork, Skokie River, and the NBCR mainstem, which consisted of the following components.

3.1.1 Continuous Monitoring

Eight sites across the watershed (**Figure 3-1**) were monitored for DO, temperature, pH, and conductivity using datasondes. Deployment occurred between July 27 and October 5, 2022, with sensors installed in phases based on site-specific flow conditions. The monitoring sites were as follows:

West Fork: WF21 and WF23
Middle Fork: MF10 and MF14
Skokie River: SR8 and SR18
North Branch mainstem: MF17 and MF19

Station SR8 is situated within the Skokie Lagoon, upstream from the NSWRD Clavey Road auxiliary discharge point. Throughout the monitoring period, the Clavey Road WRF discharged via the auxiliary location into the Skokie Lagoons, rather than through its primary outfall downstream of the Lagoons. This occurred because primary outfall underwent emergency maintenance which caused effluent flow to be redirected through a permitted bypass location within the Skokie Lagoons. In 2023, NSWRD collected additional data, including continuous chlorophyll-a measurements, at the following stations

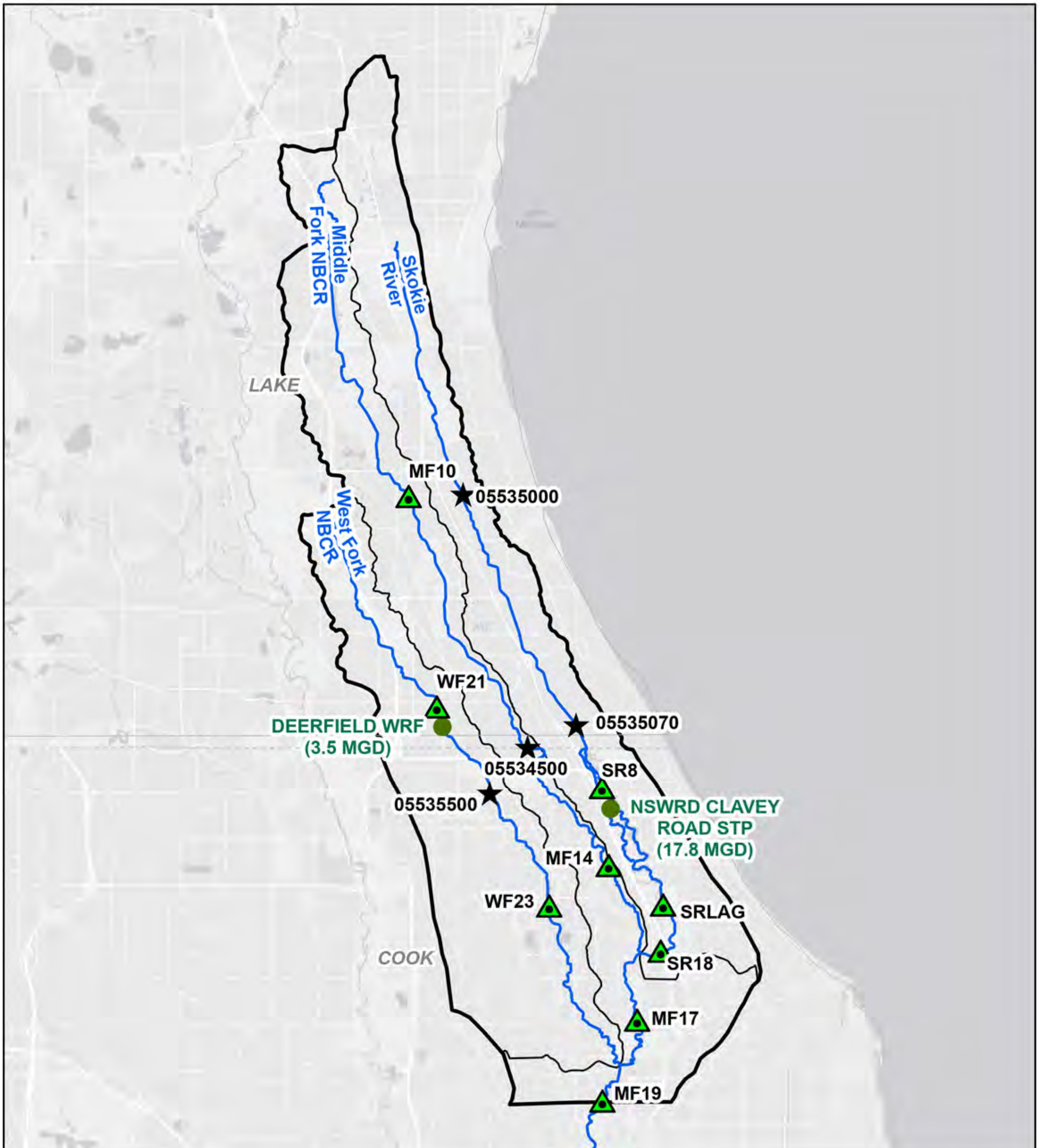
Station SR-5: Located Upstream of Skokie Lagoons
Station SRLAG: Located just upstream of last dam on Skokie Lagoons
Station SR18: Located downstream of Skokie Lagoons

During 2023 the Clavey Road WRF discharged through the primary outfall located downstream of Skokie Lagoons. The supplementary data facilitated a more comprehensive understanding of the impact of Skokie Lagoon on downstream water quality.

3.1.2 Discrete Sampling

Geosyntec undertook discrete measurements from July to October 2022 at biweekly frequency at the same monitoring locations and included water quality parameters such as nutrients, sestonic chlorophyll *a*, benthic algae (periphyton), and sediment oxygen demand (SOD). Benthic chlorophyll *a* was measured at two sites with suitable conditions for benthic algae growth (Stations WF-23 and MF-19), while SOD was assessed at four locations.

The NARP focused monitoring supported the development and calibration of the instream models discussed in **Section 3.2**.



Legend

- North Branch Chicago River Watershed
- Subwatersheds
- Counties
- Major POTWs Discharge
- Tributaries
- USGS Gages
- Monitoring Sites

2022 Monitoring Sites

(NBWW, IL)

Geosyntec consultants

(Oak Brook, IL) | December 2025

Figure 3-1

3.2 Data Analysis

3.2.1 Data Inferences

The risk of eutrophication was assessed at the 2022 monitoring stations using the methods provided in **Figure 3-1**. Stations on the Skokie River (SR-8, SR18), Middle Fork (MF14) and West Fork (WF23) were determined to be at risk of eutrophication based on the Illinois EPA risk of eutrophication methodology (see Figure 2-1) , while the Middle Fork Station MF17 and NBCR MF19 were determined to not be at risk of eutrophication. This finding is consistent with 2024 Section 303(d) listing which delisted the NBCR Segment IL_HCC-07 (Station MF19) and Middle Fork segment IL_HCC-04 (Station MF17) due to DO.

Figure 3-2a presents the measured DO level, DO saturation, and chlorophyll concentrations at Station WF-23, located downstream of Deerfield WRF. The observed DO remains above the water quality standard, with significant diel fluctuations and periods of oversaturation. Chlorophyll a levels reached as high as 55 µg/L in late August, while moderately high values of 20 µg/L were recorded in July, early August, and September. No conditions conducive to benthic algae growth were observed at this site. **Figure 3-2b** illustrates water temperature over the same period, showing both seasonal cooling and pronounced diel oscillations. Temperatures were highest in mid-summer (24–32°C) and declined steadily into early fall (15–20°C). These thermal patterns strongly influence DO dynamics: warmer water reduces oxygen solubility and accelerates algal metabolic rates, amplifying diel DO fluctuations and oversaturation events observed in **Figure 3-2a**. Conversely, as temperatures decrease, oxygen solubility increases and biological activity slows, resulting in smaller DO swings.

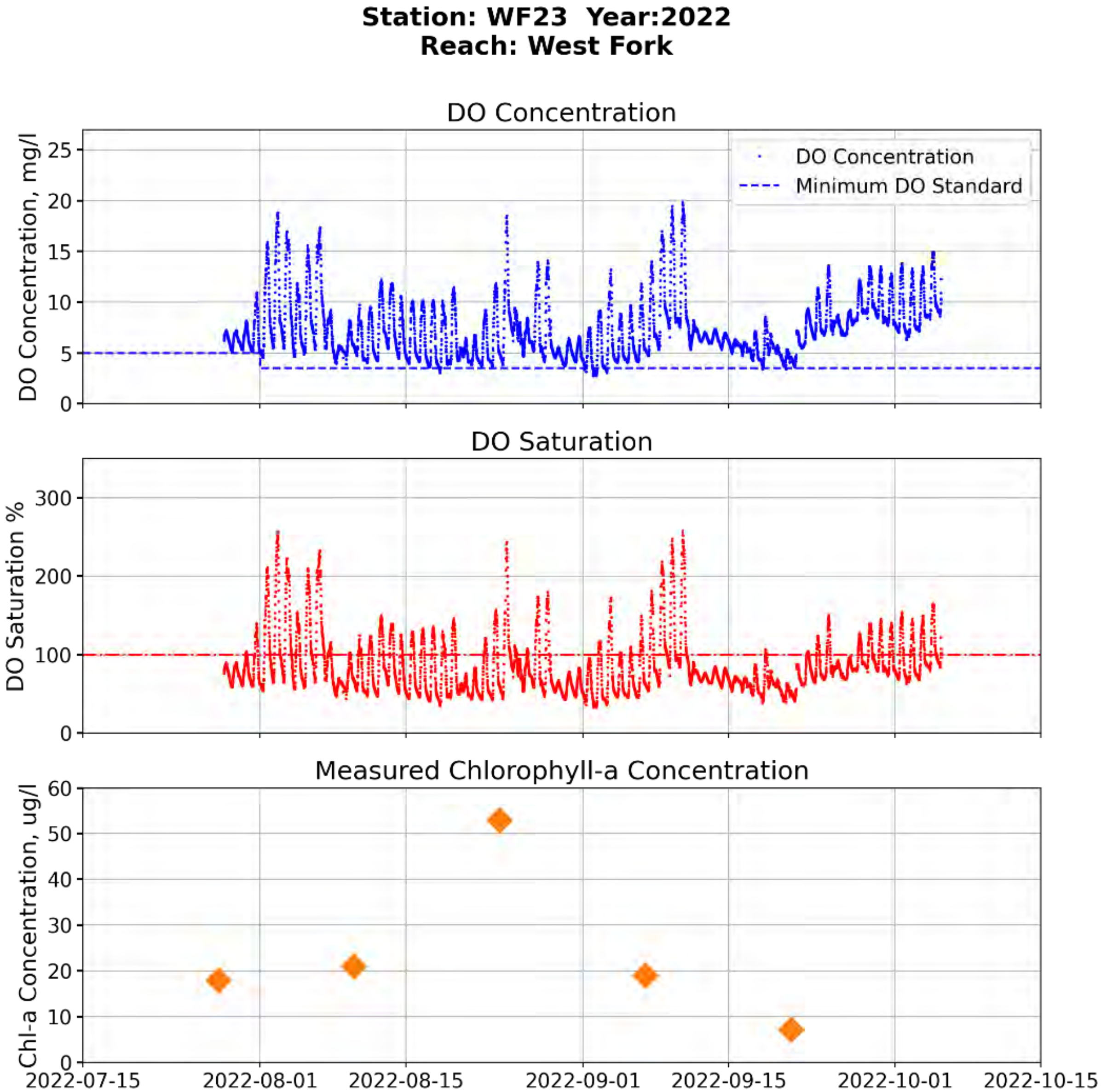


Figure 3-2a: 2022 Measured Data at Station WF-23 on West Fork

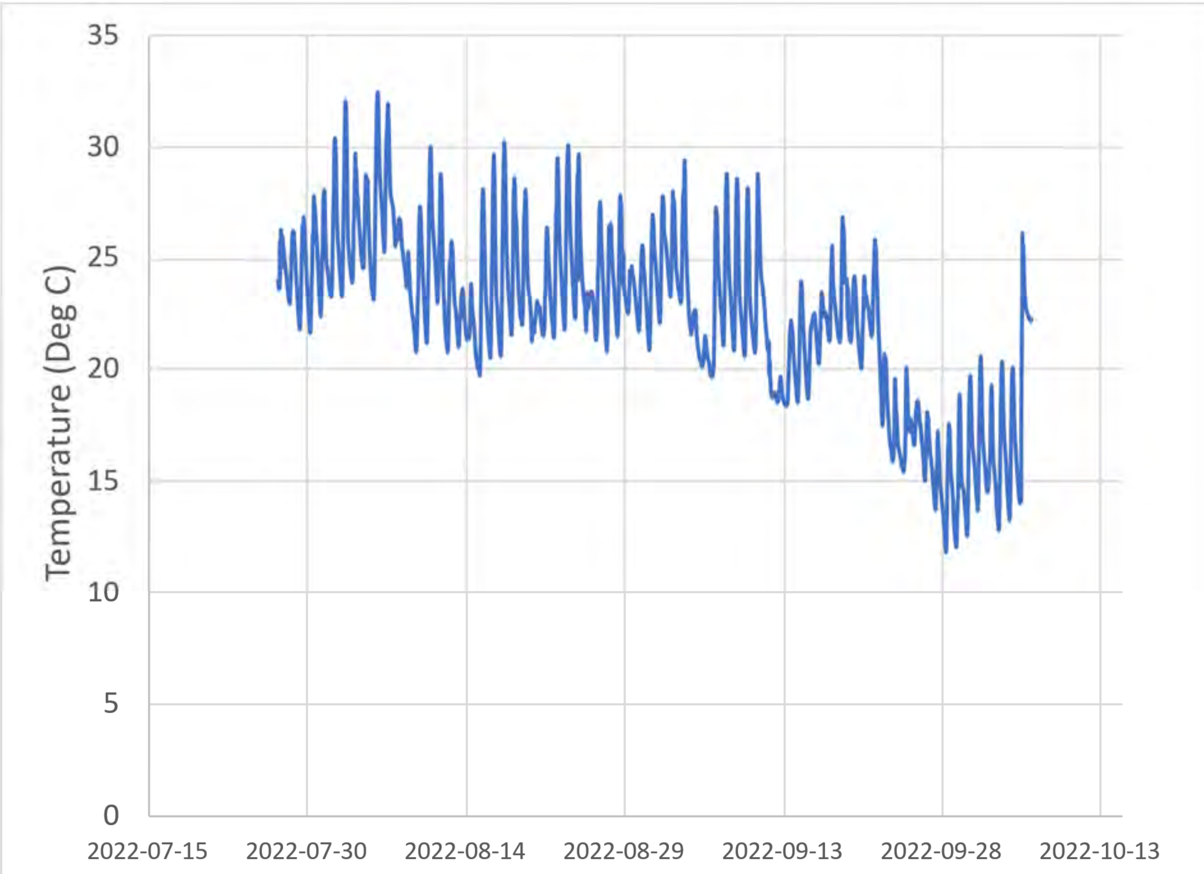


Figure 3-3a: 2022 Measured Data at Station WF-23 on West Fork

Similar data are shown for Station MF-17 (**Figure 3-4**) on the NBCR mainstem, located downstream of the Skokie River confluence. At this station, dissolved oxygen (DO) levels fall below the standard threshold of 5 mg/L from mid-July to mid-September. The site shows minimal diel fluctuations in DO and low to high chlorophyll concentrations. The elevated chlorophyll a level observed in August and September at this location was attributed to inflow from the Skokie River (**see Figure 3-5**). This station is not considered at risk for eutrophication because the Illinois EPA's assessment does not use absolute DO values and its methodology is based on median chlorophyll a levels instead of single discrete measurements. The TMDL for NBCR attributed the consistently low levels of DO to sediment oxygen demand and low aeration (CDM Smith, 2020).

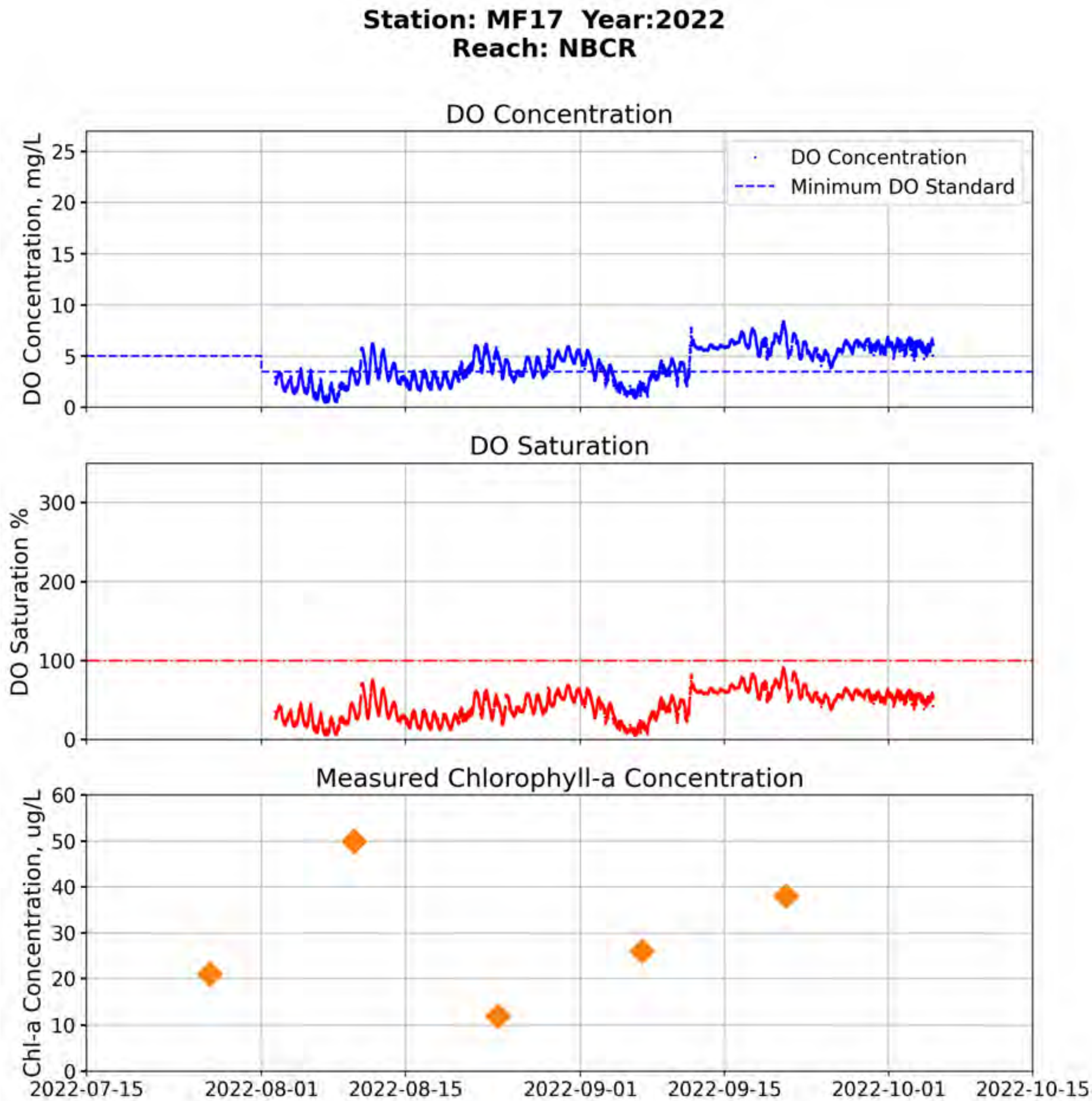


Figure 3-4: 2022 Measured Data at Station MF-17 on the mainstem North Branch Chicago River

Data for station SR18 located on Skokie River, are shown in **Figure 3-5**. This station shows high chlorophyll-a levels likely due to influence of Skokie Lagoons. The measured SOD at station SR18 was 2 to 5 grams per square meter per day (with a geomean of 3.36) which potentially resulted in low DO levels at this location along with low aeration.

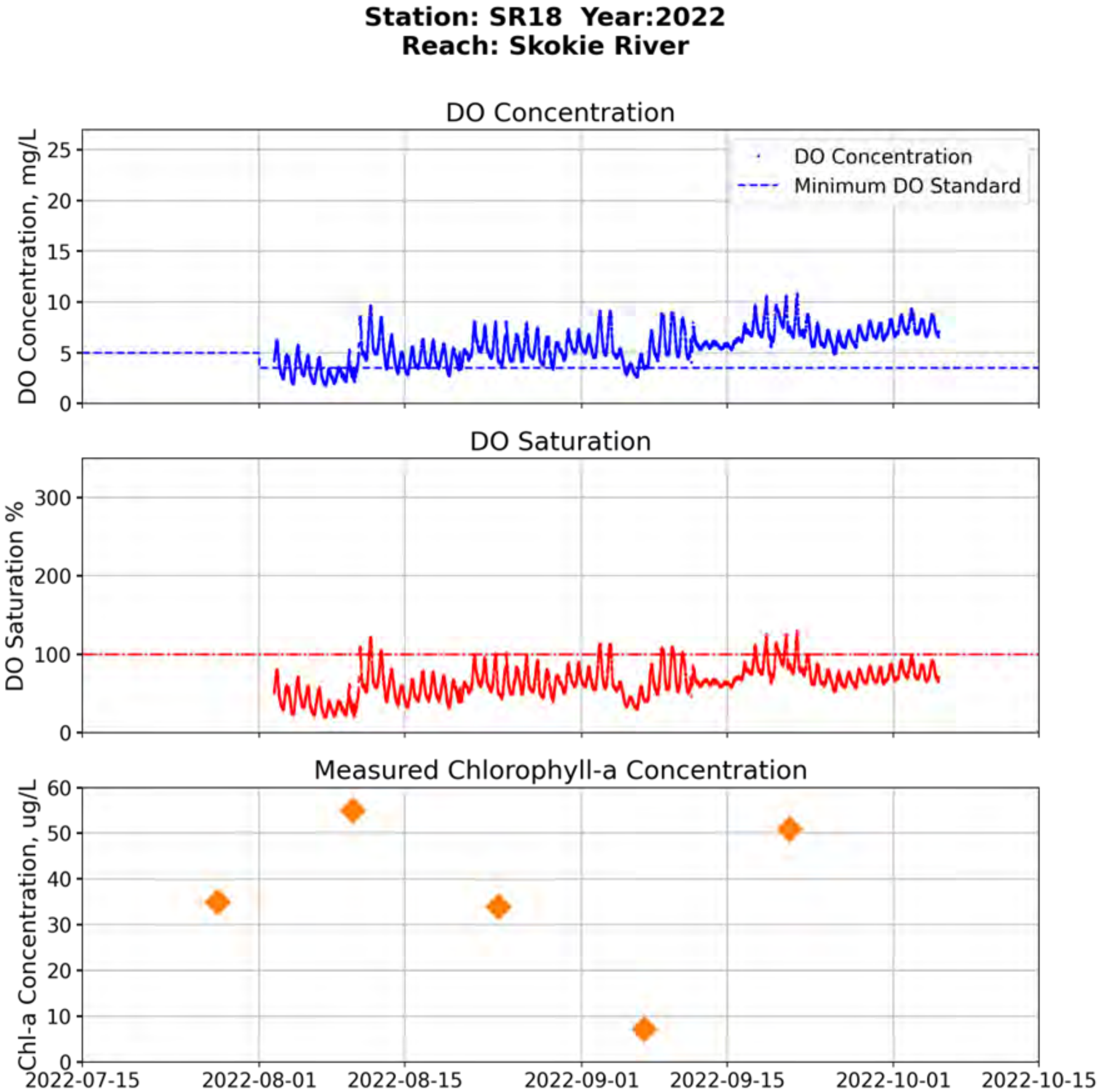


Figure 3-5: 2022 Measured Data at Station SR-18 on the Skokie River

Continuous total algae measurements[4] in 2023 at Station SR-5 (upstream of Skokie Lagoons), SRLAG (located just upstream of last dam on Skokie Lagoons and NSWRD Clavey Road WRF discharge) are shown in **Figure 3-6**. Station SRLAG shows higher levels of total algae compared to Station SR-5 due to growth of algae in Skokie Lagoons. Station SR-18, which is located

[4] The USGS has issued formal national guidance on the collection and use of fluorescence-based measurements (Foster et al., 2022). As such, these measurements are now among the mainstream of tools for water-quality management in the U.S.

downstream of NSWRD Clavey Road WRF discharge, has lower levels of total algae compared to Station SRLAG.

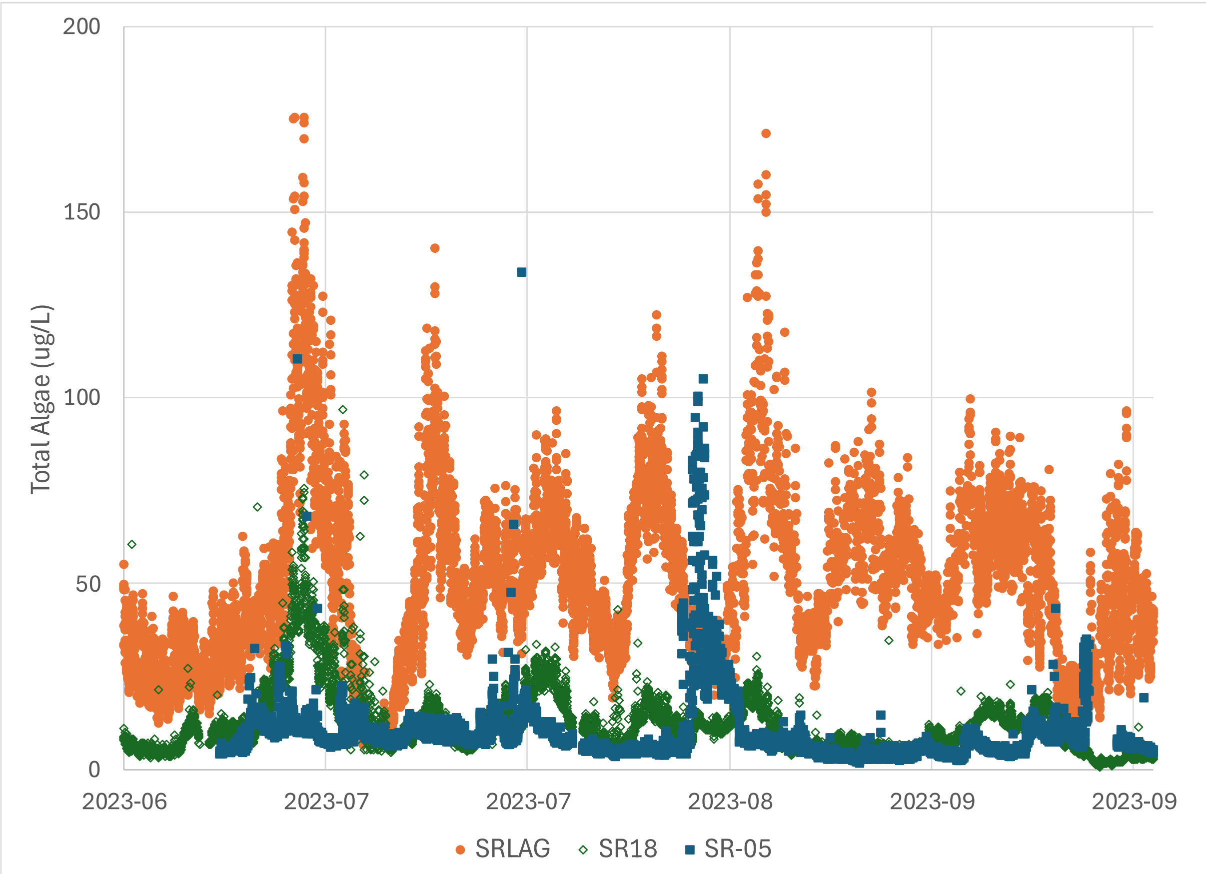


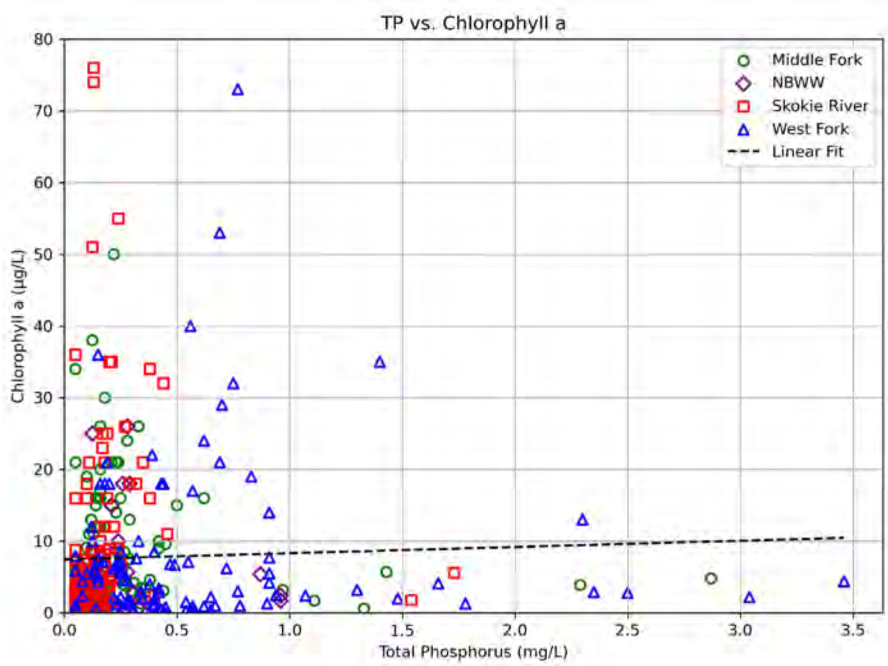
Figure 3-6: 2023 Measured Data in Skokie Lagoon and Skokie River

3.2.2 Total Chlorophyll and Phosphorus Relationship

TP is a primary nutrient influencing algal productivity in freshwater systems, and chlorophyll *a* is commonly used as a proxy for algal biomass. Therefore, assessing the TP–chlorophyll *a* relationship is critical in evaluating nutrient response dynamics and eutrophication potential within the watershed. An analysis was conducted to evaluate the relationship between TP and chlorophyll *a* levels based on discrete water quality data collected throughout the NBCR watershed.

Figure 3-7 presents a scatterplot of TP versus chlorophyll *a*, including data from NBWW, Skokie River, Middle Fork, and West Fork sites. The total number of paired TP-chlorophyll data points are 390 collected from 2018 to 2023 (Middle Fork – 155, West Fork – 94, Skokie River – 122, NBCR mainstem – 19). Although some individual sites exhibit elevated chlorophyll *a* at lower TP concentrations, the overall dataset reveals no strong or consistent increase in chlorophyll *a* with rising TP levels, even at low TP levels. The coefficient of determination (R^2) was only 0.0012, indicating that TP explains less than 0.2% of the variability in chlorophyll *a*. Log-log regression performed slightly better with an R^2 of 0.046, but this still indicates poor relationship of TP with chlorophyll *a*. Correlation analyses further support this conclusion. The Pearson correlation coefficient was 0.035 ($p = 0.49$), indicating no statistically significant linear relationship. Rank-based correlation coefficients were somewhat higher, Spearman's $\rho = 0.26$ and Kendall's $\tau = 0.19$ (both $p < 0.001$), suggesting a weak monotonic trend, but not strong enough to establish a reliable predictive relationship. These results indicate that chlorophyll *a* variability in the NBCR watershed is impacted by other factors, such as light limitation, hydraulic retention time, or temperature. This result aligns with the findings of Royer et al. (2008), which similarly reported no overall relationship between total phosphorus (TP) and sestonic chlorophyll across 109 sites in Illinois, including two locations within the NBCR watershed. The Royer et al. study found a correlation between total phosphorus (TP) and chlorophyll a at 38 sites where the canopy cover was less than 25% and TP values were 0.2 mg/L. However, the two NBCR watershed group sites included in the Royer et al. study did not meet these criteria. An NBCR stream inventory by Lake County showed that stream sections with low canopy cover (less than 33%) were mainly located in headwater reaches upstream of WRP discharges. Hence, light would be a limiting factor for algae growth in NBCR reaches rather than nutrients. Also according, U.S. EPA Nutrient Criteria Technical Guidance Manual for Rivers and Streams (USEPA, 2000b) relationships between total phosphorus and chlorophyll a in lotic systems are often weak due to confounding factors such as flow variability, light limitation from shading, and hydraulic retention time, making single-nutrient criteria unreliable for predicting algal response.

The weak correlation emphasizes the importance of considering multiple physical, chemical, and biological factors in nutrient-algal dynamics when developing management strategies and response models. This finding also shows that reducing TP to levels less than 0.1 mg/L may not necessarily result in reduction of chlorophyll *a* (algae) in the NBCR streams. Due to the limited correlation between total phosphorus (TP) and chlorophyll a in NBCR streams, the NBWW did not establish a watershed-specific TP standard for the NBCR NARP. Instead, the NBWW NARP relied upon Illinois EPA's risk of eutrophication thresholds and dissolved oxygen (DO) water quality standards to determine appropriate measures for addressing phosphorus-related impairments. The NBWW intends to undertake a subsequent evaluation of instream nutrient targets following 2030, once TP effluent limits of 0.5 mg/L have been met.



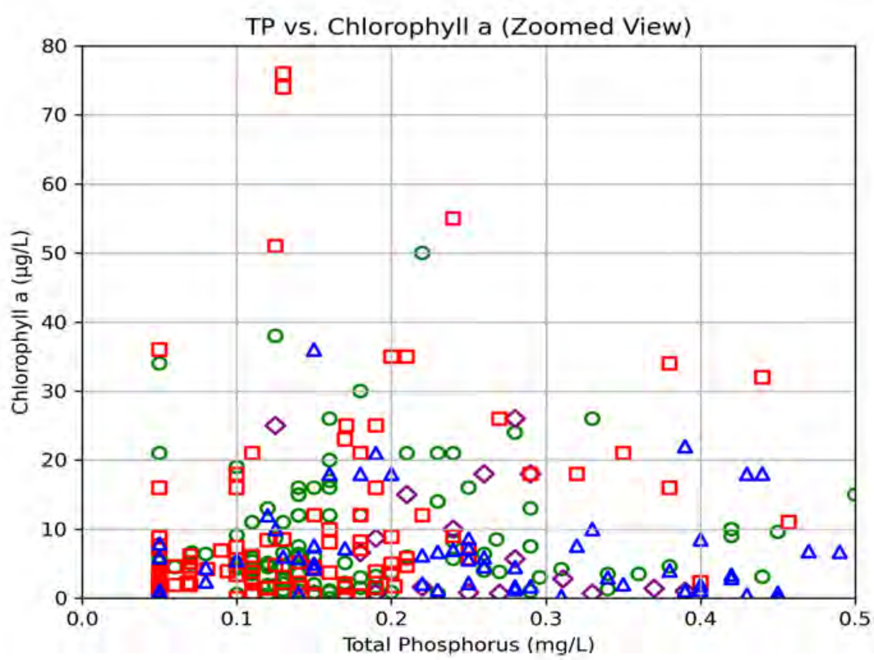


Figure 3-7: Total phosphorus and Chlorophyll *a* Relationship in the North Branch Chicago River Watershed

3.3 Modeling

The NARP requires identification of phosphorus input reductions by point-source and nonpoint-source discharges, among other necessary measures to remove phosphorus-related impairments in the watershed. Models can be used to define the linkage between the phosphorus inputs and related impairments such as DO and nuisance algae, evaluate the effectiveness of different watershed management scenarios in reducing or removing impairments, and provide useful information to decision-makers as they decide which projects to prioritize in implementing NARP recommendations.

A linked numerical modeling framework was developed for the NARP, as recommended in the NBCR NARP work plan (Geosyntec 2021). The linked modeling framework consists of two components: a watershed model and two instream models with hydraulic and water-quality components (**Figure 3-8**). The development and calibration of the two models are briefly summarized below, and further details are included with the appendices.

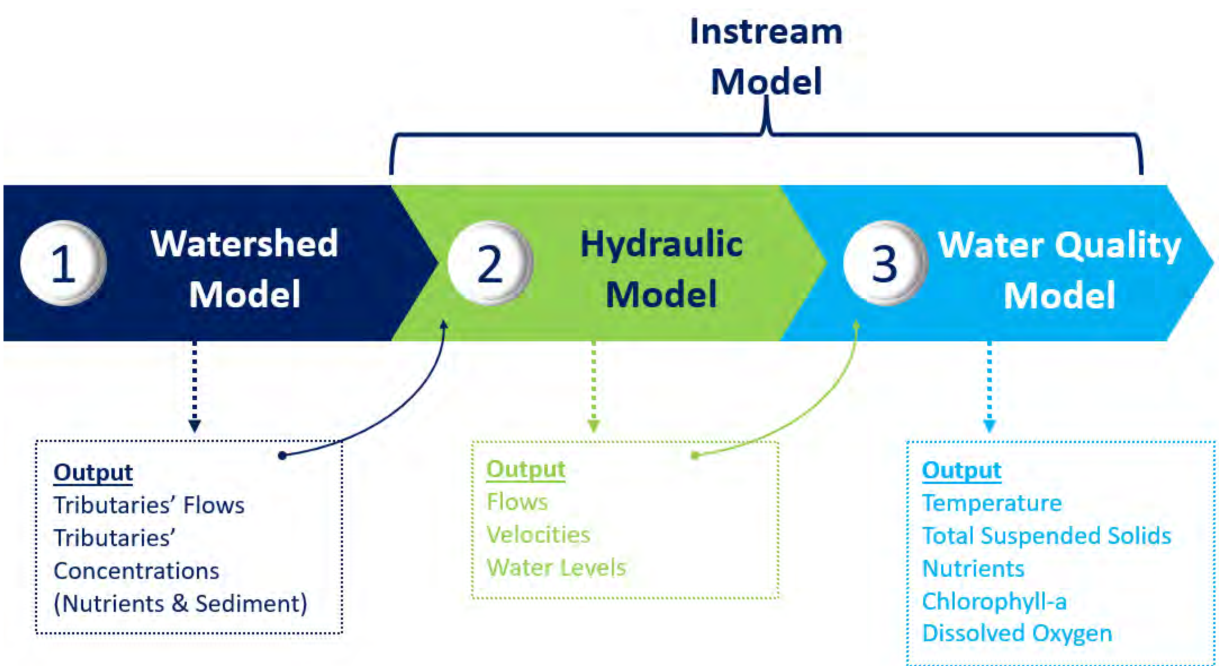


Figure 3-8: Model Framework

3.3.1 Watershed Model

The watershed model utilizes the US EPA Storm Water Management Model (SWMM; Rossman and Simon 2002). This model was selected in alignment with the NBWW NARP Workplan to simulate hydrology and nutrient loading throughout the NBCR watershed, which includes the West Fork, Middle Fork, Skokie River, and the mainstem of the NBCR up to Dempster Street. The watershed model development and calibration are described in detail in *Appendix A - NBWW Watershed Model Report* and is summarized below.

The SWMM model is a semi-distributed model capable of simulating hydrology and water quality for urban and mixed land use watersheds. For the NBWW NARP application, the model incorporates a wide range of spatial and temporal data inputs including high-resolution lidar-based elevation data, hydrologic group data from SSURGO, land use and imperviousness from from Chicago Metropolitan Agency for Planning and the National Land Cover Dataset, and rainfall records from 15 precipitation gauges. The model also integrates baseflow contributions derived using Purdue's Web-based Hydrograph Analysis Tool.

The watershed modeling domain was delineated into 23 subwatersheds (**Figure 3-9**). Each subwatershed then was divided into subcatchments based on major land use groups (e.g., transportation, residential, open space, industrial, commercial, agricultural, water) to incorporate variability in runoff water quality among the different land uses. These subdivisions allowed the model to capture spatial variability in precipitation, runoff generation, and nutrient export. The hydrology simulation includes overland flow routing, infiltration via the Green-Ampt method, evapotranspiration, and explicit storage modeling of Skokie Lagoons.

Hydrologic calibration was performed for the period 2012–2021 using daily flow records from five United States Geological Survey (USGS) stream gages within the study area. Model performance was evaluated using statistical measures including annual average flow volume during the growing season (calibration target of less than 15% between simulated and measured values), monthly annual average flow volume, monthly root-mean-square-error to standard deviation ratio (calibration target of less than 0.70), and monthly Nash-Sutcliffe model efficiency coefficient (calibration target of greater than 0.5). Adjustments to subwatershed imperviousness, depression storage, hydraulic conductivity, and baseflow inputs were made to match the model simulated output to data. **Table 3-1** represents the watershed model calibration results. The final calibration model achieved satisfactory to very good agreement with measured flow data at five USGS gages based on the calibration targets defined above. Model validation was performed for the calendar year 2022. The values of calibration metrics for the validation period were very similar, which shows that the calibration process yielded robust parameter inputs that can be used to accurately predict the magnitude and timing of flow.

Table 3-1: Watershed Model Calibration Results (Calendar Years 2012–2021)

USGS Gage	Annual Average Total Volume Percent Error	Calibration Result	Monthly RSR	Calibration Result	Monthly NSE	Calibration Result
West Fork at Northbrook, IL	−12.8%	Good	0.63	Satisfactory	0.59	Satisfactory
Middle Fork at Deerfield, IL	−7.5%	Very Good	0.68	Satisfactory	0.53	Satisfactory

USGS Gage	Annual Average Total Volume Percent Error	Calibration Result	Monthly RSR	Calibration Result	Monthly NSE	Calibration Result
Skokie River at Highland Park, IL	−6.2%	Very Good	0.61	Satisfactory	0.62	Satisfactory
Skokie River at Lake Forest, IL	10.8%	Good	0.58	Good	0.66	Good
North Branch Chicago River at Niles, IL*	−13.8%	Good	0.68	Satisfactory	0.54	Satisfactory

The water quality component of the watershed model simulates TP concentrations. Baseflow TP concentrations were set based on measured dry-weather geometric means, while runoff TP concentrations were set based on land-use-specific Event Mean Concentrations (EMCs) from the *Minnesota Stormwater Manual* (Minnesota Stormwater Steering Committee 2022). These values were applied throughout the model domain to estimate TP contributions from both dry and wet weather conditions. Output from the watershed model, including simulated flow and TP concentrations, provides a time series of nutrient loading for input into the instream model.

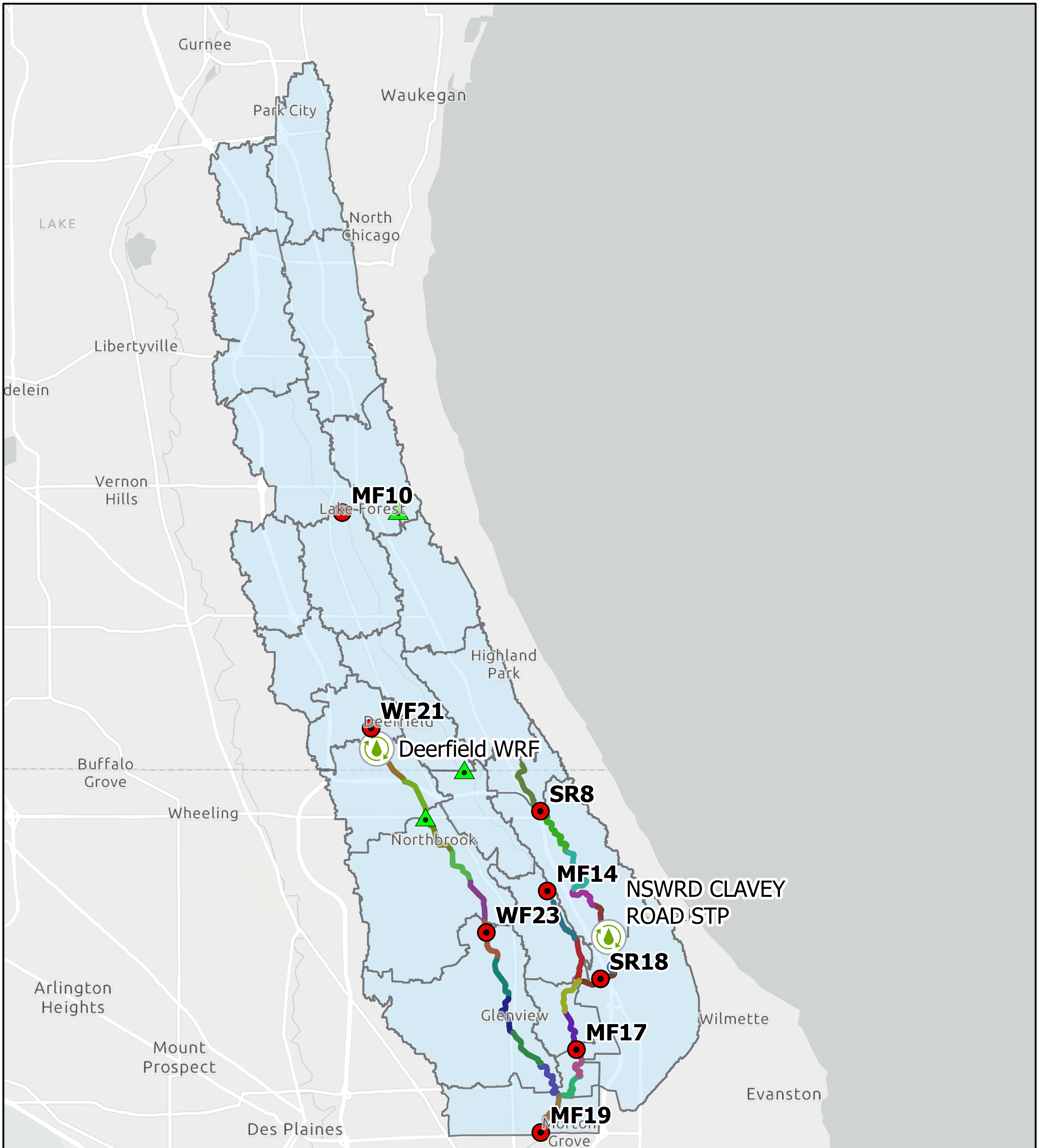
3.3.2 Instream Model

The instream model for the NBCR NARP was developed using the Water Quality Analysis Simulation Program (WASP) (Ambrose and Wool 2017). WASP is a dynamic compartment-modeling framework developed by US EPA. It is capable of simulating time-varying hydrodynamics and water quality in one-, two- or three-dimensional systems and is well suited for representing nutrient dynamics, DO processes, and algal growth in complex riverine systems.

The instream model development and calibration are described in detail in *Appendix B - 2024(0814) NARP Model Development and Baseline Analysis* and are summarized below.

3.3.2.1 Development

The WASP model domain encompasses the mainstem of the NBCR and its key tributaries: the West Fork, Middle Fork, and Skokie River. The domain was segmented into 27 discrete computational units (**Figure 3-9**) to represent hydrologic connectivity and spatial variability in flow and water quality dynamics. Segment delineation was informed by hydraulic geometry data extracted from a hydraulic model and stream alignment from GIS base layers. Segment lengths ranged from 0.9 to 0.95 miles, with three specialized weir segments defined in the Skokie River to represent impounded or flow-restricting structures. Each segment was assigned distinct hydraulic and geometric properties, including cross-sectional area, channel slope, and roughness coefficient (Manning’s n).



Legend

- WQ Monitoring Sites
- USGS Stations
- Major NPDES Outfalls
- NBWW SWMM Subbasins

N

0 2 Miles

NBWW WASP Segmentation

(NBWW, IL)

Geosyntec consultants

(Oak Brook, IL) | October 2025

Figure

3-9

Model inputs included hourly flow and nutrient loading generated by the SWMM watershed model. Clavey Road WRF and Deerfield WRF inputs into the model were set using measured effluent flow and concentration records (**Figure 3-10)**. Meteorological forcing was provided using hourly data from the Chicago Executive Airport station, including dry bulb air temperature, dew point temperature, wind speed, and cloud cover. Incident solar shortwave radiation was obtained from the National Aeronautics and Space Administration (NASA) Prediction of Worldwide Energy Resources (POWER) database to support algal and oxygen process modeling.

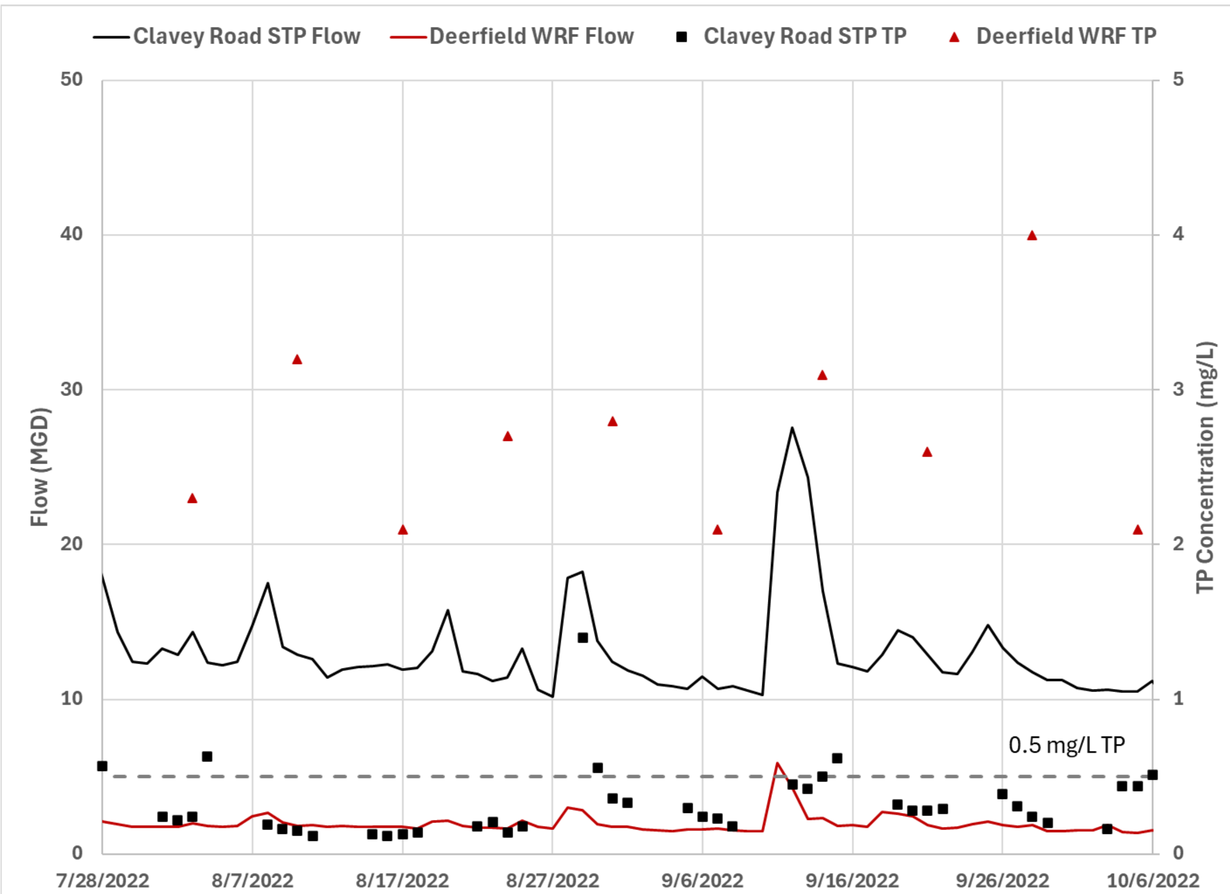


Figure 3-10: Measured Effluent Flow and Total Phosphorus Concentration for Clavey Road WRF and Deerfield WRF

River segments in WASP were configured to simulate both hydrodynamics and transport of key water quality parameters, including TP), carbonaceous biochemical oxygen demand (CBOD), DO, and chlorophyll *a*. Instream nutrient cycling, algal growth and decay, SOD, and benthic fluxes were incorporated using parameter values from literature, regional studies, and site-specific calibration. Sediment-water exchange processes were explicitly activated in segments with impounded conditions or historical sediment accumulation, especially in the Skokie Lagoon reach.

3.3.2.2 Calibration

The WASP model was calibrated for the period of July 28 to October 5, 2022, corresponding to the period of data collection for the NARP focused monitoring. Calibration included TP, chlorophyll *a*, CBOD, and DO.

To improve TP estimations in the Skokie Lagoons, a constant sediment phosphorus flux rate of 35 milligrams per square meter per day (mg/m²/day) was incorporated in the Lagoons for the month of August, consistent with the approach taken by prior modeling studies (Illinois EPA, 2020). Due to lack of site-specific sediment flux data, this flux rate was adjusted during model calibration to account for seasonal lake stratification and mixing on a monthly average basis. SOD was also calibrated to reflect instream oxygen depletion dynamics.

Figure 3-11 compares the simulated and measured TP at station MF19, which is located at the end of model domain. The model does a good job of representing the measurements. **Figure 3-12** compares simulated and measured chlorophyll *a* at station MF-19. The model captures grab sample measurements generally well but underpredicts in late September due to very low inflow chlorophyll *a* levels at the upstream boundary. **Figure 3-13** compares simulated and measured DO at station MF19. The model captures the DO diurnal fluctuations reasonably well. The model does a very good job of capturing the measurements, which include the impact from all three tributaries. Additional calibration results at other stations can be found in *Appendix B - 2024(0814) NARP Model Development and Baseline Analysis*. As a result, the model is deemed sufficiently calibrated.

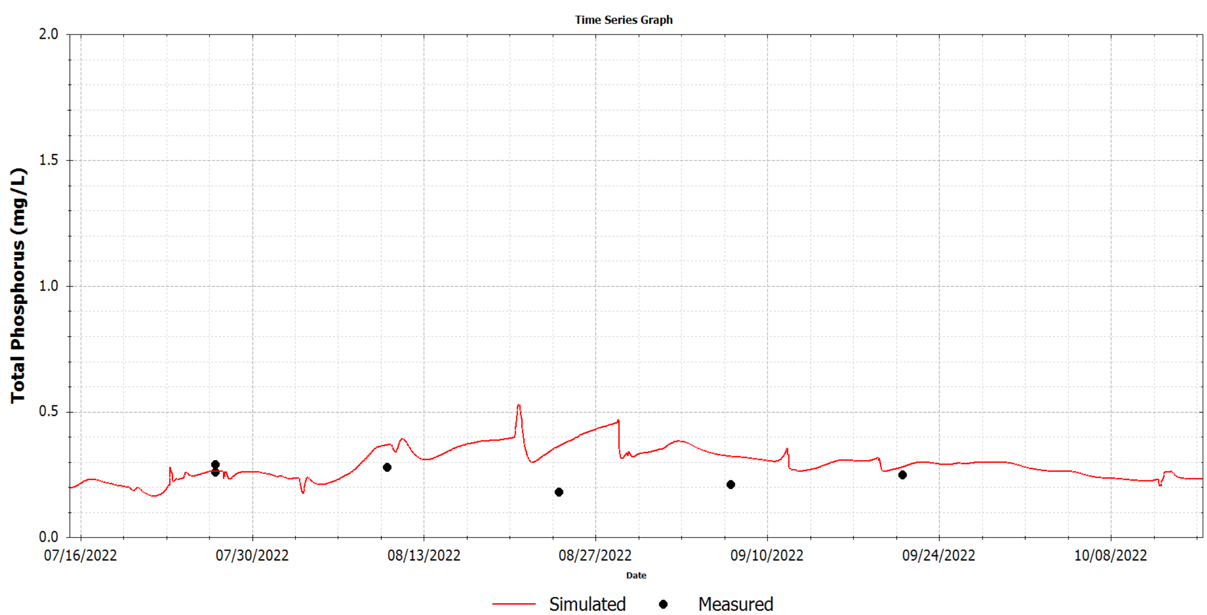


Figure 3-11: Simulated and Measured Total Phosphorus at Station MF19 on mainstem North Branch Chicago River

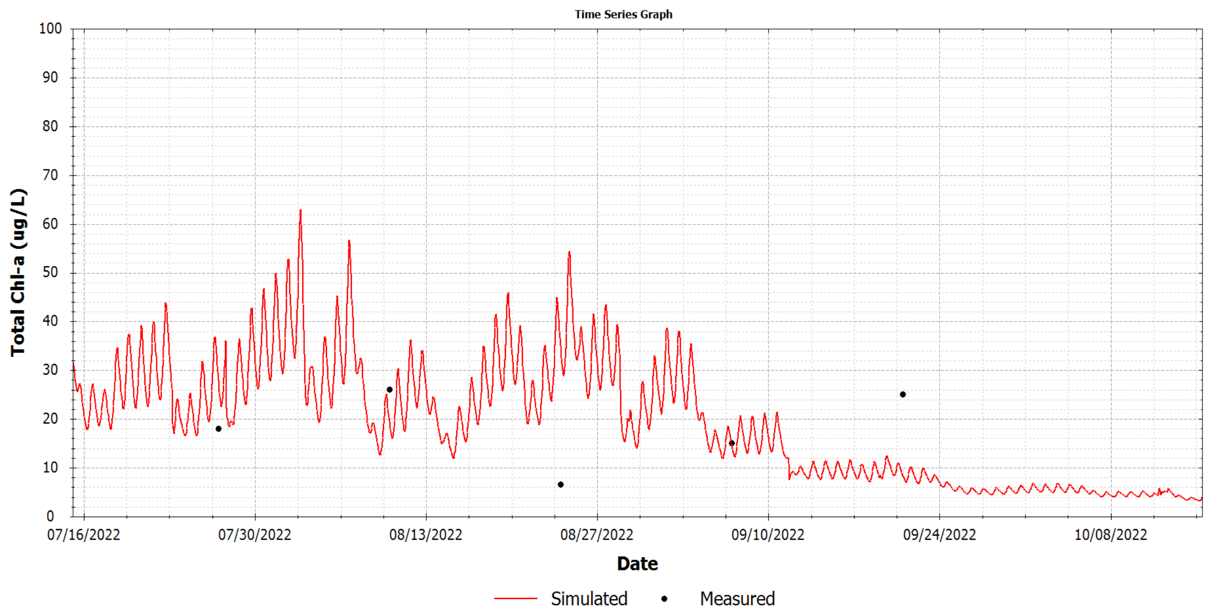


Figure 3-12: Simulated and Measured Chlorophyll a at Station MF19 on mainstem North Branch Chicago River

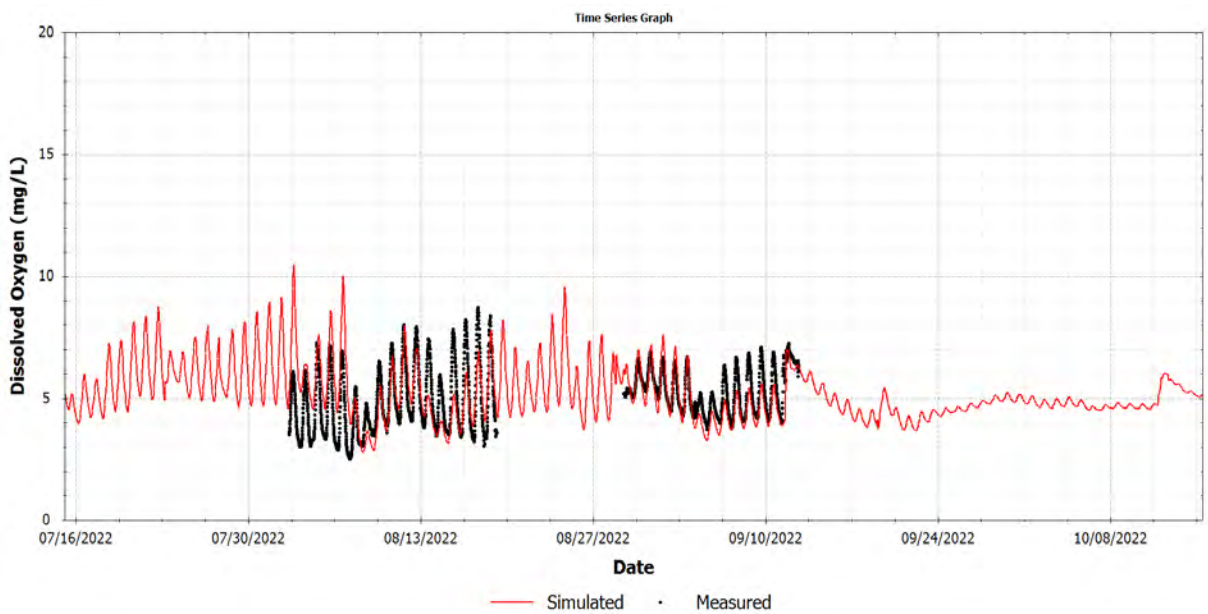


Figure 3-13: Simulated and Measured Dissolved Oxygen at Station MF19 on mainstem North Branch Chicago River

3.4 Management Scenarios

The models were used to simulate several scenarios to evaluate the effectiveness of watershed-based strategies in improving the water quality in the mainstem NBCR, Skokie River, and West Fork. These scenarios were compared with the baseline scenario, which represents the existing condition of the system. The instream calibrated model for the period of July 28 to October 5, 2022, was used as the baseline scenario for evaluating watershed management actions. The TP inputs for the two WRPs, based on measured data, are shown in **Figure 3-10.**

The watershed management scenarios are described briefly below.

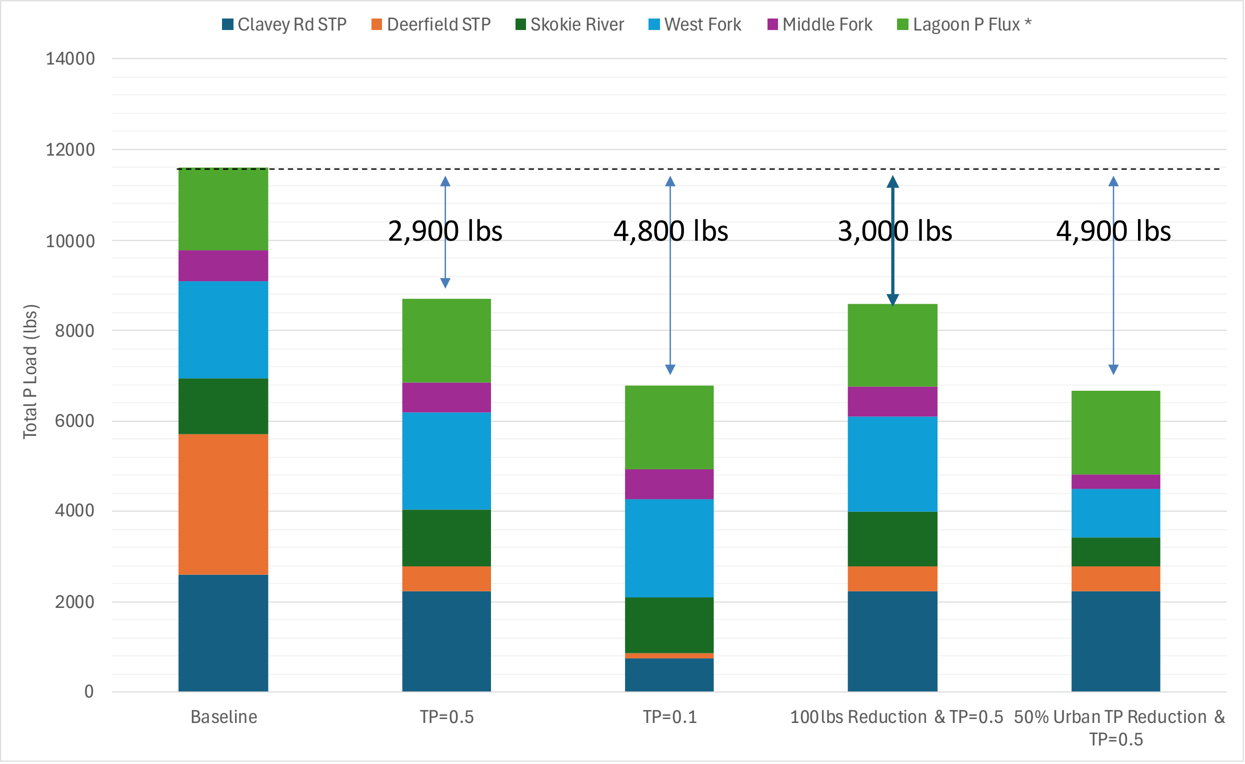
3.4.1 Load Reduction from Wastewater Treatment Plants (WWTPs)

To evaluate phosphorus load reductions from WWTPs, three scenarios were developed:

1. **Clavey Road WRF Discharge Relocation**: In 2022, Clavey Road WRF discharged into the Skokie Lagoons due to maintenance of its existing discharge outlet located downstream of the Lagoons. This scenario assesses the impact to the receiving stream if Clavey WRF discharged through its primary outfall location downstream of the Lagoons instead of upstream.
2. **WWTP TP Capped at 0.5 mg/L**: This scenario assesses the impact of capping WWTPs' effluent TP concentrations to 0.5 mg/L.
3. **WWTP TP Capped at 0.1 mg/L**: This scenario assesses the impact of capping WWTPs' effluent TP concentrations to 0.1 mg/L.

The TP loading distribution for the period of simulation for the baseline and scenarios with WWTP TP effluent TP capped at 0.5 mg/L and 0.1 mg/L is shown in ***:** P flux based on model calibration

Figure 3-14. Approximately 2,900-pound (lbs) reduction in TP loading would be achieved if the WWTP TP effluent concentrations are capped at 0.5 mg/L. Another 2,000 lbs of TP would be reduced by capping the measured TP effluent concentration to 0.1 mg/L. For these load reductions flow and TP concentration were based on measured data



*: P flux based on model calibration

Figure 3-14: Contribution of Different Sources to Total Phosphorus Loading under Different Scenarios from July 28 to October 5, 2022

3.4.2 Load Reduction from Urban Runoff

To evaluate phosphorus load reduction strategies targeting urban nonpoint sources and WWTPs, two scenarios were run including the loading reduction from urban nonpoint sources:

1. **Urban Runoff Reduction Only**: A 50% reduction in TP loads from all urban runoff sources was applied across the watershed. This scenario simulates the impact of stormwater best management practices and green infrastructure implementations. The impact of urban runoff reduction would be measured by MS4 reporting submission to Illinois EPA
2. **WWTP TP Capped at 0.5 mg/L + 50% Urban Runoff Reduction**: In this combined scenario, WWTP effluent TP concentrations were capped at 0.5 mg/L, and a concurrent 50% reduction in urban runoff TP loads was applied. This scenario reflects moderate improvements in both point and nonpoint source controls.

*: P flux based on model calibration (see Page 9 of Appendix B for additional information)

Figure 2-2 shows the relative TP contribution to the NBCR watershed from various sources for the baseline condition. While the treatment plants contribute nearly 50% of the TP load, their relative contribution dropped to 32% when their effluent TP concentrations are capped at 0.5 mg/L.

The urban watershed loading becomes the major contributor to total TP loading once the 0.5 mg/L TP effluent limit at the two WWTPs limit has been achieved. A 50% reduction in TP loads from MS4s would result in another 2,000 lbs reduction, which is 100 lbs more than the load reduction that can be achieved by reducing WWTP from 0.5 mg/L to 0.1 mg/L (see ***:** P flux based on model calibration

Figure 3-14).

3.4.3 Load Reduction from Watershed TP

A suite of scenarios was developed to assess the impact of non-point source watershed-based TP reductions in the NBCR system. These scenarios included incremental reductions in watershed TP loading alone and in combination with reduction in effluent TP at the two WWTP. A total of nine scenarios were modeled:

1. Watershed loading reduced by 100 lbs
2. Watershed loading reduced by 500 lbs
3. Watershed loading reduced by 1000 lbs
4. WWTP TP capped at 0.5 mg/L and watershed loading reduced by 100 lbs
5. WWTP TP capped at 0.5 mg/L and watershed loading reduced by 500 lbs
6. WWTP TP capped at 0.5 mg/L and watershed loading reduced by 1000 lbs
7. WWTP TP capped at 0.1 mg/L and watershed loading reduced by 100 lbs
8. WWTP TP capped at 0.1 mg/L and watershed loading reduced by 500 lbs
9. WWTP TP capped at 0.1 mg/L and watershed loading reduced by 1000 lbs

Watershed reductions were implemented by proportionally decreasing TP contributions from the nonpoint source components of the watershed model. The instream model used to evaluate changes in total TP load, instream TP and chlorophyll *a* concentrations and DO levels.

3.4.4 Enhanced Reaeration

Low DO levels were observed in the upper segment of Skokie River and West Fork during the monitoring period. This condition is associated with limited natural reaeration due to flat stream slopes. Hydraulic structures such as stepped cascades and weirs can introduce turbulence that increases air entrainment. For the instream model, an enhanced reaeration scenario was developed to simulate the effects of artificial passive reaeration using facilities such as a stepped spillway.

Laboratory experiments (Aras and Berkun 2010) have shown that the aeration efficiency varies between 1.40 and 1.95 on stepped spillways. While field conditions can vary significantly from the laboratory environment, the goal of this scenario is to provide a preliminary assessment of the potential extent of the impact due to enhanced reaeration and establish whether this option is worth further consideration. As a result, a fixed higher-end reaeration efficiency value of 1.90 was selected and applied to the river segments immediately upstream of monitoring stations SR8 in the

Skokie River and WF21 in West Fork, respectively, to represent the proposed condition of artificial stepped spillways constructions to enhance reaeration.

3.4.5 Lagoons Bypass

This scenario aims to evaluate the water quality impacts of the Lagoons bypass on the Skokie River by rerouting all flows away from the Lagoons through the discharge channel located on the west side of the Lagoons. The proposed bypass channel is shown in red in the **Figure 3-15**. The flow from the proposed bypass channel will be directed into the Skokie River. This approach will eliminate nutrient loading from the Skokie Lagoon and decrease residence time, thereby mitigating excessive algae growth. The physical characteristics of the bypass channel, including length, width, and slope, were obtained from the NBCR hydraulic model and applied to the WASP model. Through the Lagoons bypass, the P flux and SOD from the Lagoons sediment were eliminated, effectively reducing P loads and improving low DO conditions.

Figure 3-15: Skokie Lagoon and Proposed Bypass Channel

3.5 Evaluation of Management Scenarios

The models were used to evaluate the watershed management actions and combined scenarios by comparing the results to the baseline scenarios for the period of July 28 to October 5, 2022. The modeling results and key findings are summarized below. Additional management scenarios results can be found in *Appendix B - 2024(0814) NARP Model Development and Baseline Analysis and Appendix C - 2025 (0219) Management Scenarios and Implementation Survey*.

3.5.1 Key Takeaway #1: Relocating Clavey Road WRF discharge outfall has mixed impacts.

The Clavey Road WRF normally discharges through its primary outfall downstream of Skokie Lagoons. During 2022, the WRF discharged to the Skokie Lagoons because of maintenance work at primary outfall downstream of the Lagoon. Therefore, the 2022 Baseline Scenario does not reflect the normal discharge from the Clavey Road WRF.

Figure 3-16 presents a comparison of water quality along the Skokie River under the two scenarios: Clavey Road WRF discharging upstream of the Lagoon (2022 baseline, black solid line) and Scenario 2: Clavey Road WRF discharging downstream of the Lagoons (2022 baseline discharge below the Lagoons, red dashed line). The model results show that Clavey Road WRF discharge downstream of the Lagoons leads to lower chlorophyll *a* levels downstream in the Skokie River, as a result of dilution, when compared to the scenario where Clavey Road WRF discharges into the Skokie Lagoons. The proportion of time that simulated DO levels fall below the minimum standard in the Skokie River downstream of the Lagoon is also lower when the Clavey Road WRF discharge occurs downstream of the Lagoon. The simulated TP levels are also lower for scenario with Clavey Road WRF discharge downstream of the Lagoons. These scenario results show that the primary location of Clavey Road WRF discharge, downstream of the Lagoon, is beneficial to downstream Skokie River water quality compared to emergency conditions (similar to 2022) when it discharges to the Skokie Lagoon. However, the water quality in Skokie Lagoon itself is improved when the NSWRD discharges into the Lagoon rather than downstream, due to increased flow in the Lagoons which reduces the hydraulic retention time and consequently algae growth.

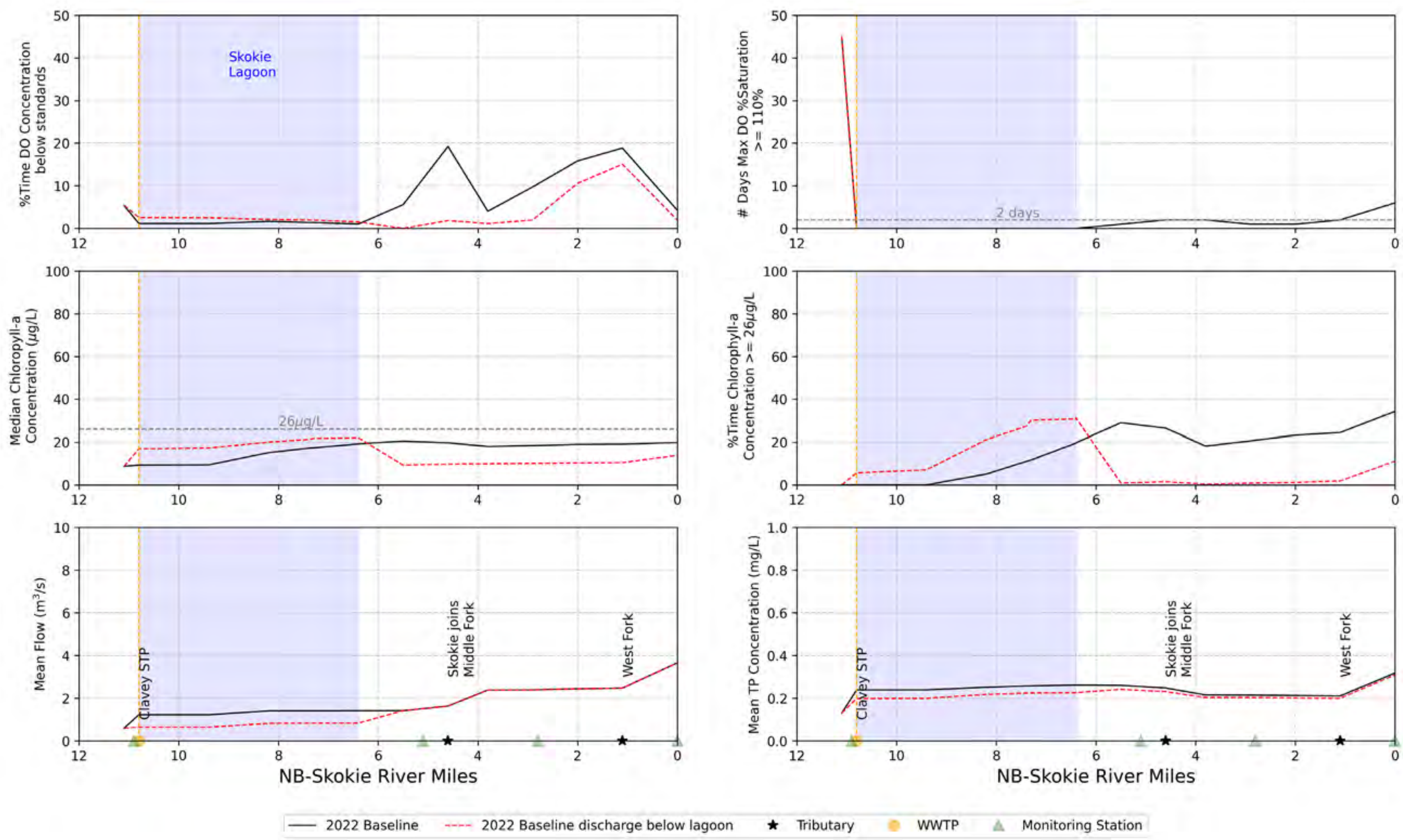


Figure 3-16: Simulated Water Quality Along Skokie River: Baseline Scenario with Clavey Road WRF Discharge into Skokie Lagoon and Scenario with Clavey Road WRF Discharge Downstream of Skokie Lagoon

3.5.2 Key Takeaway #2: WWTP total phosphorus reductions beyond 0.5 mg/L have minimal impact on water quality in both Skokie River and West Fork.

The impact of load reductions associated with more stringent effluent TP limits for WWTPs was simulated by capping the WWTP effluent concentrations to 0.5 mg/ L and 0.1 mg/L in the model.

Figure 3-17 and **Figure 3-18** compare simulated water quality along the Skokie River and West Fork, respectively, between the baseline (black solid line), WWTP effluent TP concentration capped at 0.5 mg/L (red dashed line), and WWTP effluent TP capped at 0.1 mg/L (blue dotted line). The NSWRD Clavey Road WRF has undergone significant improvements over the past decade, resulting in effluent TP concentrations at or below 0.5 mg/L under the baseline scenario (**Figure 3-10)**. Therefore, implementing a cap of 0.5 mg/L for the NSWRD Clavey WRF leads to only a marginal change in TP concentration compared to the baseline conditions. As a result, simulated instream water quality (TP, chlorophyll-a and DO) in the Skokie River remain nearly identical between the baseline scenario and the scenario where the WWTP effluent is limited to a TP concentration of 0.5 mg/L (**Figure 3-17**). Limiting the NSWRD effluent TP concentration to 0.1 mg/L leads to a small reduction in instream TP; but only results in minimal decrease in median chlorophyll a levels compared to the baseline scenario. For West Fork, capping effluent TP concentration at 0.5 mg/L leads to more significant improvements compared to the baseline condition. Further reduction of effluent TP concentration to 0.1 mg/L shows marginal change in median chlorophyll a levels during the simulation period. Based on these results, upgrades to WWTP to achieve a TP effluent concentration of 0.1 mg/L would not result in significant return on investment in terms of instream water quality. This finding is consistent with TP and chlorophyll-a relationship analysis based on data from NBCR, which found no strong correlation between TP and chlorophyll-a (**Section 3.2.2**)

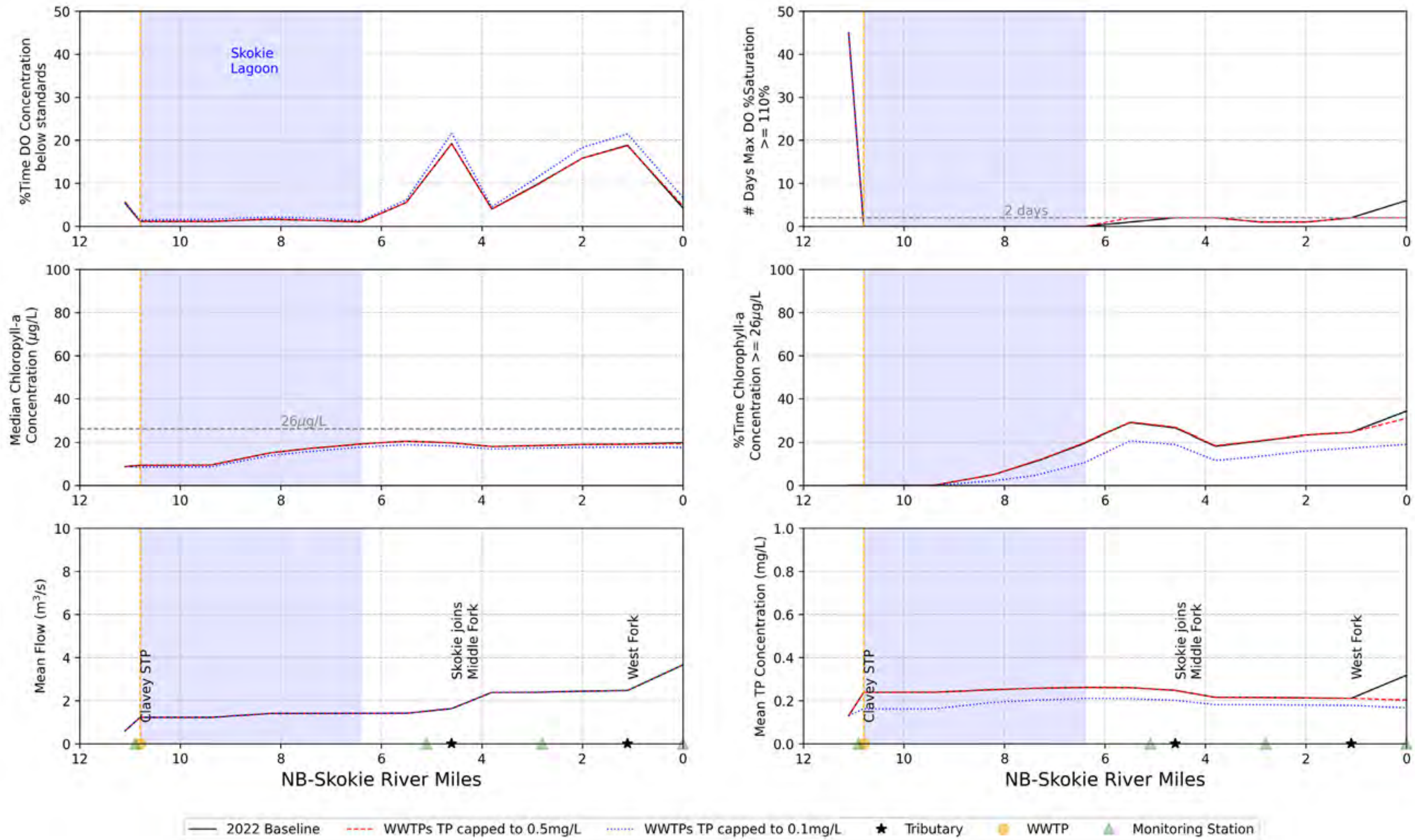


Figure 3-17: Simulated Water Quality Along Skokie River: Baseline Scenario and Scenarios with WWTP Effluent Discharge at 0.5 mg/L and 0.1 mg/L Total Phosphorus along the Skokie River

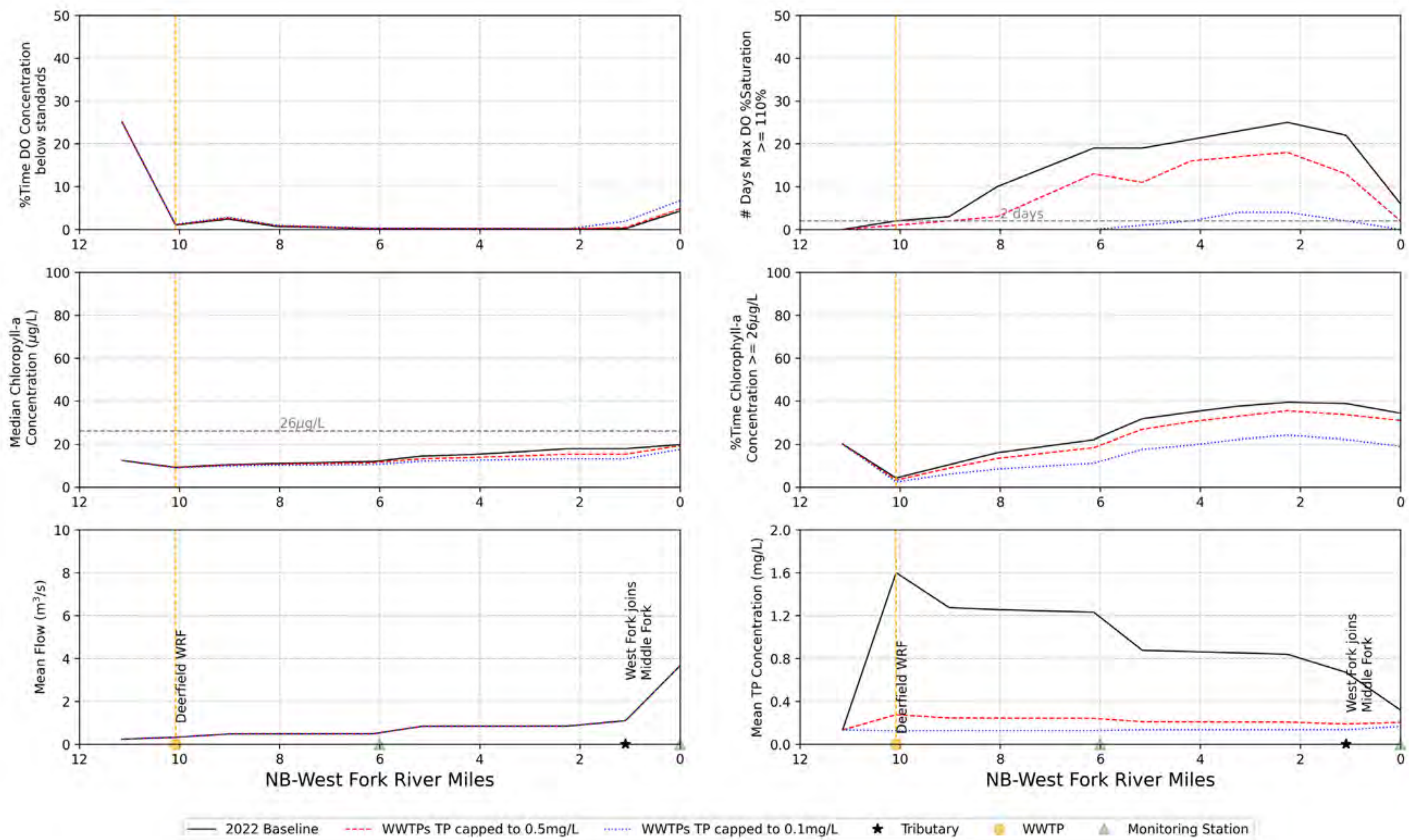


Figure 3-18: Simulated Water Quality Along West Fork: Baseline Scenario and Scenarios with WWTP Effluent Discharge at 0.5 mg/L and 0.1 mg/L Total Phosphorus Along West Fork

3.5.3 Key Takeaway #3: Reduction in urban runoff loading would result in substantial improvement in water quality after WWTPs have achieved limit of 0.5 mg/L.

The impact of reduction in urban loading was simulated by proportionally reducing the non-point source TP loading**. Figure 3-19** shows the simulated water quality in the Skokie River between the following three scenarios: WWTP TP concentrations capped at 0.5 mg/L (black solid line), WWTP at 0.5 mg/L combined with 50% TP reduction in urban runoff (red dashed line), and WWTP concentrations capped at 0.1 mg/L (blue dotted line). The combined scenario of capping treatment plant effluent TP concentrations at 0.5 mg/L and reducing urban runoff TP loads by 50% results in more reduction in TP loads and leads to lower instream TP and chlorophyll *a* levels than capping WWTP effluent TP concentration to 0.1 mg/L. Therefore, it is recommended to pursue both a reduction of WWTP total phosphorus to 0.5 mg/L and a decrease in urban runoff loads.

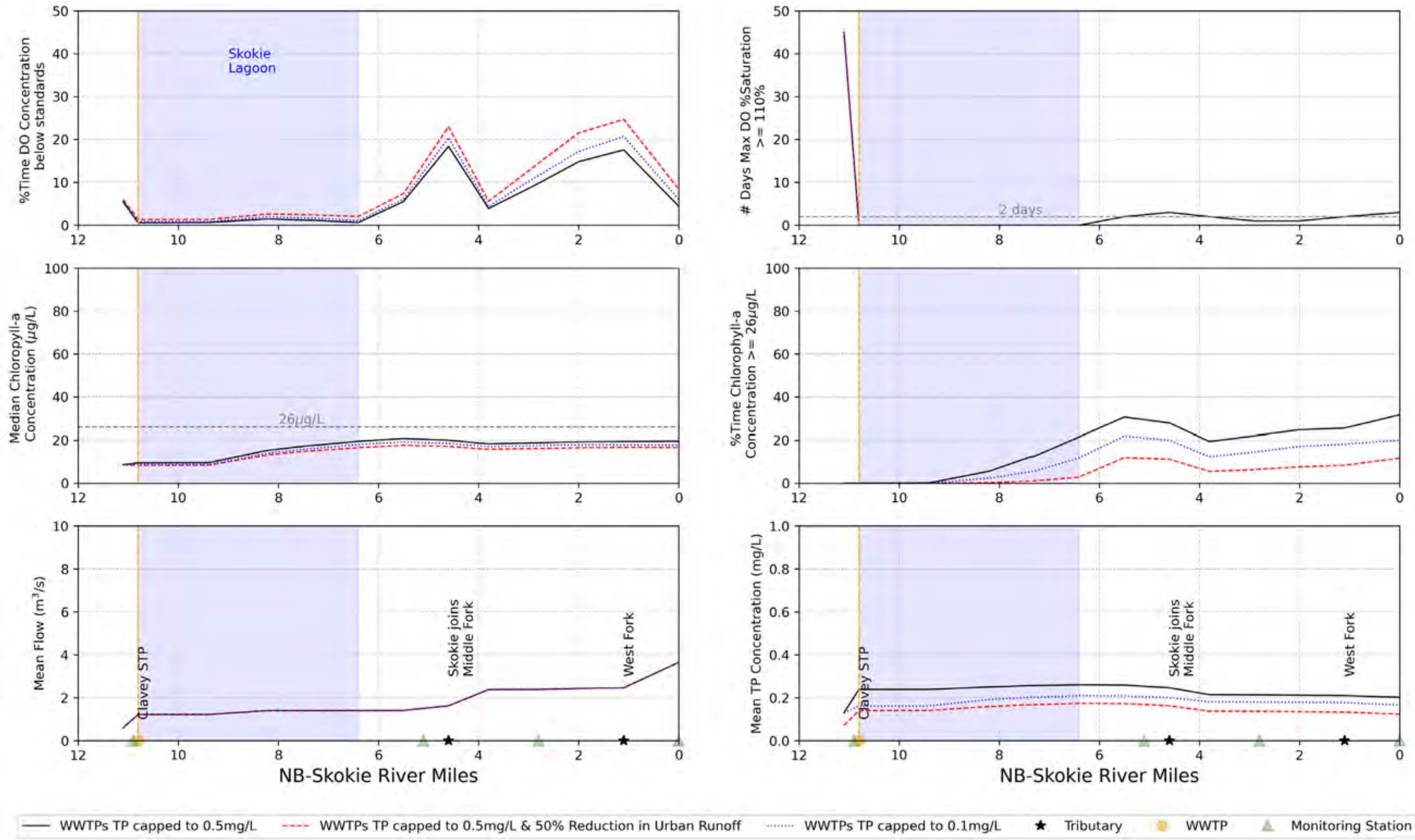


Figure 3-19: Simulated Water Quality Along Skokie River: Scenario with WWTP TP Capped at 0.5 mg/L, WWTP TP Capped at 0.5 mg/L Combined with 50% TP Reduction in Urban Runoff, and WWTP Capped at 0.1 mg/L Along the Skokie River

3.5.4 Key Takeaway #4: The water quality impact of removing 100 lbs of P from the entire MS4s is negligible

***:** P flux based on model calibration

Figure 3-14 shows that under baseline conditions, the total TP load to the system was 11,605 lbs. A 100 lbs reduction in watershed TP alone would result in only a 1% reduction in total TP load, while a 1,000 lbs reduction would result in a 9% reduction.

Simulated water quality responses under various scenarios revealed that modest uniform reductions in watershed TP (e.g., 100 lbs) had negligible impact on instream TP concentrations and associated response variables such as chlorophyll *a* and DO. **Figure 3-20** and **Figure 3-21** from the Skokie River and West Fork subwatersheds, respectively, show minimal change in chlorophyll *a* levels and DO saturation under the 100 lbs reduction scenario, even when paired with WWTP TP effluent limits.

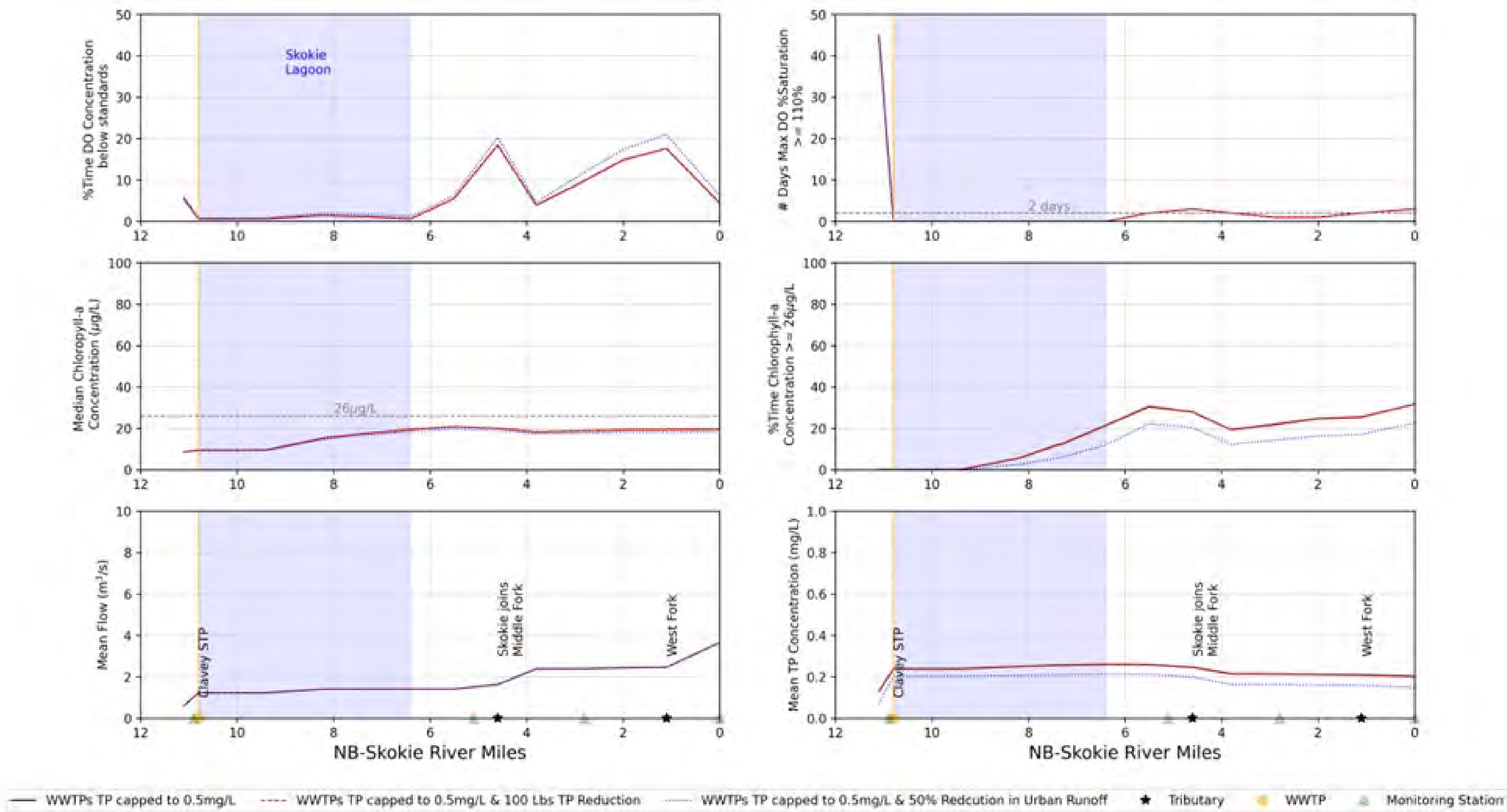


Figure 3-20: Simulated Water Quality Along Skokie River: Scenario with WWTP Effluent TP Capped at 0.5 mg/L, Scenario with WWTP Effluent TP Capped at 0.5 mg/L Combined with 100 lbs Watershed TP Reduction, and Scenario with WWTP Effluent TP Capped at 0.5 mg/L Combined with 50% Reduction in Urban Runoff TP Loading

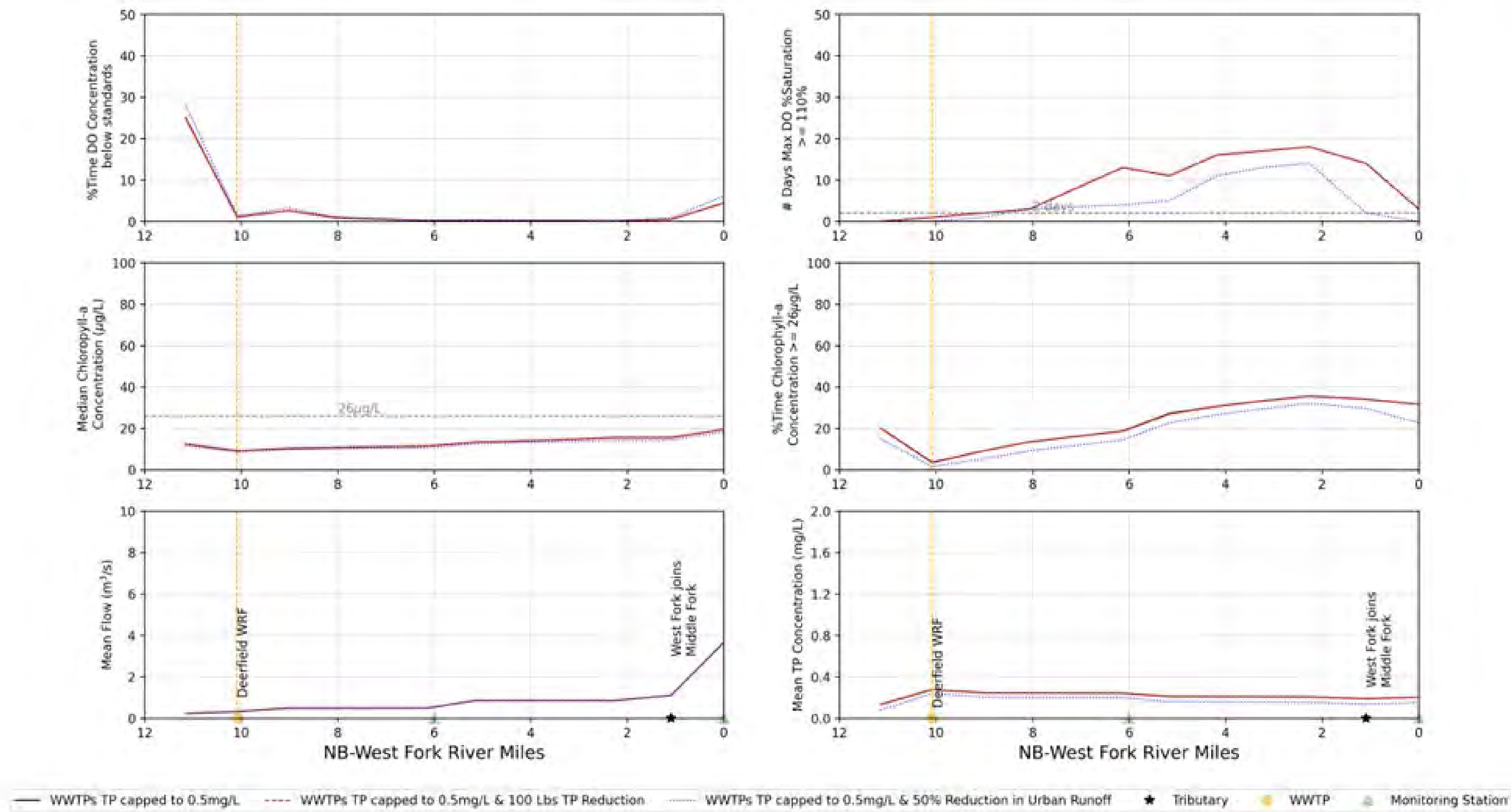


Figure 3-21: Simulated Water Quality Along West Fork: Scenario with WWTP Effluent TP Capped at 0.5 mg/L, WWTP TP Capped at 0.5 mg/L Combined with 100 lbs Watershed TP Reduction, and WWTP TP Effluent Capped at 0.5 mg/L Combined with 50% Reduction in Urban Runoffs

3.5.5 Key Takeaway #5: The effect of enhanced reaeration such as stepped spillways has localized impact on improving low DO.

The effects of increased aeration on instream DO levels was evaluated by increasing aeration levels in river segments located immediately upstream of monitoring stations SR8 on the Skokie River and WF21 on the West Fork. This approach was designed to model the anticipated conditions resulting from the construction of artificial stepped spillways intended to enhance reaeration. Average DO concentrations from July 28 to October 5, 2022, at distances of 50, 100, and 500 meters downstream of the enhanced aeration segment were compared to that of the baseline condition to assess the efficacy of enhanced reaeration. **Table 3-2** summarizes the results of enhanced reaeration at both stations SR8 and WF21.

Table 3-2: Average DO Concentrations and Improvements Through Enhanced Reaeration from July 28 to October 5, 2022

	Baseline	Distance downstream of Enhance Reaeration Segment		
		50 meters	100 meters	500 meters
DO at SR8 (mg/L)	5.5	7.9	7.5	6.2
% Change in DO	-	**43.4%**	**36.0%**	**12.0%**
DO at WF21 (mg/L)	6.0	6.1	6.1	6.2
% Change in DO	-	**2.6%**	**2.6%**	**2.8%**

DO: dissolved oxygen
mg/L: milligrams per liter

The results indicate that enhanced reaeration through stepped spillway provides localized improvements in low DO, and the effect diminishes further downstream. The improvement in DO is much more significant in the Skokie River compared to that in West Fork. This is likely due to West Fork having a lower baseflow.

3.5.6 Key Takeaway #6: The bypass of Skokie Lagoons would reduce the chlorophyll *a* level due to much shorter residence time.

Figure 3-22 shows the water quality impact on the Skokie River by bypassing the Skokie Lagoons. Due to the bypass channel having a much narrower width and shallower depth compared to the Lagoons, the residence time is now much shorter with the Lagoon bypass. As a result, the chlorophyll *a* levels are much lower due to the shorter residence time. The bypass of the Lagoon also results in elimination of P flux from the Lagoon sediment, effectively reducing the TP load in the system. Similarly, DO concentrations are also improved due to the elimination of SOD from the Lagoon sediment.

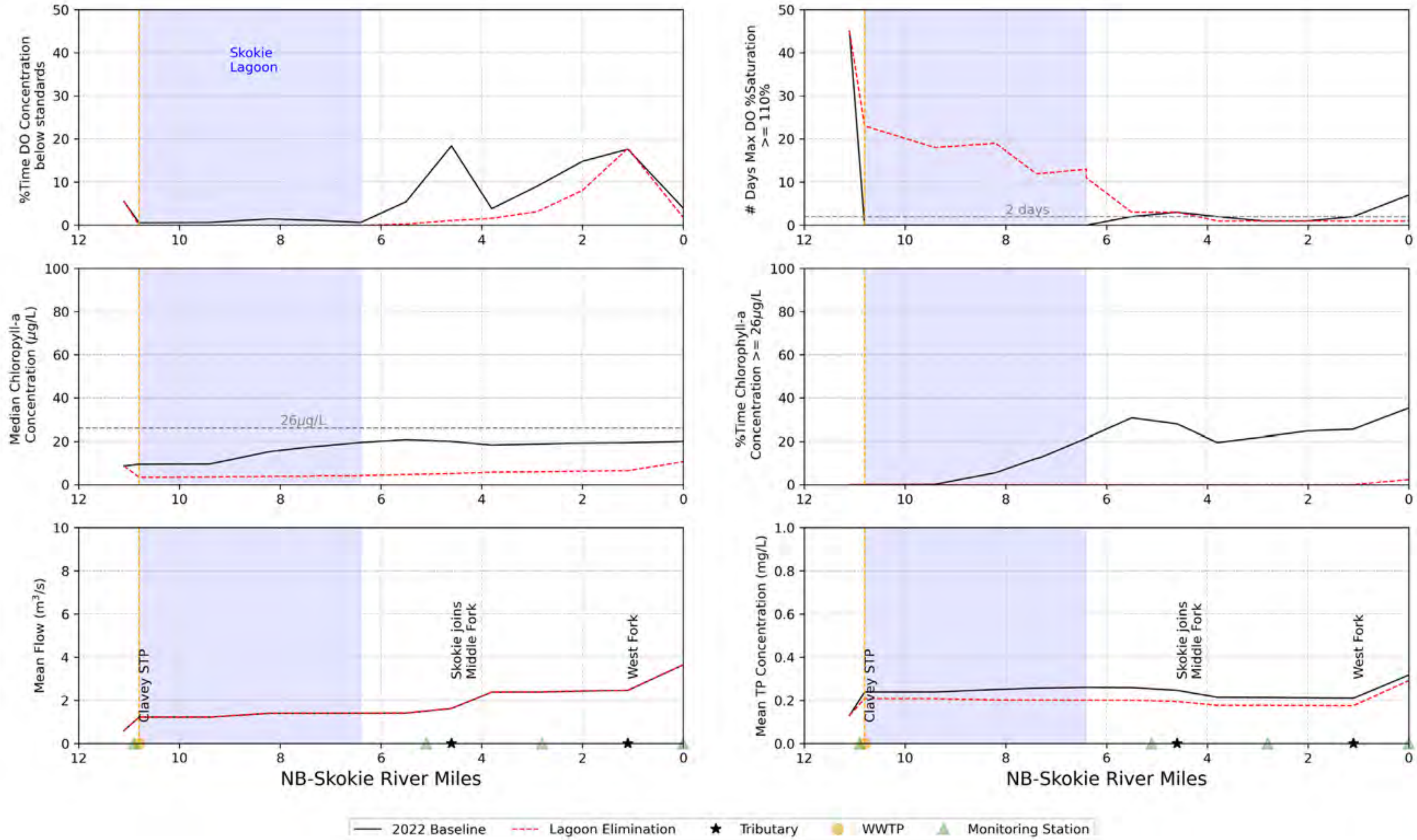


Figure 3-22: Simulated Water Quality Along Skokie River: Baseline Scenario and Scenario with Skokie Lagoon Bypass

3.6 Stakeholder and Public Engagement

The NARP special condition in the NPDES permits of both WWTPs requires them to work with other stakeholders to determine the most cost-effective methods to address the risk of eutrophication. The development of NARP by NBWW was a stakeholder driven process which included WWTPs, MS4s, local communities, park districts, and environmental groups between 2021-2025.

3.6.1 Goal and Objectives

The goal of stakeholders and public engagement was to solicit feedback on the NARP development and findings.

3.6.2 Target Audience

The target audience for the stakeholder's engagement process is provided below, along with a description of the role in NARP development and implementation.

Table 3-3: NBWW NARP Stakeholders and Roles

Stakeholders	NARP Role
Illinois EPA	The Agency responsible for reviewing the NARP and ensuring that it meets the NPDES permit requirements
North Branch Chicago River Watershed Workgroup	Lead role for development of the NARP
Sierra Club	Representatives served on the NBWW Monitoring Committee, who provided feedback on the NARP development process and findings.
NBWW members	Provide feedback on the NARP development process and findings; provided input on the NARP implementation survey. Full list of all NBWW members can be found at nbwwil.org.

3.6.3 Engagement Process

The NBWW conducted a monthly open public meetings with stakeholders identified above during the NARP development process to solicit feedback and inform the NARP development. The minutes of the meetings are available on the NBWW website (https://www.nbwwil.org/meetings/archive/). NBWW also shared NARP Workplan and NARP progress with general membership during all general membership meetings and annual newsletters (between 2021–2025), which are also available on the NBWW website (https://www.nbwwil.org/newsletters/).

The NBWW also conducted a stakeholder survey early Spring 2025 among its members to help inform the development of the NARP implementation plan. The survey collected responses from a diverse group including MS4 permittees, WWTPs, non-profits, NGOs, regulatory agencies, and other interested stakeholders. The top objectives for NBWW participation, aside from permit compliance, were water quality improvement, meeting regulatory requirements, education and outreach, and collaboration. Stakeholders identified watershed plan implementation, continued monitoring, and advocacy as key roles for NBWW after NARP completion.

While half of the survey respondents felt engagement was adequate, suggestions for improvement included more targeted communications and sharing of member-specific information. Respondents supported measures such as stream restoration, flood control, and Lagoon maintenance to address water quality and hydromodification issues. Most favored a 10- to 20-year horizon for achieving NARP compliance, with agencies willing to provide insight, oversight, and voluntary compliance toward the phosphorus reduction target. The survey questions and detailed breakdown of responses are included in *Appendix D: NARP Survey Responses*.

The NBWW requested that its members provide details regarding additional best management practice (BMP) projects—such as those addressing stormwater, water quality, and flood mitigation—that have been implemented over the past two decades (2005–2025), as well as any planned future initiatives. The purpose of this survey was to map anticipated efforts related to stormwater management, green infrastructure, and watershed recovery, while identifying areas where further investment may be warranted. The results of the survey can be accessed at the following link: https://experience.arcgis.com/experience/c63ee08c71ac43478f4a22ea04dff2eb/.

4. IMPLEMENTATION PLAN

The work completed for the NARP focused on identifying management actions to *remove phosphorus related impairments in the watershed*. Future work would continue these efforts but may also expand to study other impairments or issues, such as sedimentation and hydromodification. This section presents the recommended management actions in the Study Area. Recommended actions fall under the following categories:

1. Administrative actions
2. Actions to support NARP objectives
3. Education and outreach
4. Monitoring

The recommended actions are organized into three-time frames: short-term (less than 5 years), mid-term (5–15 years), and long-term (more than 15 years). An implementation schedule with realistic milestones has been developed to allow the NBWW and other watershed stakeholders to pursue and use funds from public and private sources more effectively. The short-term, mid-term and long-term action items, along with key stakeholders and potential funding sources, are summarized in **Table 4-1, Table 4-2,** and **Table 4-3** respectively. The NBWW plans to review and assess these actions annually as part of an adaptive management approach, investing in the NARP's ongoing effectiveness and treating the plan as a living document to guide the workgroup's efforts. The NBWW will start assessing the implementation of the recommended action items after Deerfield and Clayey Road WRF receive permits incorporating the recommended NARP implementation plan

Within the proposed timelines (short-, mid-, long-term), the NBWW will look to identify an appropriate suite of activities that will assist in promoting the continual existence of the group through its mission and goals. These activities are further divided into categories (defined above) to better define the potential benefit to the workgroup and watershed, those stakeholders who might be most involved, and possible funding mechanisms. The tables are intended to provide a strategic starting point for post-NARP submission and should not be used to limit further considerations for policy, projects, or watershed improvement. The NBWW will commence the implementation of short-term recommendations once the WRFs have received their updated permits incorporating NARP recommendations. Additional details on recommended management actions are provided in Sections 4.1 to 4.5. Section 4.6 discusses the potential funding sources for recommended management actions.

Table 4-1: Summary of Short-Term (<5 years) Implementation Activities

Category	Subcategory	Short-Term Activity (<5 years after NARP submittal)	Key Stakeholders	Potential Funding Sources
Administrative		Evaluate the role of North Branch Watershed Workgroup (NBWW) in addressing impairments related to the Nutrient Assessment Reduction Plan (NARP) • Develop post-NARP Goals after the Wastewater Treatment Plants have received updated permits based on the NARP	NBWW	NBWW
		Continuing NBWW monthly meetings and annual newsletters	NBWW	NBWW
		Begin formal discussions with IEPA on defining water quality credit trading as an allowed permit condition	NBWW, WWTP's, Municipal Separate Stormwater Systems (MS4s), Illinois EPA	NBWW, WWTP's, MS4's
		Continued coordination with watershed groups and other regional agencies including Chicago	Watershed groups	
Actions to Support NARP Objectives	Major WWTP Upgrades	Meet a total phosphorus effluent limit of 0.5 milligrams per liter (12-month rolling geometric mean, calculated monthly) by January 1, 2030	Major WWTPs; Illinois EPA; NBWW	WWTP capital budgets; Illinois EPA; State Revolving Fund loans; User rates

Category	Subcategory	Short-Term Activity (<5 years after NARP submittal)	Key Stakeholders	Potential Funding Sources
	Watershed Improvement	Consider projects for implementation (See section 4.2.2) • NARP Project prioritization • Total maximum daily load (TMDL) benefits; impairment reductions • North Branch Chicago River (NBCR) watershed-based plan (WBP) project recommendations	NBWW, municipal separate storm sewer systems (MS4s), Watershed stakeholders	Illinois EPA grants, Lake County SMC, MS4 operational budgets
Actions to Support NARP Objectives	Watershed Improvement	Consider policy recommendations on numeric total suspended solids (TSS) capture and impervious area percentage restriction per NBCR WBP • Develop pathway with membership counties for Technical Advisory Committee (TAC) review • Survey NBWW membership for local considerations in applied policy	NBWW; Lake County Stormwater Management Commission (SMC); Lake County Technical Advisory Committee (TAC); Metropolitan Water Reclamation District of Greater Chicago (MWRD) TAC; Local Communities	N/A
	Skokie Lagoon Bypass Study	Explore pathways to disconnect base flow of Skokie River from Skokie Lagoons System • Hydrologic and ecologic assessment • Engineering and improvement logistics • Stakeholder-driven input Explore potential impact of other online impoundments	NBWW; Forest Preserve District of Cook County (FPDCC); Chicago Botanic Garden Lake County SMC	NBWW, MWRD, Lake County, FPDCC, Chicago Botanic Garden Not for Profit (NFP) Partners
Education and Outreach		• Encourage and distribute educational materials focused on the MS4 driven (nonpoint source) phosphorus loading	NBWW, downstream watersheds, Illinois Department of Natural Resources (IDNR),	NBWW

Category	Subcategory	Short-Term Activity (<5 years after NARP submittal)	Key Stakeholders	Potential Funding Sources
		• Encourage/support and distribute educational materials focused on the impacts of urbanization on streams • Encourage and distribute educational materials focused on detention basin retrofit • Encourage and distribute educational materials focused on life litter collection	United States Army Corps of Engineers (USACE), Illinois EPA, US EPA	
		Support educational programs on managing road salt application such as training workshops on chloride application	NBWW, Lake County Department of Transportation, Illinois Department of Transportation	NBWW
Monitoring		Update NBWW monitoring strategy and establish a monitoring program for implementation post-2033 to assess the impact of WWTP upgrades	NBWW; WWTPs	NBWW
Monitoring		Monitoring to meet the requirements of NPDES permit requirements for WWTPs and MS4s	NBWW Members	NBWW
		Consider working with watershed partners to develop and maintain a watershed-wide tracking program of development and restoration projects	NBWW Local communities; Lake County SMC	Lake County SMC; Watershed Management Board (WMB)
		Conduct pre- and post-monitoring of the 2025-2026 SCDD Skokie River streambank stabilization project with four proposed instream aeration measures (pool/riffle structures) *	NBWW; NSWRD; Skokie Lagoons Consolidated Drainage District	NBWW
		Conduct microbial source tracking studies in watershed to determine source of high E.coli	NBWW	NBWW

Category	Subcategory	Short-Term Activity (<5 years after NARP submittal)	Key Stakeholders	Potential Funding Sources
		Consider supplementary monitoring with Riverwatch	NBWW, IDNR	IDNR

*This NBWW monitoring pilot project started in Fall 2025 to primarily assess the impacts of DO before and after project implementation and how far downstream those benefits extend. This effort began prior to the submission of the NARP

Table 4-2: Summary of Potential Mid-Term (5–15 years) Implementation Activities

Category	Subcategory	Mid Term (5-15 years after NARP submittal)	Key Stakeholders	Potential Funding Sources
Administrative	Skokie Lagoons Bypass Study	*Continue to evaluate role and growth of organization and progress* • *To be determined based on evaluation* • *Continue NBWW meetings and annual newsletters* • *Assess frequency of meetings and format*	*North Branch Watershed Workgroup (NBWW)*	*NBWW*
		• *Continued discussion with Illinois EPA on Water Quality Trading Permit with Illinois EPA with Defined Project Implementation Boundaries and parameters*	*NBWW, WWTP's, MS4's. Illinois EPA*	*NBWW, WWTP's, MS4's*
Actions to Support NARP Objectives	Wastewater Treatment Plants (WWTPs)	Monitor the impact of 0.5 mg/L effluent attainment of mainstem dissolved oxygen swings and algal growth	Major WWTPs NBWW, Illinois EPA,	NBWW; WWTP capital budgets
	Watershed Improvement	*Continue to consider projects for implementation* (*See section 4.2.2)* • *NARP Project prioritization* • *Total maximum daily load (TMDL) benefits; impairment reductions*	*NBWW, municipal separate storm sewer systems (MS4s), Watershed stakeholders*	*Illinois EPA grants, Lake County SMC,*

Category	Subcategory	Mid Term (5-15 years after NARP submittal)	Key Stakeholders	Potential Funding Sources
		• *North Branch Chicago River (NBCR) watershed-based plan (WBP) project recommendations*		
		Continue to consider policy recommendations and encourage local governmental entities to consider the recommended policy changes from short-term activities	*NBWW;* *Lake County Stormwater Management Commission (SMC);* *Lake County Technical Advisory Committee (TAC);* *Local Communities*	*N/A*
		Continue collaboration and evaluation of Skokie River Bypass • *Hydrologic and hydraulic studies* • *Economic and ecologic impact studies* • *Engineering* • *Assessment funding mechanism*	NBWW; Forest Preserve District of Cook County (FPDCC); Chicago Botanic Garden Lake County SMC	NBWW, MWRD, Lake County, FPDCC, Chicago Botanic Garden Not for Profit (NFP) Partners
	Watershed Improvement	Consider projects that could address NARP, Total Maximum Daily Load (TMDL), municipal separate storm sewer system (MS4) programs, National Pollutant Discharge Elimination System (NPDES) permits, communal stormwater programs and North Branch Chicago River (NBCR) Watershed-Based Plan (WBP) requirements (and it's 10-year update) for improved use of resources • Watershed-specific controls • Scaled, cross-community projects • Public-private partnerships (P3) solutions	NBWW; Lake County SMC, Nutrient Loss Reduction Strategy Partners: University of Illinois Extension, Illinois EPA, State of Illinois, Illinois Department of Agriculture	NBWW

Category	Subcategory	Mid Term (5-15 years after NARP submittal)	Key Stakeholders	Potential Funding Sources
Education and Outreach		*Continuing education and outreach initiative on MS4 driven (nonpoint source) phosphorus loading* • *Focus on maintenance* • *Record keeping: stormwater facility tracking* • *Detention basin retrofit* • *Leaf litter collection*	MS4s; Lake County SMC, Cook County, US EPA	MS4s; Lake County SMC
		Continue to support educational programs on managing road salt application	*NBWW, Lake County Department of Transportation, Illinois Department of Transportation*	*NBWW*
Monitoring		*Continue monitoring to meet the WWTP and MS4 NBWW member's NPDES instream permitting requirements for NBWW members and any additional monitoring approved by the NBWW members*		*NBWW*
		Consider supplementary monitoring with Riverwatch	*NBWW, IDNR*	*IDNR*

Italicized item indicate items that represent continuation of work started in previous term

Table 4-3: Summary of Potential Long-Term (>15 years) Implementation Activities

Category	Subcategory	Long Term (>15 years)	Key Stakeholders	Potential Funding Sources
Administrative		*Continue to evaluate the role of organization in function as related to Nutrient Assessment Reduction Plan (NARP), and any other ongoing collaborative efforts* • *To be determined based on evaluation*	*North Branch Watershed Workgroup (NBWW)*	*NBWW*

Category	Subcategory	Long Term (>15 years)	Key Stakeholders	Potential Funding Sources
		• *Continue NBWW meetings and annual newsletters* • *Assess frequency of meetings and format*		
		Next Steps on Water Quality trading based on discussions with Illinois EPA	*NBWW, WWTP's, MS4's. Illinois EPA*	*NBWW, WWTP's, MS4's*
Actions to Support NARP Objectives	WWTPs	Assess monitoring program based on results and permitting needs. Coordinate with Illinois EPA on anticipate National Pollutant Discharge Elimination System (NPDES) changes for WWTPs based on discussion with Illinois EPA.	Major WWTPs; Illinois EPA; NBWW	WWTP capital budgets; Illinois EPA; State Revolving Fund loans; User rates
	Watershed Improvement	*Support projects for implementation (See section 4.2.2)* • *NARP Project prioritization* • *Total maximum daily load (TMDL) benefits; impairment reductions* • *North Branch Chicago River (NBCR) watershed-based plan (WBP) project recommendations*	*NBWW, municipal separate storm sewer systems (MS4s), Watershed stakeholders*	*Illinois EPA grants, Lake County SMC,*
		Evaluate existing policies in practice, determine if new policies or policy adjustments should be revisited and/or supported.	*NBWW;* *Lake County Stormwater Management Commission (SMC);* *Lake County Technical Advisory Committee (TAC); Metropolitan Water Reclamation District of Greater Chicago (MWRD);* *Local Communities*	*N/A*

Category	Subcategory	Long Term (>15 years)	Key Stakeholders	Potential Funding Sources
	Skokie Lagoons Bypass Study	*Choose the next steps on Skokie lagoon bypass based on the studies results in short and mid term*	*NBWW; Forest Preserve District of Cook County (FPDCC); Chicago Botanic Garden Lake County SMC*	*NBWW, MWRD, Lake County, FPDCC, Chicago Botanic Garden Not for Profit (NFP) Partners*
Education & Outreach		*Develop watershed-wide collaborative programs focused on education and outreach* • *Consider collaborative, watershed-wide maintenance tracking program* • *Consider collaborative, watershed-wide green infrastructure program* • *Detention basin retrofits* • *Leaf litter collection*	*NBWW; MS4s; Nongovernmental organizations (NGOs); Not for Profit (NFP) partners*	*NBWW; NGOs; NFPs*
		Continue to support educational programs on managing road salt application	*NBWW, Lake County Department of Transportation, Illinois Department of Transportation*	*NBWW*
Monitoring		*Continue monitoring to meet the POTW and MS4 NBWW member's NPDES permitting requirements for NBWW members and any additional monitoring approved by the NBWW members* on as needed basis	*NBWW; WWTPs; MS4s*	*NBWW*

Italicized items indicate items that represent continuation of work started in previous term

4.1 Administrative Activities

The NBWW will continue to work on its mission to "bring together a diversion coalition of stakeholders to preserve and enhance the water quality in the North Branch Chicago River and its tributaries". The NBWW will continue to meet monthly with it's Monitoring and Water Quality Improvement Committee and Executive Board, and biannually with its general membership and/or as needed based on membership need. Part of the importance of maintaining a regular meeting schedule is to continue to provide ongoing education opportunities and a forum for interaction with the NBCR WBP activities, which are typically aligned with the NARP but might not necessarily directly impact NARP regulatory requirements. The NBWW will continue to evaluate its role in its implementation of NARP recommendations in 2026 and beyond.

The NBWW intends to communicate NARP efforts with local advocacy groups and member communities, particularly those with NARP responsibilities to coordinate potential future monitoring or project implementation efforts. This can also provide a forum for members or attendees to share ideas, successes, or failures, and prompt activity for cooperation on projects and funding opportunities. Some recommended actions for consideration include the following:

- **Project Coordination:** NBWW can serve as a resource and committed support partner for communities and watershed collaborators interested in implementing projects or undertaking other beneficial activities. NBWW may also wish to reestablish the watershed planning committee that was originally envisioned to assist in the promotion of project initiation and implementation.
- **Watershed Clearinghouse:** NBWW can function as the primary information resource for the watershed by effectively directing individuals seeking data, contacts, opportunities for involvement, or a deeper understanding of waterway dynamics. With a substantial collection of existing materials, any supplementary content may be efficiently integrated into NBWW's current website.

4.2 Actions to Achieve NARP Objectives

The recommended actions for eliminating low DO and nuisance algae impairments in the Study Area include WWTP upgrades, watershed improvement measures, and the Skokie Lagoons bypass potential study. These are described below.

4.2.1 WWTP Upgrades

The NPDES permits for the Village of Deerfield WRF and NSWRD Clavey Road WRF have a requirement to meet a 0.5 mg/L effluent limit for TP (12-month rolling geometric mean, calculated monthly) by January 1, 2030. The water quality model simulations indicate that further reductions at the WWTPs beyond 0.5 mg/L will not provide significant benefits to instream water quality. Hence, the NARP does not recommend further TP reductions for the two WWTPs.

The two facilities are in the process of upgrading to meet the 0.5 mg/L TP effluent limits. The technologies being used to meet these targets include biological phosphorus removal and chemical (ferric chloride) dosing. A detailed description of these technologies is included in the phosphorus optimization feasibility reports and the annual progress reports submitted to Illinois EPA by each facility. A summary of progress made by WRFs in reducing TP is provided in **Table 4-4**

Table 4-4: Wastewater Treatment Plants Total Phosphorus Upgrade Progress

WWTP	Meeting Monthly Average Total Phosphorus (TP) of 1.0 mg/L?	Annual Average TP (mg/L)	Meeting Annual Geometric Mean of 0.5 mg/L TP?	Current Process	Planned Upgrades
North Shore Water Reclamation District (NSWRD) -Clavey Road Facility (WRF)	Yes	0.65	No	Biological phosphorus removal with chemical phosphorus removal back-up system	Current design would be able to meet a 0.5 mg/L annual geometric mean by dosing additional chemical and without additional capital expenditures.
Village of Deerfield WRF	Yes	0.75	No	Chemical phosphorus removal (Ferric Chloride)	None related to nutrients at this time.

mg/L : milligrams per liter

Special conditions within NPDES permits for WRF's in the watershed require identifying and providing adequate justification of any exception or circumstance to meeting an effluent limit of 0.5 mg/L TP 12-month rolling geometric mean by January 1, 2030. This justification is required to be submitted to the Illinois EPA at the time of renewal of the permits or by December 31, 2023, whichever date is first. NSWRD indicated that they've submitted such a report to Illinois EPA on November 30, 2023, for its Clavey Road WRF identifying two exceptions which may apply to the Clayey Road facility.

4.2.2 Watershed Improvement Measures

Nonpoint sources contribute substantial amount of runoff to the NBWW stream during wet weather conditions. While there are considerable land holdings with the Lake County Forest Preserve District, the Forest Preserve District of Cook County (FPDCC), Lake Forest Open Lands, and other open space organizations, most of the nonpoint-source contribution is associated with the MS4 communities. Due to the lack of other contributing sources and highly impervious nature of the watershed, these MS4 inputs will likely require improvement to meet the water quality objectives of the Illinois EPA

Once the NARP is submitted, the NBWW will have three important watershed recovery documents to leverage: the NARP, the TMDL, and the WBP. While each document has a specific role, there are several potential projects that can help to address overlapping issues. Some considerations for the aforementioned documents that can help to improve water quality in the NBCR watershed are further discussed below.

4.2.2.1 NARP Project Prioritization

While most nonpoint-source reduction projects are likely to benefit the NARP, projects which focus specifically on phosphorus load reduction, DO improvement, and algal growth abatement during base flow conditions will greatly assist in addressing the NARP special conditions in the WWTP NPDES permits. The amount of effort used to develop the NBCR WBP (SMC 2008) and update (SMC 2022) should also be recognized, which identifies hundreds of potential projects, including programmatic considerations, costs, potential collaborators, and funding approaches. This implementation plan recommends targeting specific projects from the WBP projects that would align with NARP objectives of removing DO and algae impairments and reducing phosphorus loading to the streams. Example projects that would meet these objectives include the following.

- **Stream Restoration with Reaeration:** The highly urbanized streams of the NBCR watershed carry significantly higher storm-driven flow velocities and increased system volume, with a highly effective, largely trapezoidal cross-sectional area augmented over time to convey water compared to a natural stream system. The NBCR streams are highly efficient in conveying stormwater but are prone to stagnation during base flow conditions, providing ideal conditions for algal growth. While stream stabilization and restoration are heavily focused on bank stabilization, reduction of profile downcutting and reaeration should be a key consideration for the NBWW's NARP. Instream structures such as cross vanes, j-hooks, stream barbs, and sills are all beneficial structures that can provide aeration benefits to streams as part of a restoration project or as standalone practices. Costs can often be minimized if coupled with an already planned stabilization or restoration project. Implementing creative solutions like reno gabion mattresses can also contribute to lowering levels of instream TSS and TP.

- **Reno Mattresses:** Implementing creative solutions like reno gabion mattresses can also contribute to reducing levels of instream TSS (total suspended solids) and TP (total phosphorus). Reno gabion mattresses are wire mesh structures filled with rock or stone and are typically installed along streambanks, channel beds, or in areas vulnerable to erosion. By stabilizing streambanks and dissipating the energy of flowing water, these mattresses help to reduce bank erosion and prevent soil and sediment from entering the water column. As a result, there is a direct reduction in TSS, which often carries attached phosphorus particles; lowering sediment input also means less phosphorus is transported downstream. In addition, by reducing sediment resuspension and trapping particulate matter, reno gabion mattresses can indirectly lower the available phosphorus that fuels algal growth and

Reno mattress Image source: https://gabionsupply.com/reno-mattresses/

impairs water quality. These structures not only provide immediate physical stabilization but can also serve as long-term restoration measures that support improved habitat conditions for aquatic life and enhance the overall effectiveness of watershed management plans.

- **Constructed Wetlands**: Constructed wetlands are an effective, nature-based solution for reducing total phosphorus (TP) in wastewater and surface runoff. They work through a combination of physical, chemical, and biological processes, including sedimentation, plant uptake, and adsorption onto substrates rich in calcium, iron, or aluminum. Larger wetlands with longer retention times generally exhibit higher and more consistent phosphorus removal. Beyond nutrient reduction, constructed wetlands provide co-benefits like habitat creation, flood mitigation, and carbon sequestration, making them a cost-effective alternative to advanced treatment upgrades for meeting stringent phosphorus limits in water quality regulations. Within the NBCR watershed, forest preserve districts offer an excellent setting for establishing constructed wetlands.

- **Pond Retrofits with Sediment Assessment:** As part of the watershed plan update, SMC inventoried 665 stormwater ponds to perform general conditions assessment and/or retrofit needs. An ongoing need will be assessing dead pool volume, which is the available storage below the elevation of the outgoing pipe. While not regulatory, SMC recommends reviewing dead pool storage biannually (SMC 2021). Sediment buildup stores phosphorus, which can spur the growth of unwanted rooted aquatic vegetation and algae. Excessive sediment can be a catalyst to convert sediment-laden phosphorus to dissolved phosphorus in the water column under the right conditions. Recent research indicates that stormwater ponds may serve as net exporters of dissolved phosphorus if they are not properly maintained (Lusk et al. 2025). Dissolved phosphorus is more readily available for algal and floating aquatic macrophyte uptake. NBWW will provide educational outreach to members on the importance of regularly assessing and retrofitting ponds as needed.

4.2.2.2 TMDL Allocation Reduction for Skokie Lagoons

The TMDL for the Skokie Lagoons was completed in 2020 and subsequently approved by Illinois EPA. The TMDL determined TP allocations for the Skokie Lagoons. As an online reservoir of the Skokie River, the Lagoons are the sink and sum of their watershed inputs. Allowable TP allocations for the tributary MS4 communities were provided in the TMDL report. Encouraging NBWW membership MS4 communities to meet the allocated TP load would improve water quality conditions for the Skokie Lagoons and downstream waters. Under the current MS4 NPDES permit cycle, communities with identified TMDLs are expected to develop an approach to meet the allocated loadings.

4.2.2.3 NBCR WBP Project Recommendations

Numerous projects were identified in the NBCR WBP, many of which provide TP reduction quantification. The location of projects identified in NBCR WBP are shown in the webapp link North Branch Watershed-Based Plan. Below are just a few of the topics encompassed within the WBP that reduce TP or help address phosphorus-based impairments.

- ***Stormwater***: Drainage from MS4s contributes to watershed base flow and most stormwater runoff volume due to rain-driven events. Once WWTP effluent reductions have been made, pollutants from MS4s will become a more significant contributor to the total remaining load. Modeled simulations indicate that further stormwater load reductions could benefit in reducing phosphorus-based impairments of the West Fork Chicago River, Skokie River, and the NBCR.

- ***Tributary sources***: Increases in tributary base flow and storm-generated flows create increased velocities and system volume, which can result in unstable stream banks and profile downcutting. Eroding stream reaches generate excessive sediment and phosphorus, which can settle and resuspend or become trapped in deep pools, impoundments, or other similar areas and manifest itself in the form of algal blooms, which can cause localized DO depletion and further lead to biological impacts for aquatic life.
- ***Nutrient Reduction-Focused Natural Restoration* –** This is a key concept of credit trading within defined watershed boundaries and agreed reduction outcomes as part of the credit trading agreement with the Illinois EPA. It allows for scalable and measurable restorations for properties of any size.
- ***Impervious area reduction projects***: Developed areas are typically associated with high imperviousness, with the NBCR watershed being 35% impervious within the NARP Study Area based on land use data used to develop the NARP SWMM model. Impervious surface is well documented as being related to surface water impacts, both volumetric surplus and water quality degradation. Impervious areas promote the following NARP-related impacts:
  - **Temperature**: Impervious surfaces store significant heat during warm temperatures and from direct sunlight. Heat transfer to rainwater creates conditions where water chemistry occurs faster, DO concentration is reduced, and phosphorus can be made bioavailable, creating an environment for ideal algal growth and detrimental to aquatic life.
  - **Pollutant buildup and runoff**: There is a myriad of pollutants that have been known to persist and build up on blacktop and concrete surfaces that continually reset between rain events and runoff into the streams. This effect is intensified by the heightened severity of storms resulting from climate change. During winter there can be an addition of chlorides due to salting activities. Some of these constituents can deplete oxygen while supplying additional nutrients.

4.2.3 WBP Policy Considerations

Enacting policy can be a useful structure that often becomes necessary when voluntary measures fail. Neither the current Lake County Watershed Development Ordinance (WDO) nor the Metropolitan Water Reclamation District of Greater Chicago (MWRD) Watershed Management Ordinance (WMO) directly addresses phosphorus or phosphorus-based impairments but requires general BMP approaches that would likely have phosphorus reduction benefits. The WBP does provide directions for regulatory/policy action recommendations that would be useful for improving water quality in the NBCR streams.

- **WBP Regulatory Policy (RP)-8**: *In compliance with Illinois EPA, establish TSS or appropriate water quality standards for new development or redevelopment within the NBCR planning area*. The State of Wisconsin has established an 80% annual capture standard (this is regulatory, not policy) for post-construction performance. This can be done with a combination of stormwater management approaches but is typically done with practices prior to stormwater reaching the detention facility to minimize accumulation of sediment. Additional states requiring TSS reduction include Massachusetts, Rhode Island, Vermont, New Jersey, New York, Pennsylvania, Tennessee, Minnesota, Ohio, and Arkansas. NBWW was identified as lead partner in the policy recommendation with MWRD and SMC.

- **WBP RP-12**: *Consider impervious surface cover regulations at appropriate scales such as parcels or catchments to reduce volumes from new development and redevelopment.* Impervious cover limits are typically defined in local ordinance language; however, it is not uncommon for communities to inadvertently overlook this requirement during the review process. Additional impervious buildout is not uncommon in residential development upon homeowner acquisition. This would therefore require direct coordination with MS4 entities, and any changes would be voluntary unless otherwise codified internally or by a cooperating agency. To this end, there have been progressive MS4 permit renewal requirements initiated elsewhere throughout the United States requiring communities to reassess drivers of their imperviousness, such as street and parking lot design standards to better conform with conservation design practices. NBWW was identified as lead partner in the policy recommendation with MWRD and SMC as having supporting roles.

- **Impervious Area Reduction Requirements in Local Code:** The highly impervious nature of the watershed creates a number of indirect impacts secondary to the significant increase in stormwater runoff volume. Direct runoff, summertime temperature spikes, and increased velocities are a few examples. Since the WDO and WMO do not regulate imperviousness caps, each of the MS4 communities may wish to revisit existing local codes to determine whether site reductions can be accommodated either through new development or the redevelopment process.

- **MS4 Ordinance Review Coordination:** Many unintentional conflicts exist between local codes (zoning, subdivision, landscaping, streets, etc.) that can undermine the intent of county stormwater ordinances. Examples can include mandatory curb and gutter, downspout connections, street widths, landscaping and screening needs, and planting restrictions. The disconnection can often occur between different departments within the community that may be responsible for reviewing non-stormwater-related content. Communities could choose to evaluate their internal review process to better understand the issues or reevaluate and update local codes and ordinances to better align with green infrastructure application in stormwater management.

- **Additional Programmatic/Policy Considerations:** The following programmatic approaches may be worth future consideration by NBWW.

- **Maintenance and Monitoring:** Improving and assessing that gray and green stormwater infrastructure is maintained and functional should be a top priority. Lack of proper maintenance can lead to lack of performance and in some cases, particularly for stormwater wet detention facilities, become a source of phosphorus and TSS.
    - Street Sweeping and Leaf Litter Collection
    - Phosphorus Reduction Requirement for Stormwater: Application of phosphorus reduction could be viewed independently or potentially coupled with TSS reduction. The following states have requirements for TP reductions in stormwater: Rhode Island, Vermont, New York, Pennsylvania, Virginia, Minnesota, and Maine. Wisconsin is currently undergoing an independent review of BMP approaches to directly address phosphorus in stormwater. Collaborate with Illinois EPA at the State level to develop legislation that addresses this issue, similar to the examples of other states.
    - Project Database: Develop a working project database of implemented projects in North Branch Planning Area to help with maintenance and monitoring. Features to include are:
    - Beneficial projects
        i. Stormwater
        ii. Flood reduction
        iii. Green infrastructure
    - Annual load reduction reporting (TP, TSS)
    - Annual impervious area reduction reporting

4.3 Skokie Lagoons Bypass Study

Monitoring data revealed the potential of the Skokie Lagoons to produce chlorophyll-a and supersaturated DO concentrations. Additional monitoring conducted in 2023 by the NSWRD confirmed that considerable internal cycling of phosphorus was taking place within the Skokie Lagoons, and a potential systemic improvement could be made by bypassing the system or at least temporarily by addressing the internal phosphorus issues. Additionally, the project has the potential for a high return on investment as initial discussion with the FPDCC suggests that a bypass between the Tollway and the Skokie Lagoons already exists. This provides the NBWW an option to explore a bypass once an understanding of how the Lagoons might function without the base flow contribution while still maintaining the originally intended flood storage capability. Changes might require additional study and feedback prior to disconnection as discussed below.

- **Hydrologic and Ecologic Assessment:** While the NBWW has invested in better understanding the impacts of the Lagoons, the bypass was likely designed under different circumstances and could lack capacity based on today's climate. Additionally, there could be unforeseen ecological impacts to impoundment species due to disconnection.

- **Engineering and Improvement Logistics:** Any changes needed to accommodate the finding of the hydrologic and ecological assessment might need engineering and science-based integration to successfully complete the bypass.
- **Stakeholder Driven Input:** Any significant project that could have an impact on local users should initiate education and outreach while gathering information on public concerns.
- **Other Online Reservoirs:** While even small stormwater management ponds can increase the presence of algae and impact DO oxygen availability, larger online impoundments might also warrant review. While not as big, the following reservoirs could have a localized impact on the West Fork due to size and the reduced base flow of the waterway:
    - **Lake Eleanor:** The Lake Eleanor Association has actively been working to address sediment-related issues for the past 30 years. Lake Eleanor currently has more sediment than water in its vertical profile. The lake is located approximately one mile upstream of the Deerfield WRF and might impact water quality in West Fork however, it has yet to be monitored in conjunction with the NARP.
    - **Techny Reservoir 32B**: The MWRD constructed Techny Reservoir 32B in 1987. Nearly 25% of the surface area of Techny Reservoir has silted in. The extent of dead pool storage is currently unknown.

4.4 Education and Outreach

Based on survey results completed in 2025, the majority of NBWW members consider the education and efforts of the NBWW to be adequate and full membership meetings continue to be well attended. Meetings will continue to bring value to stakeholders due to the unique nature of the NBCR watershed, the extremely high imperviousness, the aging infrastructure, the impact of the Skokie Lagoons, and the significance of the MS4s. These meeting provide a platform for interested NBWW members and members of the general public to understand the function and value of local water resources and how landscape conditions and infrastructure influence water quality specific to the NBCR watershed. This could include subjects from general aesthetics to recreation to sewer rates. These meetings also serve as a public forum for discussing and charting watershed and waterway health and recovery while obtaining feedback on potential projects and group trajectory. The value of this component of work, which can unite watershed goals beyond the NARP, are further expressed below.

Goals and Objectives: The NBWW meetings and other outreach efforts provide a public forum for members and the public that:

- Foster group growth and engagement under changing environmental and regulatory conditions.
- Include active discussion around anticipated compliance and regulatory change to promote innovation and collaboration.
- Reach a broad group of stakeholders:

- General public and interested stakeholders (residents, NFPs, NGOs)
- Community collaborators (adjacent community groups)
- Public officials who are integral in local decision-making and land use planning within their respective communities (Village boards, trustees)
- Technical partners with working knowledge of the watershed, the waterways, and practical project implementation practices (regulatory community, agencies, academia, consultants)

Delivery Approach: The NBWW will communicate the NARP in the following intended manner as SMC continues to serve as the fiscal agent and communication liaison through:

- The NBWW website (https://www.nbwwil.org/)
- Annual Newsletter
- Workgroup email database (requires sign up through website)
- Public meetings (location provided via email or website)
- Member communications

4.5 Monitoring

As part of the overall improvement of the NBCR watershed, the NBWW will continue monitoring to evaluate and document the benefits of plant improvements. Recommended monitoring approaches are as follows:

- Review the NBWW monitoring strategy annually and update based on the NARP results and recommendations.
- Execute monitoring program in short-term, mid-term, and long-term timelines to assess the impact of implementation.
- Work with watershed partners to develop a watershed-wide tracking program for development and restoration projects.
- Conduct pre- and post-monitoring of large-scale stream restoration projects
- Continue biological assessment of NBCR watershed streams based on the updated watershed
- Continue conducting microbial source tracking studies to determine the sources of high *E.coli* in NBCR streams

The NBCR WBP suggests collaborating with the Riverwatch program, which provides education and training for volunteers in collecting basic data on macroinvertebrates and aquatic habitat. This collaboration could enable broader public participation in watershed activities. The NBWW should consider implementing a Riverwatch program in coordination with IDNR to complement its monitoring activities. This program would however not replace the monitoring being carried by NBWW which is needed for instream permit conditions of WWTPS and MS4s in the watershed.

4.6 Budgeting and Funding

The potential revenue needed to confront the water quality impairment and reach the goal of use attainment will be best addressed as a group, provided the challenge can be approached from an incremental and adaptable standpoint. Any approach will require an assessment of the financial resources of the group and a means to use those resources in a fiscally responsible way that demonstrates progress based on membership consensus.

Because the amount of effort needed to make measurable progress is not easily assessed, the NBWW will be well suited to establish reasonable milestones that are complemented with monitoring. Projects for consideration may also be shared among members to maximize financial resources wherever possible.

Before the amount of money necessary to reach the desired nutrient reductions is determined, it is first necessary to understand whether ongoing improvement projects are providing the necessary beneficial returns needed to improve the baseline phosphorus conditions assessed as part of the NARP. The potential sources of funding for the recommended projects are provided below.

4.6.1 Annual Budget

The NBWW should continue to evaluate costs to continue group facilitation after the NARP and consider the provided costs for implementation given the completed scenarios. It is anticipated that the annual budget will be the main source for continued operations. Once the NARP is submitted and subsequently accepted by Illinois EPA, the NBWW should discuss an overarching approach to watershed recovery, which could potentially include systematic implementation of projects. This will entail the need to determine a pathway to consistent funding, which may be supported by varying sources to facilitate timely improvement.

4.6.2 Grants

The NBWW currently encourages and will continue to support member efforts to opportunistically make improvements in the watershed. As an appropriate course of action, it will be valuable to investigate and take advantage of grant opportunities that might become available to offset the costs of project implementation. It is understood that grant cycles, sources, and funding availability may change from year to year. The NBWW will work with watershed partners to review and support opportunities for grant acquisition to enhance existing projects or implement new standalone water quality protection projects. Numerous projects, along with potential recommended funding sources, are already identified within the NBCR WBP; therefore, the listing below is limited to some key funding sources and considerations:

- **Illinois EPA Grants:** Illinois EPA offers annual funding through their Non-Point Source Control Program. It is important that applicants follow through with the requirements of any grant prior to submittal, particularly for Illinois EPA funding, and preregister through the Grant Accountability Transparency Act (GATA) portal. The following Illinois EPA grants may be considered for implementation or other beneficial uses:

- **Section 319h:** Program funding for watershed-based planning projects and WBP implementation projects to prevent, eliminate, or reduce water quality impairments to Illinois's surface and groundwater resources. Since the NBCR currently has an approved nine-element plan through Illinois EPA, Section 319h funding is available. The Illinois EPA funding is cyclical; therefore, applicants may find project application more suitable during years when the NBCR watershed is prioritized for implementation.
- **Section 604b:** Program funds can be used to determine the nature, extent, and causes of point and nonpoint source water pollution; develop water quality management plans; develop technical and administrative guidance tools for water pollution control; implement administrative water pollution controls; and educate the public about the impact and importance of water pollution control. The funding is slightly different from 319h funding in that it cannot typically be accessed for in the ground projects, but rather programmatic, planning, or potential monitoring activities. Qualifying for funding is unique in that it requires a specific charter language typically unique only to a set number of planning agencies and Soil and Water Conservation Districts; therefore, it can prove easier to collaborate with any of those prequalified entities to access this funding.

- **Green Infrastructure Grant Opportunities (GIGO):** funds projects to construct green infrastructure BMPs that prevent, eliminate, or reduce water quality impairments by decreasing stormwater runoff into the rivers, streams, and lakes of Illinois.
- **Community Development Block Grants:** Commonly used by communities to help fund any number of public projects. The project can be leveraged for stormwater improvement with the intent to make communities more resilient. It could offer a strategic means to add water quality components that might benefit NARP objectives when coupled with other infrastructure improvement projects. For example, trying to allocate native vegetation, stream corridor BMPs, or additional conveyance storage with a road crossing improvement project.
- **Lake County Grants:** Lake County offers the following local cost share programs:
  - Watershed Management Board (WMB) Grants: The Lake County SMC administers this annual grant program to help reduce flood damage and improve water quality. The WMB oversees the allocation of SMC funding and staff resources for projects across the four watersheds of Lake County. The funding prioritizes flood relief but can be improved with water quality enhancements.
  - Stormwater Infrastructure Repair Fund (SIRF): This is a discretionary funding program facilitated by SMC to address drainage and flooding related issues. May opportunistically provide water quality benefits.
- **MWRD Green Infrastructure Partnership:** This grant includes construction reimbursement program for green infrastructure in Cook County. Selected projects are based on effectiveness, needs, and available funding. Projects cannot be placed in the floodplain to qualify for this funding.

- **Other Grants:** There are a number of conditional grants currently active at the federal and state levels that support environmental directives but are weighted toward environmental justice, climate resiliency, or traditionally underserved communities. Some may be previously mentioned in the NBCR WBP, while others continue to evolve given the federal budget restrictions of 2025.

A detailed list of grants available for watershed project is available on the Lake County website (Watershed-Potential-Funding-Sources-WEBSITE-DRAFT_08012023)

4.6.3 Alternate Funding

Under certain conditions, it could be advantageous to consider additional options to finance watershed improvements. While grants have often been viewed as a means to address water quality projects, there is a considerable amount of cost associated with the managing grants through documentation and proper execution. As compliance needs increase, the available pool of grant funding is also more competitively sought, ultimately leading to a scarcity of funding. While grants can play a key role in funding improvement projects, the following additional mechanisms should be explored by NBWW.

4.6.3.1 Nutrient Trading

The need to offset compliance and NARP Special Conditions allow for such considerations as mentioned within the NARP Special Conditions of POTW NPDES permits. In 2024, the Northern Moraine Water Reclamation District of the Fox River Watershed, negotiated a trading process on their behalf with Illinois EPA and began negotiating trades with the McHenry County Conservation District. From a fully developed watershed, such as the NBCR, this might be best explored with forest preserve districts, park districts, or other open space entities.

4.6.3.2 Public-Private-Partnership (P3):

Another innovative funding source for programmatic implementation or retrofit of green infrastructure is a public-private partnership (P3). P3s provide an opportunity to leverage private industry to capture scale efficiencies and coordinated maintenance. 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 bears the full burden. This cooperation helps to drive innovation and build strong, long-term relationships. For example, the Milwaukee Metropolitan Sewerage District is currently implementing green infrastructure to reduce overflows into Lake Michigan through a P3 program. In light of the newly published MS4 permit, the NBWW might wish to explore the potential efficiencies of a P3. Rather than administering a series of independent one-off projects, a singular contractor is selected or contractor pool is negotiated with to execute a set number of projects and maintain them over a set period of time (typically 10 or 20 years), ensuring performance. This approach has been proven to provide cost savings based on scale, both from an implementation and administration standpoint.

5. REFERENCES

Aras, E., and M. Berkun. 2010. Comparison of stepped and smooth spillway effects on stream reaeration 36.

Ambrose, R. B., & Wool, T. A. (2017). Water Quality Analysis Simulation Program (WASP) User Documentation. Washington, DC: U.S. Environmental Protection Agency Office of Research and Development.

CDM Smith, 2020. North Branch Chicago River Watershed Total Maximum Daily Load (TMDL) Report. Prepared for Illinois EPA. March 2020

Foster, G.M., Graham, J.L., Bergamaschi, B.A., Carpenter, K.D., Downing, B.D., Pellerin, B.A., Rounds, S.A., and Saraceno, J.F. (2022). Field techniques for the determination of algal pigment fluorescence in environmental waters—Principles and guidelines for instrument and sensor selection, operation, quality assurance, and data reporting, U.S. Geological Survey Techniques and Methods, Book 1, Chapter D10.

Geosyntec. 2021. *Nutrient Assessment Reduction Plan Workplan for the North Branch Chicago River, Illinois*. Prepared for the North Branch Chicago River Watershed Workgroup. Geosyntec Consultants, Inc. December 2021 .

Geosyntec. 2025. *NBWW 2018-2023 Water Quality Summary Report*. Prepared for North Branch Chicago River Watershed Workgroup. Geosyntec Consultants, Inc. January 2021.

Illinois EPA. 2020/2022. *Illinois Integrated Water Quality Report and Section 303(d) List, 2020/2022. Clean Water Act Sections 303(d), 305(b) and 314. Water Resource Assessment Information and List of Impaired Waters*. Illinois Environmental Protection Agency. June.

Illinois EPA. 2024. *Illinois Integrated Water Quality Report and Section 303(d) List, 2024 Draft. Clean Water Act Sections 303(d), 305(b), and 314. Water Resource Assessment Information and List of Impaired Waters*. Illinois Environmental Protection Agency. June 2024.

Illinois EPA. 2025. "River and Streams." Illinois Environmental Protection Agency. https://epa.illinois.gov/topics/water-quality/monitoring/river-and-stream.html#sw4

Lusk, Mary G., Eban Z. Bean, Basil V. Iannone, and Alexander J. Reisinger. 2025. Stormwater ponds: Unaccounted environmental challenges of a widely-adopted best management practice. Journal of Environmental Management, February 2025.

Minnesota Stormwater Steering Committee. 2022. *Minnesota Stormwater Manual*. Minnesota Stormwater Steering Committee. https://www.pca.state.mn.us/business-with-us/minnesota-stormwater-manual.

NBWW. 2019. *Quality Assurance Project Plan: Water Quality and Sediment Chemistry, and Bioassessment Monitoring of the North Branch Chicago River Watershed*. Prepared by Midwest Biodiversity Institute.

NBWW. 2025. "Members." North Branch Chicago River Watershed Workgroup. https://www.nbwwil.org/about-us/members.

Rossman, L.A., and M.A. Simon. 2022. *Storm Water Management Model User's Manual*. Version 5.2. EPA/600/R-22/030. United States Environmental Protection Agency, Center for Environmental Solutions and Emergency Response, Office of Research and Development, Cincinnati, OH. Revised February 2022.

Royer, Todd V., Mark B. David, Lowell E. Gentry, Corey A. Mitchell, Karen M. Starks, Thomas Heatherly II, and Matt R. Whiles. 2008 Assessment of Chlorophyll-a as a Criterion for Establishing Nutrient Standards in the Streams and Rivers of Illinois." *Journal of Environmental Quality*

SMC. 2021. *North Branch Chicago River Watershed-Based Plan* 2021. Lake County Stormwater Management Commission. December 2021.

Appendix A: NBWW NARP Watershed Model Report

NORTH BRANCH CHICAGO RIVER

NUTRIENT ASSESSMENT REDUCTION PLAN: WATERSHED MODEL

Prepared for

North Branch Chicago River Watershed Workgroup (NBWW)
500 W Winchester Road, Suite 201
Libertyville, IL 60048

Prepared by

Geosyntec Consultants, Inc.
1420 Kensington Road, Suite 103
Oak Brook, IL 60523

Project Number: MOW5618

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ACRONYMS AND ABBREVIATIONS

ASCE	American Society of Civil Engineers
CMAP	Chicago Metropolitan Agency for Planning
DEM	digital elevation model
EMC	event mean concentration
EPA	Environmental Protection Agency
ET	evapotranspiration
GIS	geographic information system
HSG	hydrologic soil group
IEPA	Illinois Environmental Protection Agency
IGDC	Illinois Geospatial Data Clearinghouse
ISWS	Illinois State Water Survey
MWRD	Metropolitan Water Reclamation District of Greater Chicago
NARP	Nutrient Assessment Reduction Plan
NBWW	North Branch Chicago River Watershed Workgroup
NCEI	National Center for Environmental Information
NLCD	National Land Cover Database
NSE	Nash-Sutcliffe model efficiency coefficient
PBIAS	percent bias
RSR	root squared residual
SMC	Lake County Stormwater Management Commission
SSURGO	Soil Survey Geographic Database
SWMM	Storm Water Management Model
TP	total phosphorus
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WHAT	Purdue Web-based Hydrograph Analysis Tool
WWTP	wastewater treatment plant

1. INTRODUCTION

The Nutrient Assessment Reduction Plan (NARP) for the North Branch Chicago River Watershed will address phosphorus-related impairments in the river by identifying phosphorus load reductions from point and nonpoint source discharges, among other necessary measures. Models can define the linkage between the phosphorus loading and other factors (dams, lack of shading, etc.) in the watershed and the related impairments, such as dissolved oxygen and nuisance algae in the river. Models can also be used to assess the effectiveness of different watershed management scenarios in removing or reducing impairments. This information informs project prioritization for the NARP implementation.

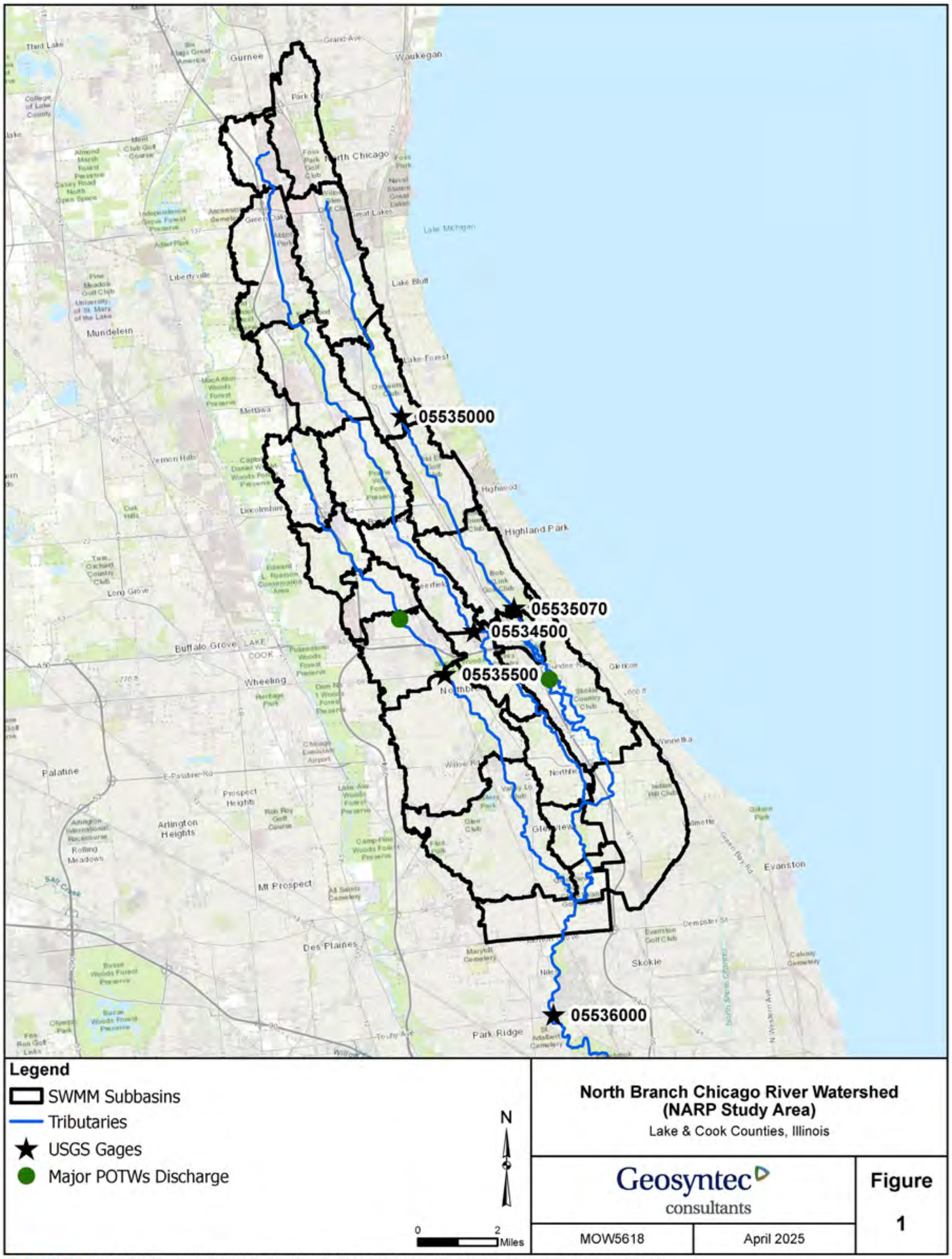
This report details efforts by Geosyntec to develop and calibrate a watershed model of the Skokie River, West Fork of the North Branch Chicago River, and the North Branch Chicago River downstream of the confluence of the Skokie River and the Middle Fork of the North Branch Chicago River. These efforts included data acquisition and processing, watershed delineation, calibration and validation of the model. Flow and nutrient loading output from the watershed model is used as inputs to an instream water quality model of the respective river sections to examine the impacts of different management scenarios on water quality. The development and calibration of the instream model will be documented in Appendix B of the NARP report.

1.1 Study Area

The North Branch Chicago River originates as far north as Gurnee, Illinois, and drains an area of 94 square miles through Lake and Cook Counties in northeastern Illinois (**Figure 1**). The river joins the North Shore Channel near Foster Avenue in Chicago, Illinois, and then flows south through Chicago before converging with the South Branch Chicago River.

The study area for the NARP focuses on the entire 94 square mile watershed tributary to the North Branch Chicago River. The North Branch Chicago River Watershed is made up of three tributaries: West Fork, Middle Fork, and Skokie River. The West Fork is approximately 14 miles long prior to the confluence with the North Branch Chicago River in Morton Grove, IL. The Middle Fork is approximately 24 miles long prior to the confluence with the North Branch Chicago River. The Skokie River is approximately 17 miles long prior to the confluence with the Middle Fork. The NARP study area terminates at the intersection of Dempster Street with the North Branch Chicago River in Morton Grove (Figure 1).

Land use in the study area is predominantly residential (49%) and conservation/recreation open space (19%). The remaining area comprises commercial, institutional, industrial and vacant lots (Lake County Stormwater Management Commission, 2008). The watershed is 35% impervious.



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2. MODEL DEVELOPMENT

2.1 Modeling Framework

A linked numerical modeling framework was developed for the NARP, as recommended in the North Branch Chicago River Watershed Workgroup (NBWW) NARP Workplan (Geosyntec 2021). The linked modeling framework consists of two components: a watershed model and an instream model with hydraulic and water quality components. The results from the watershed model, including flow and nutrient concentration from the tributary areas to the North Branch Chicago River reaches, will be used as input to the instream model.

The Stormwater Management Model (SWMM) was used as the modeling framework for the watershed model in accordance with the NARP Workplan. The SWMM model is a river basin-scale model that is currently hosted and supported by the U.S. Environmental Protection Agency (EPA).

SWMM can be used to determine the long-term impact of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds with varying soils, land uses, and management conditions. Since its creation from several predecessor models in the early 1970s, SWMM has undergone regular updates and several major improvements. It is a valuable modeling tool for combined and mixed urban systems with the ability to model simultaneous runoff with hydraulics suitable for watershed such as the NBWW NARP study area. For this study, SWMM version 5.2.3 was used. This version was released in March 2023. ArcGIS 10.4 was used for GIS data processing and watershed delineation.

2.2 Data Acquisition and Processing

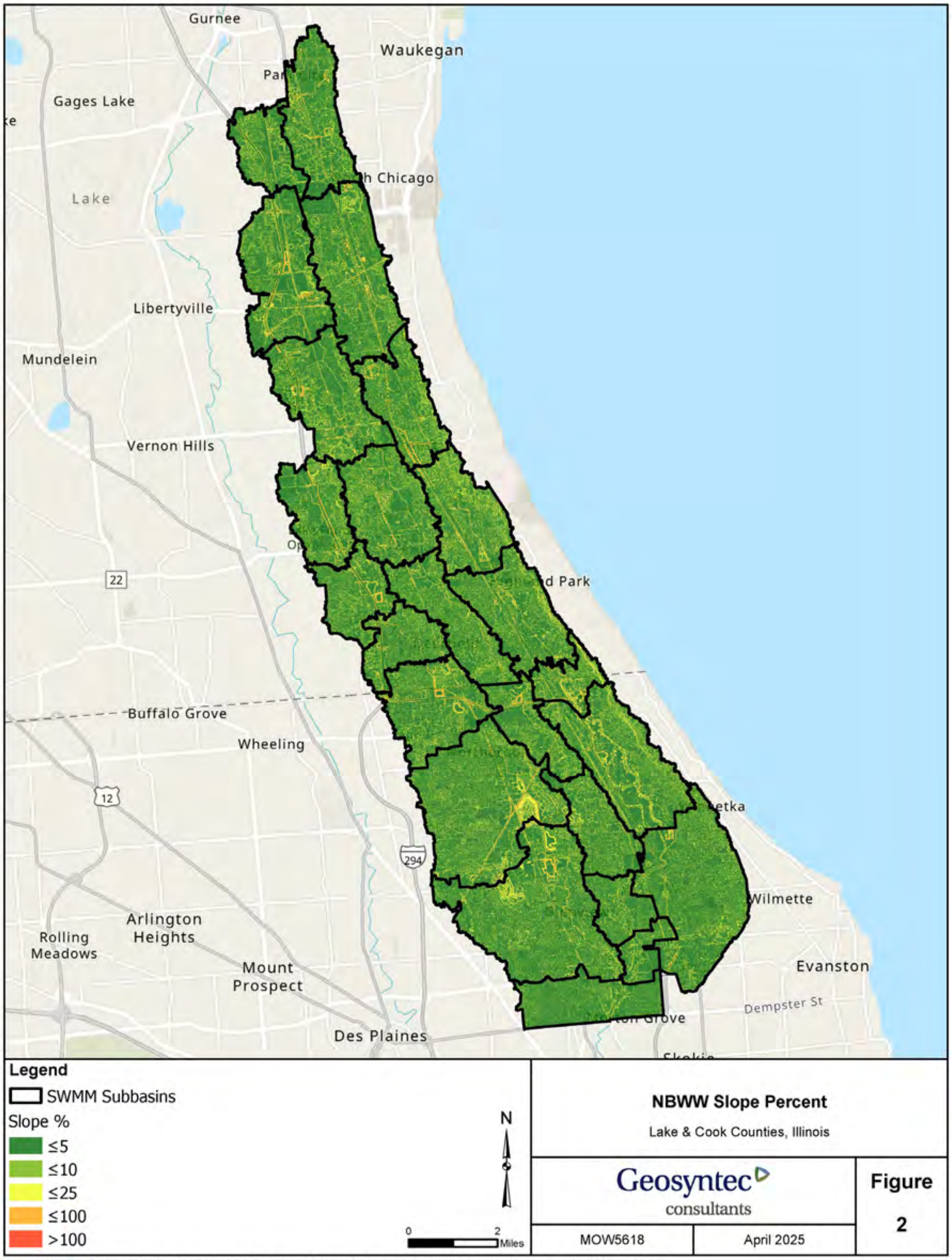
SWMM requires a range of geophysical and anthropological data to drive model simulation and model calibration. Table 1 lists the data acquired and processed for the development of the SWMM model, including descriptions of the properties of these datasets and their applications in the model.

Table 1 Datasets Used for Building and Calibrating the SWMM Model

Type	Dataset	Origination	Version/Coverage	Purpose
Elevation	Light Detection and Ranging (LiDAR)-based 3ft resolution digital elevation model (DEM)	Illinois Height Modernization: LiDAR Data (IGDC)	2017	Watershed and sub-basin delineation Slope derivation

Type	Dataset	Origination	Version/Coverage	Purpose
Soils	Soil Survey Geographic Database (SSURGO)	United States Department of Agriculture Natural Resource Conservation Service (USDA)	2022	Extraction of soil properties, including hydrologic soils group and infiltration parameters
Land use	Parcel-based polygon land use coverage	Chicago Metropolitan Agency for Planning (CMAP)	2018	Model land use mapping and definition
Imperviousness	National Land Cover Database (NLCD) Percent Developed Imperviousness	Multi-Resolution Land Characteristics Consortium (MRLC)	2019	Imperviousness value for subbasins
Stream Characteristics	SMC Stream Inventory	Lake County Stormwater Management Commissions (SMC)	2019	Length, slope, bathymetry and roughness of stream reaches.
Stream Baseflow	Web-based Hydrograph Analysis Tool (WHAT) Output from selected USGS stations	Purdue Engineering	Daily, 1/1/2012-12/31/2022	Extract baseflow from daily streamflow measurements
Skokie Lagoon	H&H Model from North Branch Chicago River Detailed Watershed Plan	Metropolitan Water Reclamation District of Greater Chicago (MWRD)	2011	Stage-storage-discharge relationship
Meteorological data	Hourly Precipitation Monthly Evapotranspiration	United States Geological Survey (USGS); SMC; National Center for Environmental Information (NCEI) ISWS	1/1/2012–12/31/2022 Monthly Average	Meteorological inputs

Type	Dataset	Origination	Version/Coverage	Purpose
Stream flow	Daily average stream flows	4 USGS stations	Daily, 1/1/2012-12/31/2022	Model hydrology calibration and validation
Nutrient concentrations	Land-use-specific event mean total phosphorus (TP) concentration; Baseflow TP concentration	North Branch Chicago River Watershed Workgroup (NBWW); Geosyntec	Discrete sampling results collected from the model waterways, 2011-2023	Model water quality input



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2.3 Model Extent and Watershed Delineation

The watershed area used in the SWMM model includes the West Fork, Middle Fork the Skokie River and the portion of the North Branch Chicago River starting at the confluence with the Skokie River extending downstream to intersection with Dempster Street in Cook County (model watershed). The model watershed as described is coincident with the NBWW NARP study area (Figure 1).

SWMM is a semi-distributed model meaning it considers the spatial variability of phenomena acting on a watershed as opposed to more global models such as physical-based conceptual models or empirical models. The watershed within SWMM is broken down into catchments. It is critical to have enough catchments in the model to accurately represent different types of soil and land use, precipitation conditions, flow and material travel distances, and other location-sensitive processes taking place in the watershed.

The purpose of the watershed model is to estimate the volume of water and nutrient loading from the upland area discharging into the waterways in the model watershed. However, because no calibration data for flow or water quality is available in the upland watershed, the SWMM model is extended to include the waterways. The model waterways include Middle and West Fork North Branch Chicago River, the Skokie River and the portion of the North Branch Chicago River.

Delineation of the model watershed and its catchments was a key step in the SWMM model setup. The modeled watershed was delineated into 23 subwatersheds along the model watershed to represent spatial variability in rainfall, imperviousness, and other hydrologic parameters across the modeled watershed. Each subwatershed then was divided into subcatchments based on major land use groups, including transportation, residential, open space, industrial, commercial, agricultural and water to incorporate variability in runoff water quality among the different land uses.

2.4 Defining Model Parameters

2.4.1 Hydrology and Hydraulics

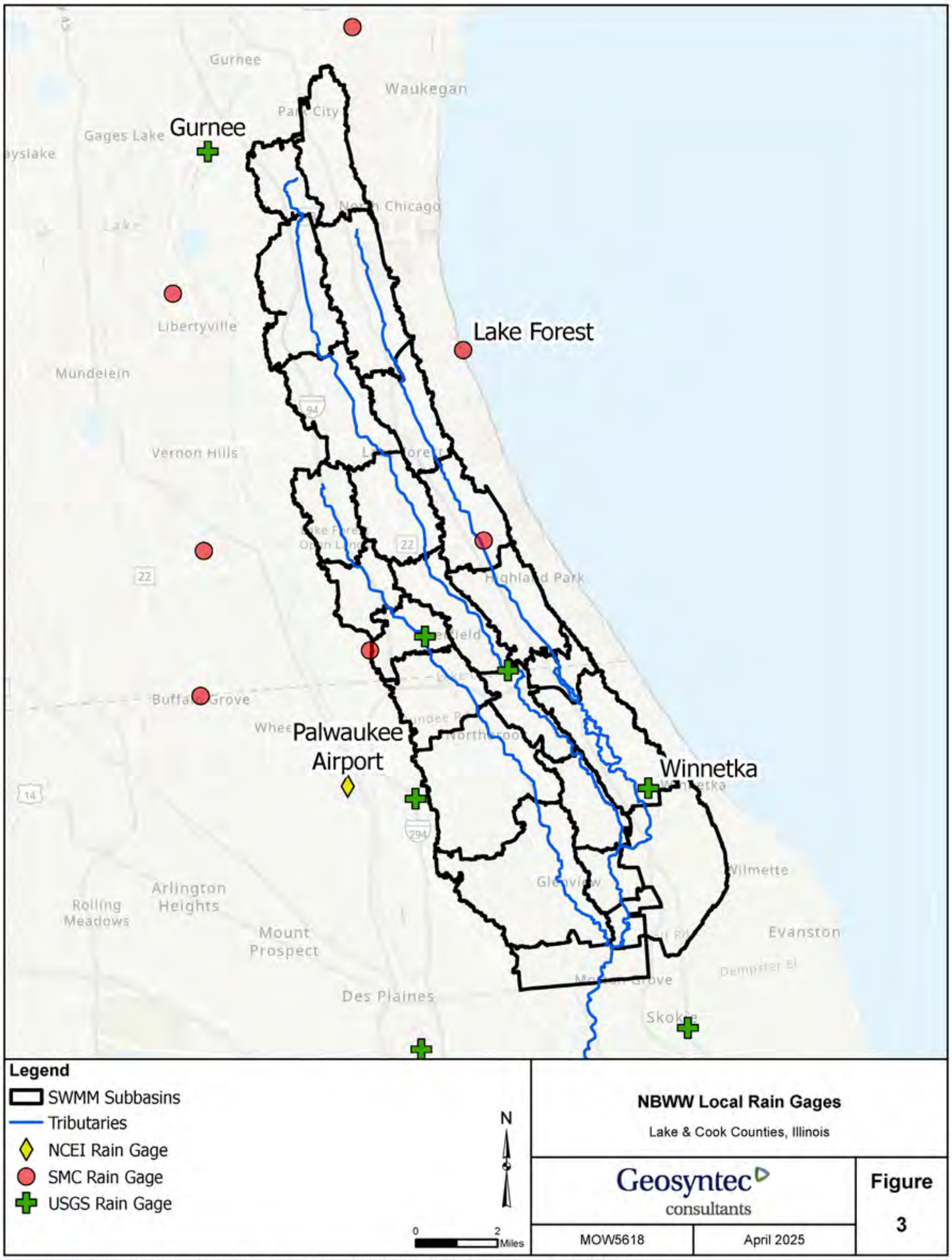
The hydrologic process in SWMM uses precipitation input in each subcatchment, in combination with the characteristics of the subcatchment (slope, roughness, infiltration, imperviousness etc.), to estimate runoff from both the impervious and pervious portions of a subcatchment during rainfall events. The runoff is subsequently routed to a network of streams representing the waterways in the modeled watershed. SWMM uses the flow volume from the subcatchments and the hydraulic characteristics of the channels to determine the flow depth and velocity in the modeled streams. During periods without precipitation (dry weather), baseflow in the stream was modeled as direct inflow time series and evapotranspiration (ET) process is also included in the model using monthly varying potential ET values. In addition, Skokie Lagoon was modeled explicitly as a storage unit in the model. The hydrologic and hydraulic inputs in the SWMM model are detailed in the following section.

2.4.1.1 Rainfall Analysis

To conduct long-term continuous simulation in SWMM, accurate and localized rainfall records are the most important model input. Rainfall records from 15 rain gages managed by 1) Lake County Stormwater Management Commission (SMC) 2) National Center for Environmental Information (NCEI), and 3) United Stated Geological Survey (USGS) within 2 miles from the boundary of the model watershed were processed and used as precipitation input. These hourly rainfall records were analyzed for completeness during the period of record from calendar year 2012 to 2022 and outlier values. Gage records with large data gaps (longer than 1 year) were eliminated and smaller data gaps for the remaining gages were filled using records from an adjacent gage with complete data. As a result, hourly rainfall records from the following four stations were assigned to subwatersheds in the SWMM model based on proximity. As shown in Table 2, approximately 33 inches of annual average precipitation was recorded at the four gages used in the SWMM model, which is consistent with the typical annual precipitation of 25 to 45 inches in Northeast Illinois (Illinois State Water Survey, 2023).

Table 2 Annual Average Precipitation Records used in the SWMM Model

Rain Gage	Data Source	Annual Average Total Precipitation from 2012 to 2022, inches
Gurnee Station	USGS	33.7
Lake Forest Station	SMC	32.2
Palwaukee Airport Station	NCEI	33.2
Winnetka Station	USGS	33.3



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2.4.1.2 Subcatchment Parameterization

The Chicago Metropolitan Agency for Planning (CMAP) Land Use Inventory for 2018 was used in the watershed model. The 56 land use classes in the CMAP land use dataset were aggregated into seven land use categories for modeling based on professional judgment.

Subcatchment input for imperviousness was derived from the 2016 National Land Cover Dataset (NLCD) Percent Developed Imperviousness layer. This raster data has a resolution of 30 m by 30 m and covers the entirety of the model's spatial extent. The resulting impervious percent of the entire model watershed is approximately 35 percent which is slightly more than 30 percent estimation in the Watershed-Based Plan in 2008 *(Lake County Stormwater Management Commission, 2008)*.

Topographic data is required to compute the average slopes and elevation for each subwatershed within the model domain. Both average elevation and slope was calculated from the digital elevation model data in ArcGIS for each subwatershed.

Green-Ampt infiltration parameters were derived from the Soil Survey Geographic Database (SSURGO). SSURGO data covering the model watershed were downloaded from the USDA Natural Resource Conservation Service's Web Soil Survey portal. The database also contains soil physical properties in tabular format for the mapped soil series. The soils in SSURGO are categorized into seven hydrologic soils groups (HSG) and "urban". Soils labeled as "urban" in SSURGO were considered HSG C/D (compacted soils) for the purpose of this modeling effort. The Green-Ampt Infiltration method was used in the SWMM model, which assumes that a sharp wetting front exists in the soil column, separating soil with some initial moisture content below from the saturated soil above. During dry periods, the recovery rate of the moisture deficit is empirically related to the hydraulic conductivity of the soil (US EPA, 2015). The associated parameters were assigned to each of the seven hydrologic soil groups (HSGs). The capillary suction and initial moisture deficit values for the HSGs were obtained from the Handbook of Hydrology (ASCE, 1996), and the average hydraulic conductivity values for each HSG in the model extent were extracted from SSURGO as shown in Table 3.

Table 3 Soil Property Input for the SWMM Model

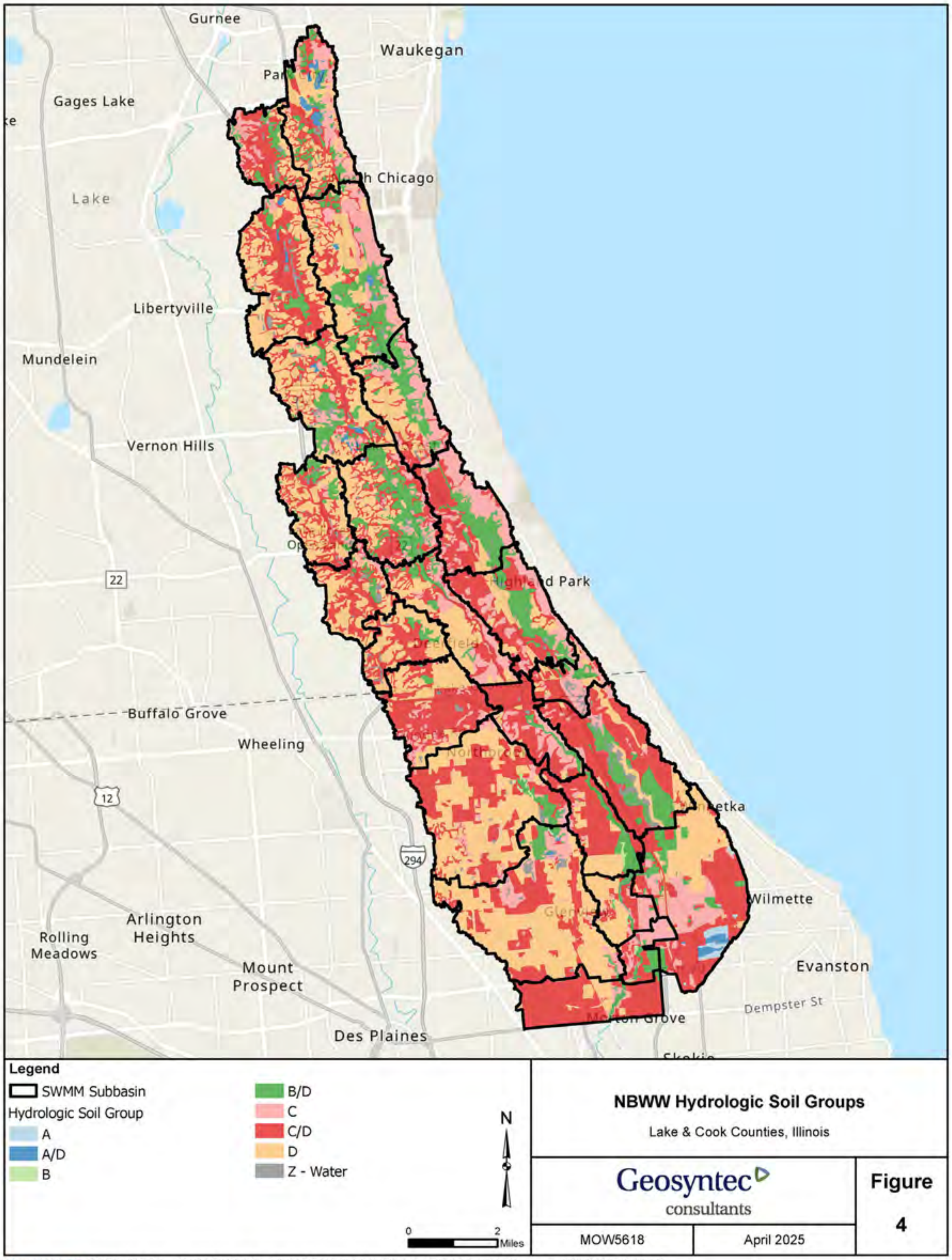
HSG	Capillary Suction, inches	Saturated Hydraulic Conductivity, inches per hour	Initial Moisture Deficit
A	1.95	13.00	0.346
A/D	2.41	3.48	0.312
B	4.33	1.30	0.246
B/D	4.33	1.04	0.246
C	6.57	0.33	0.171

C/D	6.57	0.94	0.171
D	8.22	0.07	0.146

Other subcatchment parameters including surface roughness, depression storage and flow path width were assigned universally to the subcatchments based on typical values and professional judgement as shown on Table 4. These parameters are among the least sensitive catchment parameters and can be adjusted during the calibration process.

Table 4 Subcatchment Parameter Values

Parameter	**Values for Impervious Catchments**	**Values for Pervious Catchments**
Flow Path Width	500 feet	
Manning's n	0.01	0.1
Depression Storage	0.01	0.01


Gurnee
Waukegan
Gages Lake
Lake
Libertyville
Mundelein
Vernon Hills
Highland Park
Buffalo Grove
Wheeling
Arlington Heights
Rolling Meadows
Mount Prospect
Des Plaines
Wilmette
Evanston
Dempster St
Legend
SWMM Subbasin
Hydrologic Soil Group
A
A/D
B
B/D
C
C/D
D
Z - Water
N
0
2
Miles
NBWW Hydrologic Soil Groups
Lake & Cook Counties, Illinois
Geosyntec
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2.4.1.3 Channel Parameterization

Data inputs representing the modeled waterways, including length, cross-section geometry, bank stations and roughness, was extracted primarily from the SMC Stream Inventory dataset (2019) and supplemented with H&H model data from the North Branch Chicago River Detailed Watershed Plan (MWRD, 2011). For each link in the SWMM model, three to five cross-sections from the aforementioned datasets were simplified into one cross section. The manning's roughness coefficients for stream and overbank areas were selected based on typical values in the H&H model data. The length of the stream and conduits were estimated from the National Hydrography Dataset layer.

2.4.1.4 Baseflow Estimate

Baseflow constitutes the portion of stream flow from seepage of groundwater and/or interflow into the surface watercourse. Baseflow for tributaries was estimated using the flow records from the USGS stream gages in the modeled watershed.

Three USGS stream gages located within the watersheds were selected for the baseflow analysis. The long-term (2012-2022) monthly average baseflow values were computed using Purdue University's Web-based Hydrograph Analysis Tool (WHAT) (Lim et al., 2005). The baseflow was subsequently correlated with the acreage of the tributary area to each USGS gage in a linear regression analysis. The analysis found that the long-term average baseflow correlates well with the total tributary area with a correlation coefficient of 0.98. As a result of this regression analysis, an area-based prorating factor of 0.0011 cfs per acre was applied to each subwatershed to estimate the baseflow magnitude.

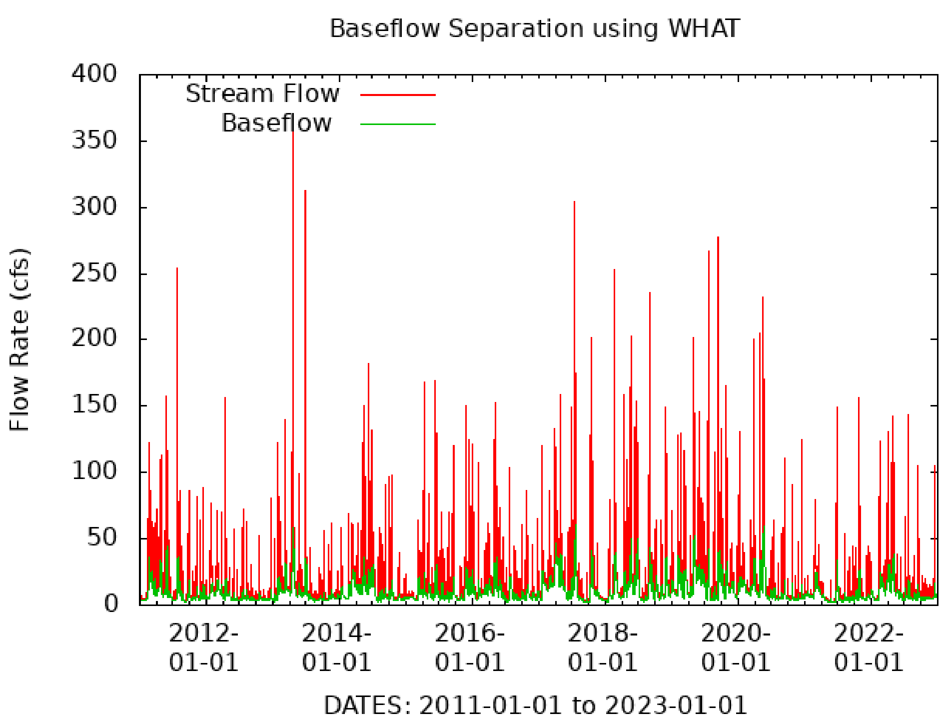


Figure 5: Purdue WHAT Baseflow Separation for West Fork

The baseflow varies throughout the year based on the groundwater table and weather pattern. Hence, a monthly varying pattern also was calculated and accounted for in the SWMM model baseflow input. The monthly varying factor, expressed as the ratio between the monthly average baseflow and the annual average baseflow, was calculated for all three gages included in this baseflow analysis.

2.4.1.5 Skokie Lagoons

Skokie Lagoons are modeled explicitly as a storage unit in the SWMM model. The stage-storage relationship was extracted from HEC-RAS model cross-section data provided by SMC. Inflow to the Skokie Lagoons were determined by the SWMM model combining the runoff and baseflow from the Skokie River watersheds upstream of the Lagoons. Outflow from the Skokie Lagoons was determined using a stage-discharge relationship extracted from the HEC-RAS model results. To obtain the stage-discharge relationship, the storage area in the HEC-RAS model was filled up to the maximum water surface elevation and the during the drawdown period, the depth and outflow results were extracted and used as input in the SWMM model. This simplified method to model the Lagoons ensures that the hydraulic characteristics of the Lagoons are accurately represented in the SWMM model without modeling the multiple compartments and outlets of the Lagoons individually.

2.4.2 Water Quality

The water quality component of the SWMM model was incorporated to simulate long-term pollutant concentration for total phosphorus (TP) from the modeled watersheds. The water quality simulation requires two types of input: baseflow TP concentration and runoff TP concentration. During dry weather, the TP concentration stays at the baseflow TP level; During rainfall events, the volume of runoff carrying different TP loading mixes with the baseflow and results in varying TP concentration in the modeled streams.

Baseflow (dry weather) TP concentration is estimated using monitoring data and applied to all of the subwatersheds in the model. Two options are available in SWMM to simulate water quality from stormwater runoff in a watershed: the buildup washoff method and the event mean concentration (EMC) method. The EMC method was chosen for this project because no monitoring data is available for characterizing the buildup and washoff rates.

Instream measurements of TP collected by NBWW and Geosyntec were utilized in determining the TP concentration input in the watershed model. The baseflow TP concentrations were calculated from the geometric mean dry-day concentration from samples collected at water quality stations upstream of water reclamation facilities in the model watershed. Dry days are defined as less than 25% of the stream flow consists of direct runoff based on the results from the baseflow analysis detailed in Section 2.4.1.4. Typical runoff EMC TP values from the Minnesota Stormwater Manual were used as inputs to the watershed model as shown in Table 5.

Table 5 Base Conditions Phosphorus Reference Levels

Total Phosphorus Input	Value,	Range, mg/l	Data Source

		mg/l		
Baseflow Concentration		0.11	N/A	Dry-weather monitoring data at water quality monitoring stations in the model watersheds
Runoff EMCs	Agriculture	0.53	0.13-1.35	Minnesota Stormwater Manual (MSSC, 2022)
	Commercial	0.2	0.20-0.34	
	Industrial	0.24	0.23-0.55	
	Open Space	0.19	0.12-0.31	
	Residential	0.29	0.18-0.40	
	Transportation	0.28	0.25-0.45	
	Water	0	0	

3. MODEL CALIBRATION AND VALIDATION

The SWMM model is a complex set of calculations that use both measured meteorological inputs (temperature, wind speed, precipitation, solar radiation, relative humidity) and model coefficients as variables. Hydrologic models use empirical relationships as a compromise to generate output with commonly available resources. As empirical relationships are specific to the time, place, and the conditions of the data upon which they were formulated, the coefficients they use need to be calibrated. The general premise of model calibration is to use measured data (flow rates and nutrient concentrations) and modify model coefficients to maximize agreement between the model output and measured data. This agreement is otherwise known as "goodness-of-fit." In essence, calibration is an optimization problem, with goodness-of-fit being the optimization goal.

For model validation, the model results are compared with the measured data for a different period without changing the parameters. This helps ensure that the model can handle different model inputs than were used during the model calibration period.

3.1 Hydrology Calibration and Validation Process

The SWMM program was used to run a simulation for the period of calendar year 2012 – 2021 (calibration period of record). Several calibration metrics were calculated from the model output to compare how closely the model output matches the measured flow data. A set of selected model input parameters were adjusted based on findings from each iteration of the model outputs until all of the calibration targets are met. An additional year of simulation was conducted for calendar year 2022 and used as a validation period. The same metrics used to calibrate the model were calculated for the validation period. The detailed calibration and validation processes are described in the following subsections.

3.1.1 Calibration Data

Measured data from five USGS stream gages were utilized for calibration. The gages are listed in Table 6, and their locations are shown in Figure 1. The model input parameters were adjusted to match measured flows at the calibration points.

The simulated and measured flow data at each station were compared for the following three calibration metrics:

- **Annual Average Flow Volume during the Growing Season (PBIAS)**: calibration target for this metric is less than 15 percent difference between simulated and measured annual average flow volume;
- **Monthly Root-Mean-Square-Error to Standard Deviation Ratio (Monthly RSR)**: calibration target for this metric monthly RSR is smaller than 0.70;
- **Monthly Nash-Sutcliffe Model Efficiency Coefficient (Monthly NSE)**: calibration target for this metric monthly NSE is greater than 0.50;

PBIAS is a metric that shows the overall accuracy of the hydrologic model in predicting the quantity of flow at each calibration station; Monthly RSR shows the accuracy of the model in predicting the seasonal variation in stream flow magnitude; Monthly NSE indicates how well the plot of observed and simulated monthly flow data fits a 1:1 line. The watershed model was calibrated for hydrology (flow) using the data for the period of calendar year 2012 to 2021.

Table 6: Calibration Subwatersheds and Associated USGS Stations

Subwatershed	USGS Station Name	Station ID
West Fork	West Fork at Northbrook, IL	USGS 05535500
Middle Fork	Middle Fork at Deerfield, IL	USGS 05534500
Skokie River	Skokie River at Highland Park, IL	USGS 05535070
Skokie River	Skokie River at Lake Forest, IL	USGS 05535000
North Branch Chicago River	North Branch Chicago River at Nile, IL	USGS 05536000

3.1.2 Calibration Methods

The calibration effort is an iterative process between adjusting the model parameters within reasonable ranges obtained from literature reviews and assessing model performance based on the foregoing calibration metrics. The following model parameters were adjusted for this process:

1) **Subcatchment Imperviousness**: urban compaction introduces uncertainty in this subcatchment parameter that directly impacts the quantity of runoff from subcatchments. During the calibration process, this parameter is adjusted within 10 percent of the original imperviousness assigned to the catchment.
2) **Subcatchment Depression Storage**: distributed detention features in the watershed, which are not explicitly modeled, introduces uncertainty in this parameter which affects the model's response to small storm events. During the calibration process, this parameter is adjusted between 0 to 1 inch.
3) **Soil Infiltration:** similar to imperviousness, inaccuracy in soils infiltration parameters introduces uncertainty in this subcatchment parameter that directly impacts the quantity of runoff from subcatchments. During the calibration process, the saturated hydraulic conductivity (infiltration rate) is adjusted within 50 to 200 percent of the original values assigned to each HSG.
4) **Baseflow:** detention features, shallow groundwater interflow and other factors that were not explicitly modeled in the SWMM simulation introduce uncertainty in the baseflow input which directly affects the model's accuracy in dry-weather flow prediction. During the calibration process, baseflow is adjusted within 50 percent of the original values.

These four parameters were adjusted universally during the calibration process, meaning they were increased or decreased for all subcatchments or all timesteps at a time.

Table 7: Hydrologic Parameter Ranges for SWMM

Variable	Unit	Default	Minimum	Maximum
Subcatchment Imperviousness	Ratio: Calibration/Default	1	0.9	1.1
Subcatchment Impervious Depression Storage	Inches	0.05	0	1
Subcatchment Pervious Depression Storage	Inches	0.05	0	1
Soil Saturated Hydraulic Conductivity	Ratio: Calibration/Default	1	0.5	2
Baseflow	Ratio: Calibration/Default	1	0.5	1.5

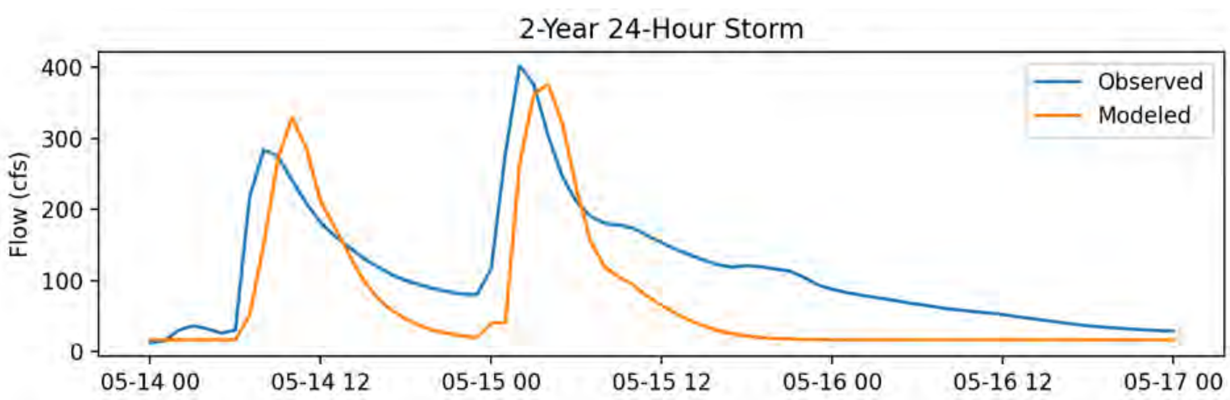


Figure 6: SWMM Calibration Plot Example

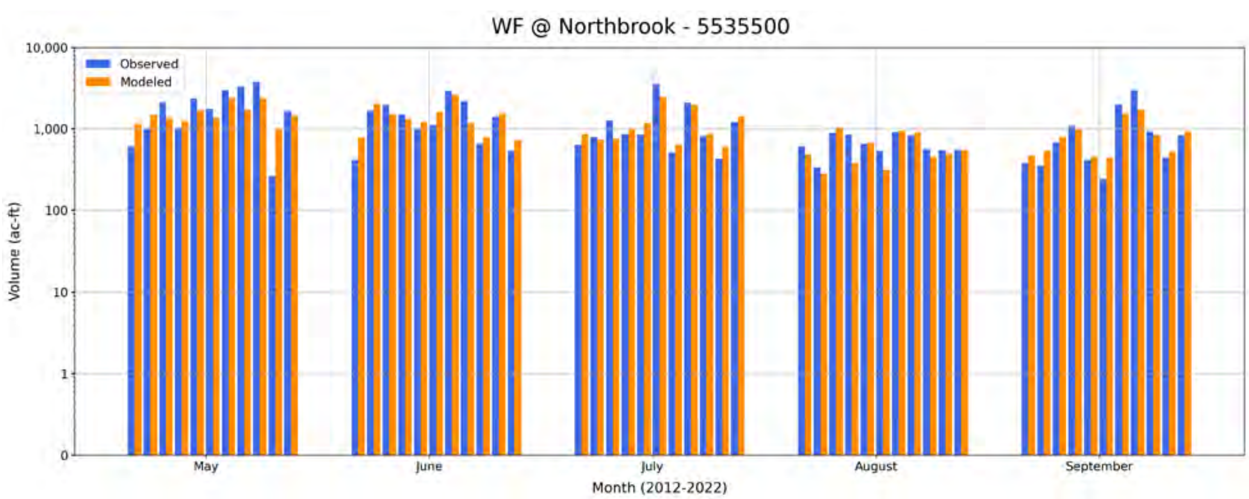


Figure 7: SWMM Monthly Volume Comparison

3.2 Hydrology Model Calibration and Validation Results

The final calibrated values of model parameters for the SWMM model are listed in Table 8. During the calibration process, the subcatchment imperviousness was increased by 10% to better match the model flow volume to the measured flow, resulting in imperviousness percentage of 38% for the entire watershed. Depression storage for both impervious and pervious areas were increased to represent the detention features (lakes, ponds, large pipe storage etc.) which were not explicitly modeled. Soil hydraulic conductivity was decreased to better match the model flow volume to the measured data and the baseflow was decreased by 25% to better match the flow volume during dry periods.

Table 8 Final Calibrated Parameter Values

Variable	Unit	Default	Calibration Result
Subcatchment Imperviousness	Ratio: Calibration/Default	1	1.1
Subcatchment Impervious Depression Storage	Inches	0.05	0.5
Subcatchment Pervious Depression Storage	Inches	0.05	0.1
Soil Saturated Hydraulic Conductivity	Ratio: Calibration/Default	1	0.5
Baseflow	Ratio: Calibration/Default	1	0.75

The calibration results are shown in Table 9, calculated from the model results from 2012 to 2021. Based on the metrics defined in Section 3.1, good to very good results were achieved to match the model and measured annual average flow and satisfactory to good calibration results were achieved for the monthly RSR and NSE. In summary, all of the calibration targets for the SWMM model were achieved by tuning the model parameters within a reasonable range.

Table 9: Calibration Results (Calendar Year 2012 – 2021)

	Annual Average Total Volume Percent Error		Monthly RSR		Monthly NSE	
West Fork at Northbrook, IL	-12.8%	Good	0.63	Satisfactory	0.59	Satisfactory
Middle Fork at Deerfield, IL	-7.5%	Very Good	0.68	Satisfactory	0.53	Satisfactory
Skokie River at Highland Park, IL	-6.2%	Very Good	0.61	Satisfactory	0.62	Satisfactory

Skokie River at Lake Forest, IL	10.8%	Good	0.58	Good	0.66	Good
North Branch Chicago River at Nile, IL	-13.8%	Good	0.68	Satisfactory	0.54	Satisfactory

The validation results were shown in Table 10, calculated from the model output for the validation period of record (calendar year 2022). Based on the metrics defined in Section 3.1. As shown in Table 10, the values for the calibration metrics were very similar for the validation period of record when compared to the calibration period. This validation result shows that the calibration process yielded robust parameter inputs which can be used to accurately predict the magnitude and timing of flow in the model waterways.

Table 10: Validation Results (Calendar Year 2022)

	Total Volume Percent Error		**Monthly RSR**		**Monthly NSE**	
West Fork at Northbrook, IL	-6.8%	Very Good	0.47	Satisfactory	0.74	Good
Middle Fork at Deerfield, IL	0.3%	Very Good	0.57	Good	0.62	Satisfactory
Skokie River at Highland Park, IL	-10.8%	Good	0.67	Satisfactory	0.48	Satisfactory
Skokie River at Lake Forest, IL	5.9%	Very Good	0.55	Good	0.65	Satisfactory
North Branch Chicago River at Nile, IL	-11.2%	Good	0.67	Satisfactory	0.48	Satisfactory

4. SUMMARY

The EPA Stormwater Management Model (SWMM) was used to develop the watershed model from the NBWW NARP, helping to develop the necessary hydrology to simulate loading to the West Fork of the North Branch, the Skokie River and the North Branch Chicago River within the NARP study area. Flows and water quality data were calibrated to available records and collected field data. The information calculated from the SWMM model is to be used to support the development of the NARP WASP water quality model in helping assess the baseline water quality of the streams and simulate alternative watershed approaches to addressing phosphorus-based water quality impairments.

5. REFERENCES

ASCE. 1996. *Handbook of Hydrology*. American Society of Civil Engineers.

CMAP. 2018. *Land Use Inventory Dataset.* Chicago Metropolitan Agency for Planning. https://www.cmap.illinois.gov/data/land-use/inventory.

Geosyntec. 2021. *North Branch Chicago River Watershed Workgroup NARP Workplan*. Geosyntec Consultants.

IGDC. 2017. *Illinois Height Modernization: Lidar Data*. Illinois Geospatial Data Clearinghouse. https://clearinghouse.isgs.illinois.edu/data/elevation/illinois-height-modernization-ilhmp.

ISWS. 2023. *Rainfall Trends in Northeast Illinois*. Illinois State Water Survey. University of Illinois at Urbana-Champaign: Prairie Research Institute.

Lim et al. 2005. *Web GIS-based Hydrograph Analysis Tool, WHAT*. JAWRA, 41(6): 1407-1416. https://engineering.purdue.edu/mapserve/WHAT/.

MRLC. 2016. *National Land Cover Dataset Percent Developed Imperviousness*. Multi-Resolution Land Characteristics Consortium. https://www.mrlc.gov/.

MSSC. 2022. *Minnesota Stormwater Manual*. Minnesota Stormwater Steering Committee. https://www.pca.state.mn.us/business-with-us/minnesota-stormwater-manual.

MWRD. 2011. *North Branch Chiago River Detailed Watershed Plan*. Chicago Metropolitan Water Reclamation District.

NCEI. 2023. *Global-Hourly Rainfall Dataset*. National Center for Environmental Information. 2012 – 2022. Prepared by the National Oceanic and Atmospheric Administration. https://www.ncei.noaa.gov/cdo-web/.

SMC. 2008. *North Branch Chicago River Watershed-Based Plan*. Lake County Stormwater Management Commision.

SMC. 2019. *Stream Inventory Dataset*. Lake County Stormwater Management Commision.

SMC. 2023. *Lake County Rain Gage Network Dataset*. Lake County Stormwater Management Commission. 2012 – 2022.

SSURGO. *Soil Survey Geographic Database*. United States Department of Agriculture: National Resources Conservation Service. https://websoilsurvey.nrcs.usda.gov/app/.

US EPA. 2015. *Storm Water Management Model User’s Manual Version 5.1*.

USGS. 2020. *National Hydrography Dataset High Resolution*. United States Geological Survey. HUC0404. Published March 27, 2020. https://www.sciencebase.gov/catalog/item/57645ff2e4b07657d19ba8e8.

USGS. 2023. *Sub-Hourly Rainfall Dataset*. United States Geological Survey. https://maps.waterdata.usgs.gov/mapper/index.html.

USGS. 2023. *Sub-Hourly Streamflow Dataset*. United States Geological Survey: National Water Information System. Gages: 05535500, 05534500, 05535070, 05536000. https://maps.waterdata.usgs.gov/mapper/index.html

Appendix B: NARP Model Development and Baseline Analysis

NORTH BRANCH CHICAGO RIVER WATERSHED WORKGROUP

Geosyntec consultants

NBWW NARP: Hydraulic Model Development and Baseline Analysis

August 14, 2024

Monitoring & Executive Committee Meeting

AGENDA

- Instream Water Quality Model Development
- Baseline and Management Scenarios Analysis
- What does it mean?

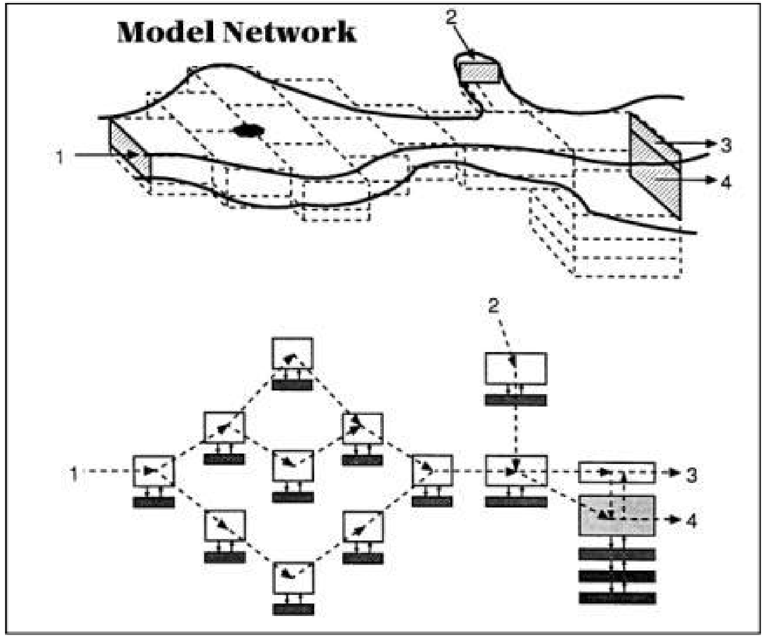
NORTH BRANCH CHICAGO RIVER WATERSHED WORKGROUP

Geosyntec consultants

NBWW NARP: Instream Model Development

Instream Model Development

- WASP
  - Water Quality Analysis Simulation Program (WASP)
  - US EPA Developed (Region IV)
  - Utilizing on several NARPs throughout the state
  - Popular water quality modeling tool
    - Pollutants, Nutrients, Multiple Algae, and Macro-Algae
    - Multiple Dimensions (1D, 2D, 3D)



WASP Model Domain & Segmentation

Total of 27 segments, segment geometries (length, width, slope, bathymetry etc.) derived from the HEC-RAS model

Skokie River (Clavey STP)

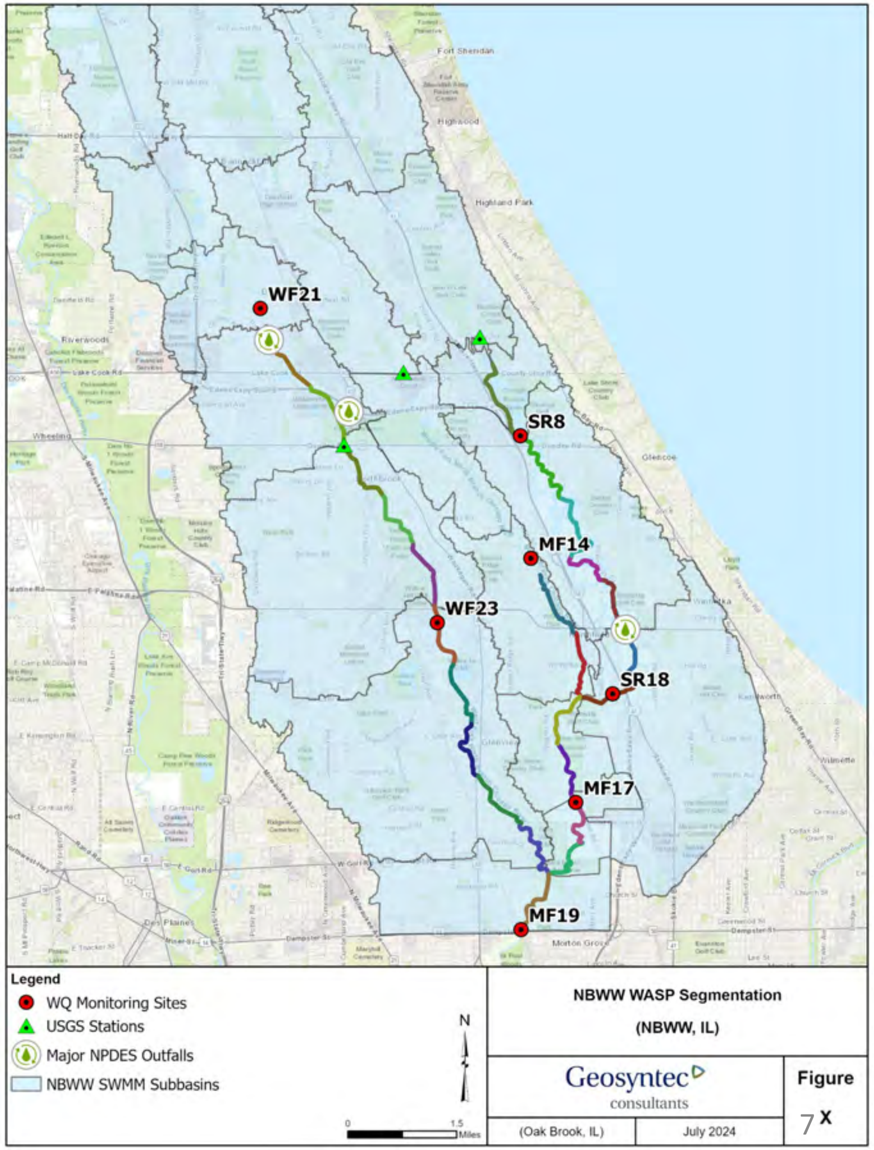
- 7 instream segments
  - Average segment length of 0.9 mi
  - Average segment width of 238 ft
- 3 weir segments
  - Average segment length of 164 ft
  - Average segment width of 69 ft

Middle Fork

- 7 instream segments
  - Average segment length of 0.95 mi
  - Average segment width of 56 ft

West Fork (Deerfield WRF)

- 10 instream segments
  - Average segment length of 0.95 mi
  - Average segment width of 56 ft

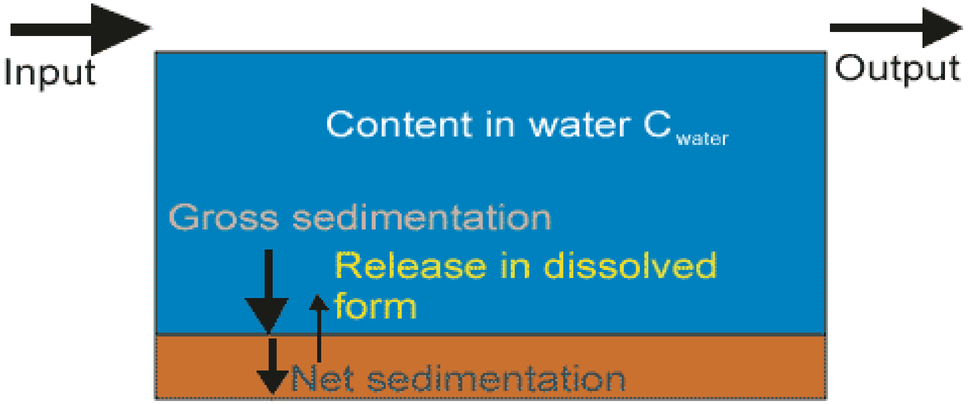


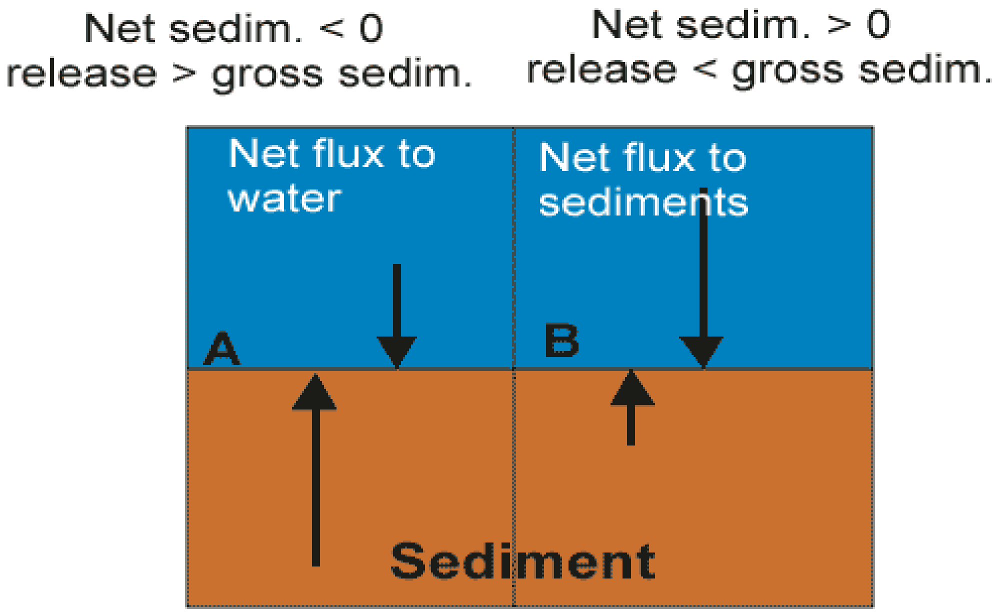
WASP Model Setup

- Calibration Period: 7/28/2022 – 10/5/2022
- Weather Data
  - U.S. Local Climatological Data (LCD) at Palwaukee Airport (dry bulb temp, dew point temp, wind speed etc.)
  - NASA Prediction of Worldwide Energy Resource (POWER) Database (solar radiation)
- Hydraulic Data
  - SWMM watershed runoff
  - STP effluent
- Water Quality Data
  - SWMM watershed runoff for N and P (partitioning based on measured data at MF14, SR8, and WF21)
  - WQ monitoring sites for other parameters

WASP Model Setup

- Sediment Flux
  - Sediment Oxygen Demand (SOD): initial values based on field measurements and were fine-tuned through calibration process.
  - Sediment Phosphorus Flux: a value of 35mg/m^2/day was imposed only in the Skokie Lagoon for the month of August. No P flux was imposed for other time periods. This setup is similar to the NBCR Watershed TMDL study where P flux had to be imposed in the lagoon during summer because the model was underpredicting P.





Preliminary Calibration Results Summary

- Hydraulics
  - The model captures the low flows well, which is important in addressing ROE.
  - SWMM inflows overpredict the high flows, but the overall inflow volume matches well
- Water Quality
  - TP: The model captures TP well in all tributaries. However, sediment P flux was implemented during model calibration. It is recommended to conduct sediment sampling in the lagoon to measure the actual P flux.
  - TN: The model captures TN well in the West Fork but overpredicts TN in Skokie (and Middle Fork after Skokie joins). This is likely due to high TN in the Clavey plant effluent (only one data point for the months of July, August and September, and model linearly interpolates between the data points)

Preliminary Calibration Results Summary

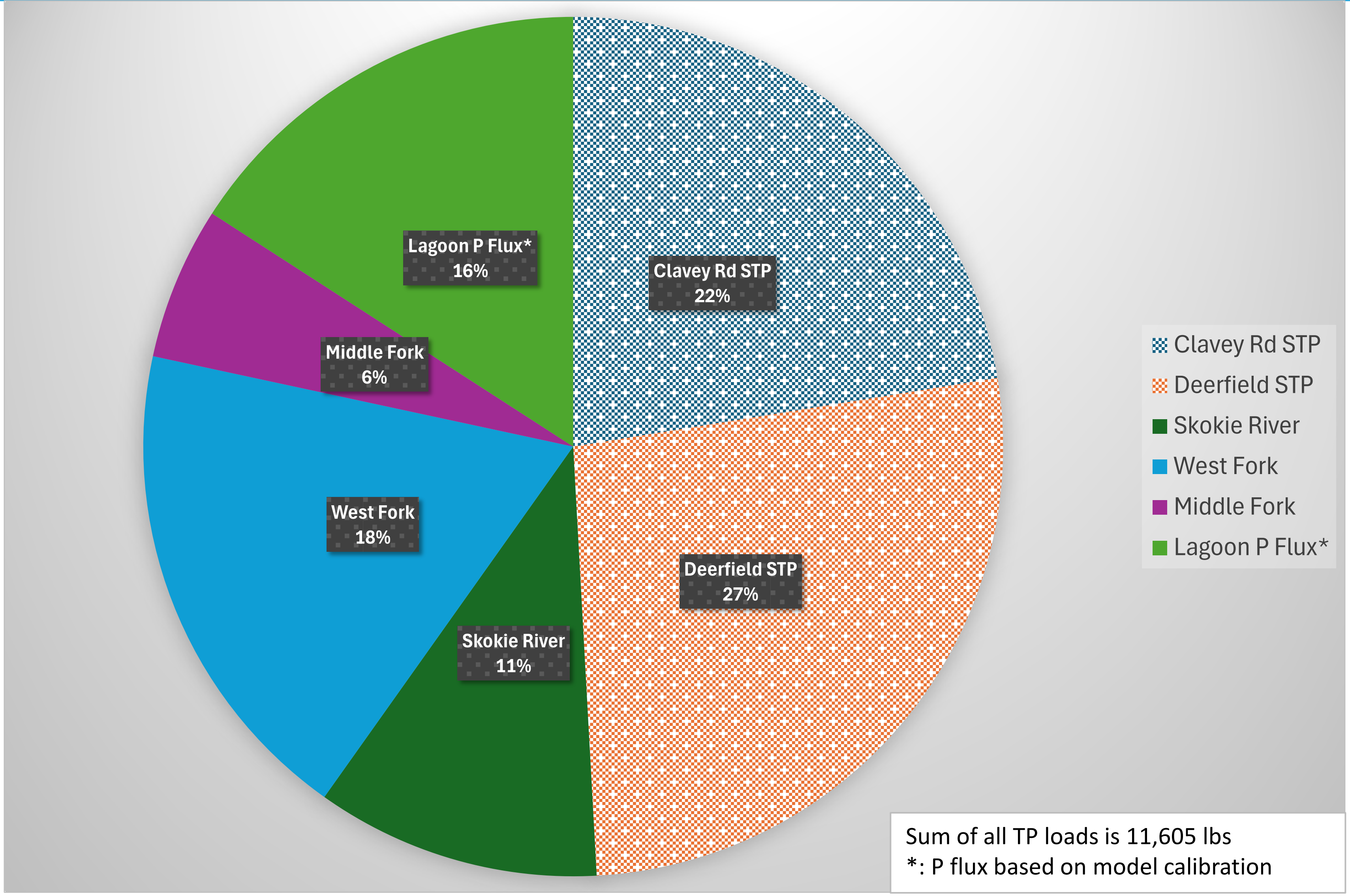
- Water Quality
  - CBOD: The model captures CBOD reasonably well, most of the measurements are below detection limit (4 mg/L).
  - Chl-*a*: In general, the model captures grab-sample measurements well, except for the lagoon where the trend is difficult to capture due to the complexity of the system and limitation of the model
  - DO: the model is doing okay at capturing DO trend but are underpredicting some diurnal fluctuations after September due to low inflow chl-a concentrations.

Management Scenarios

The calibrated 2022 model is selected to be the baseline scenario. Additional management scenarios include:

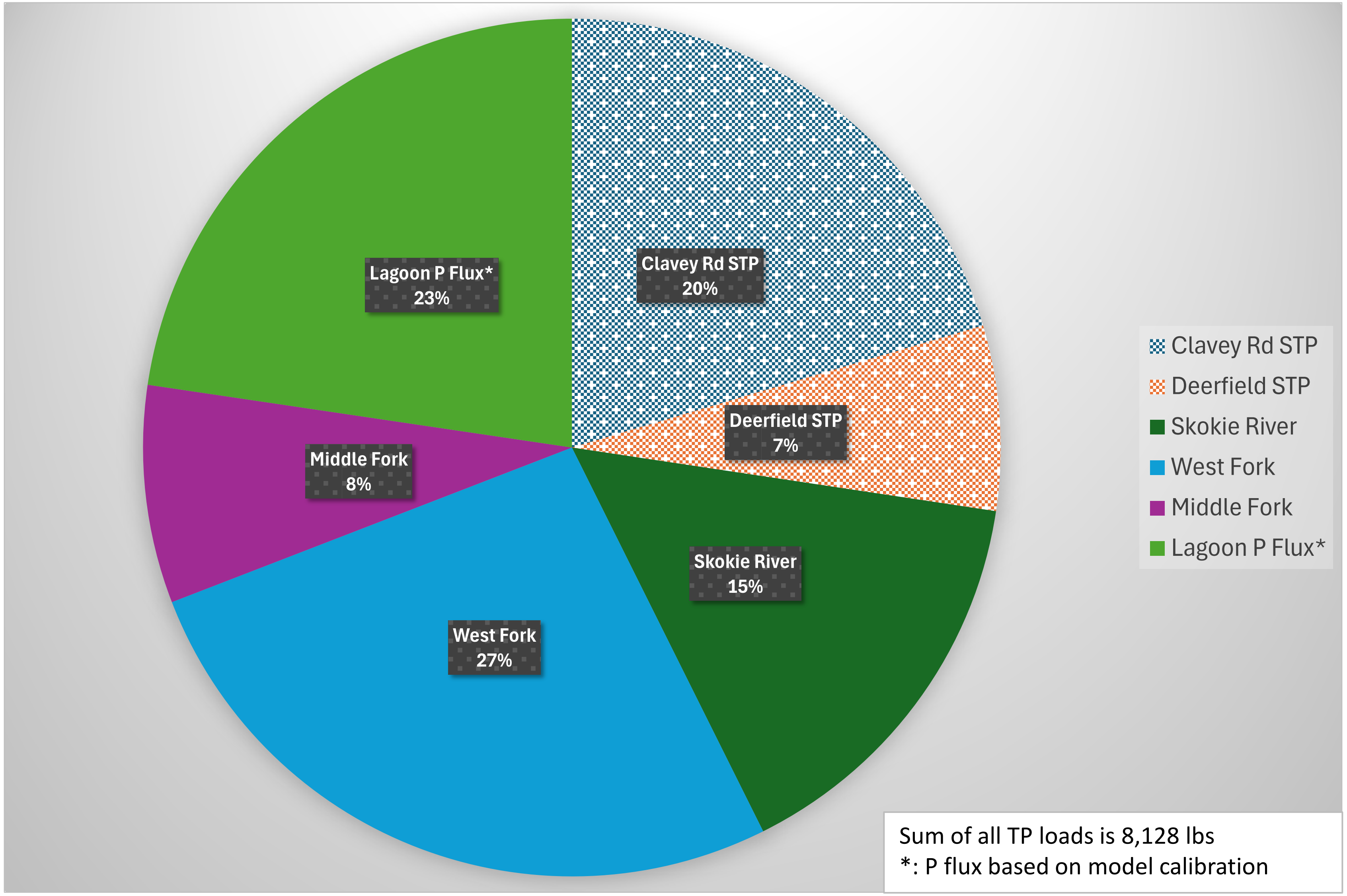
1. Impact to receiving streams if Clavey STP discharges downstream of the lagoon instead of upstream in 2022
2. Impact to receiving streams when POTWs cap effluent TP concentrations to 0.5 mg/L
3. Impact to receiving streams when POTWs cap effluent TP concentrations to 0.1 mg/L

Baseline - TP Loads in lbs from Jul 28 to Oct 5, 2022

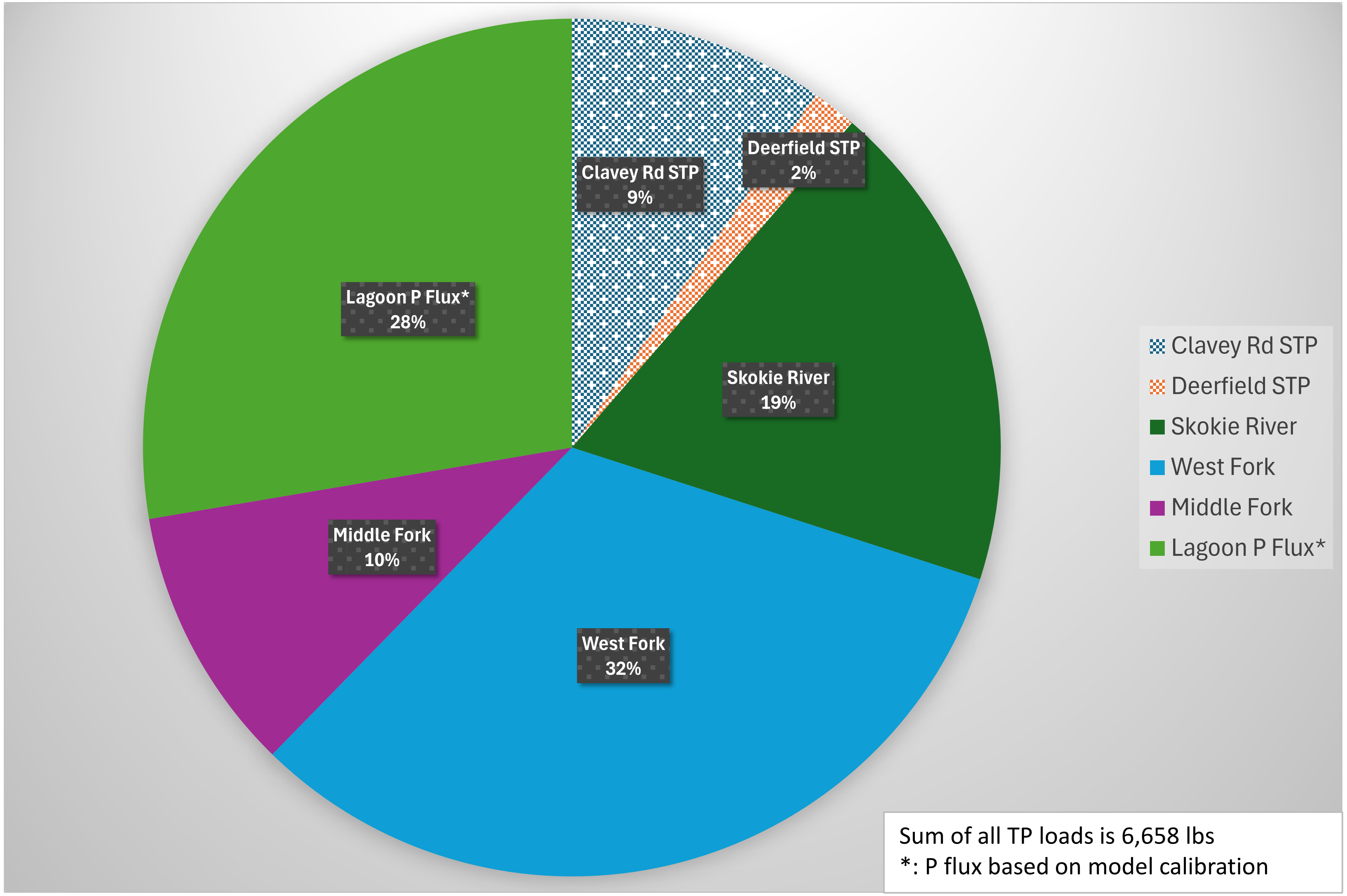


Sum of all TP loads is 11,605 lbs
*: P flux based on model calibration

Capped to 0.5 mg/L - TP Loads in lbs from Jul 28 to Oct 5, 2022



Capped to 0.1 mg/L - TP Loads in lbs from Jul 28 to Oct 5, 2022

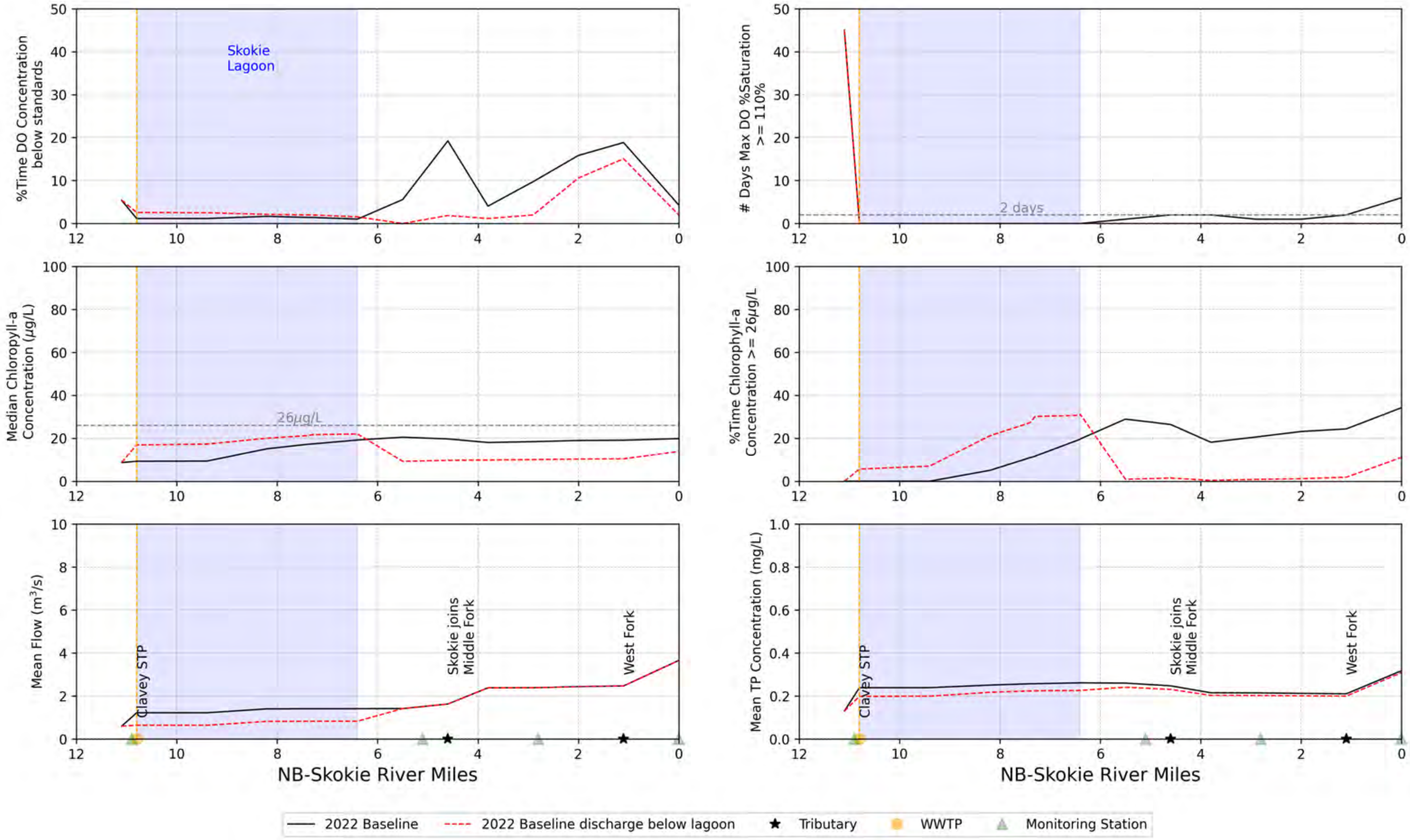


How we analyze the results

Percentage of time when DO concentrations are below minimum standards (5mg/L for March through July and 3.5mg/L for August through Feb)	Number of days in which the daily maximum %DO Saturation is greater than 110%
Median sestonic chlorophyll *a* concentration	Percentage of time when chlorophyll *a* concentrations exceed 26µg/L
Mean flow	Mean TP concentration

River Miles

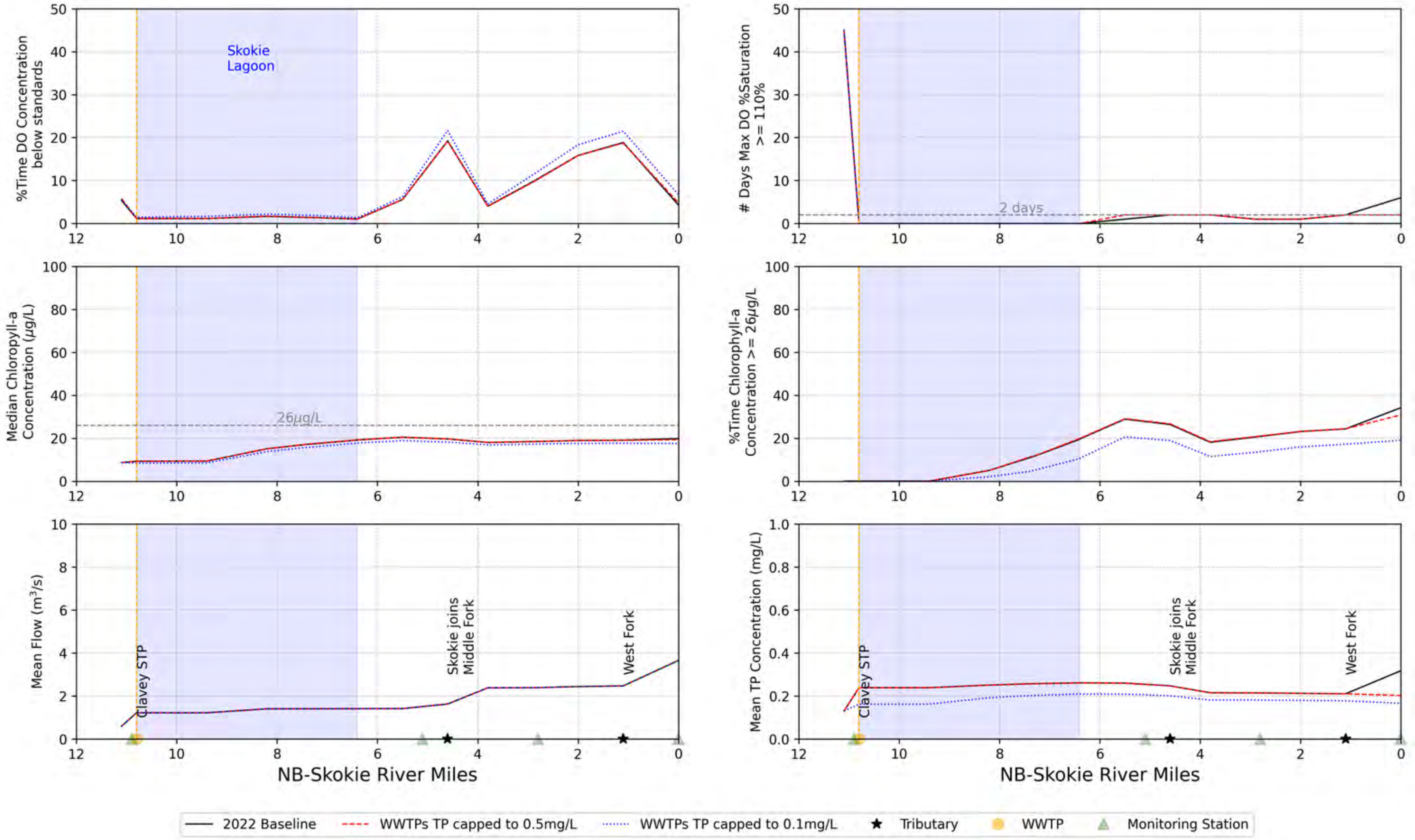
Impact of moving Clavey STP discharge point downstream of the Skokie Lagoon in 2022



Takeaways

- Moving the Clavey STP discharge outfall from upstream of the lagoon to downstream of the lagoon will lead to:
  - Reduced chl-*a* concentration downstream of the lagoon due to dilution but increased chl-*a* concentration upstream of the lagoon
  - Improved DO condition downstream of the lagoon (reduced %time DO below minimum standards)

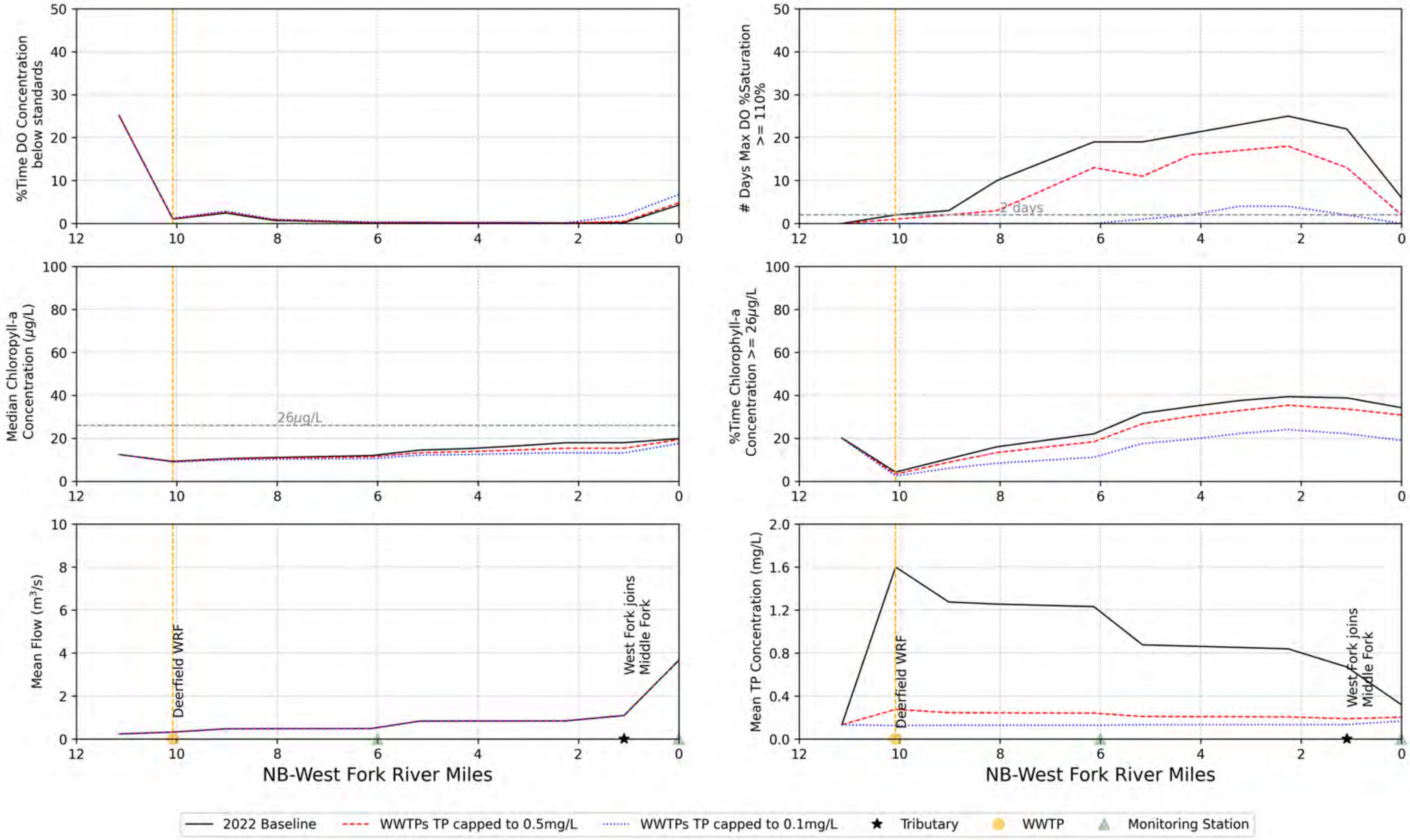
Capping WWTPs effluent TP - Skokie



Takeaways

- For 2022 baseline condition, most of the Clavey STP effluent TP measurements were already below 0.5mg/L, so capping TP to 0.5 mg/L does not show much difference
- Capping effluent TP to 0.1 mg/L improves downstream chl-*a* and TP conditions very slightly. However, due to uncertainties associated with the sediment flux and model limitations, it’s hard to justify the additional costs for the limited benefits

Capping WWTPs effluent TP – West Fork



Takeaways

- The West Fork sees a much more significant improvements in terms of DO, chl-*a*, and TP for 2022.
- Capping Deerfield WRF effluent TP to 0.5 mg/L makes significant improvements compared to the baseline condition. Additional improvements by further reducing effluent TP to 0.1 mg/L are less significant.

Future Model Scenarios

Potential Future Management Scenarios

1. Urban reductions (MS4s) - %, load by community

2. Lagoon – online/offline

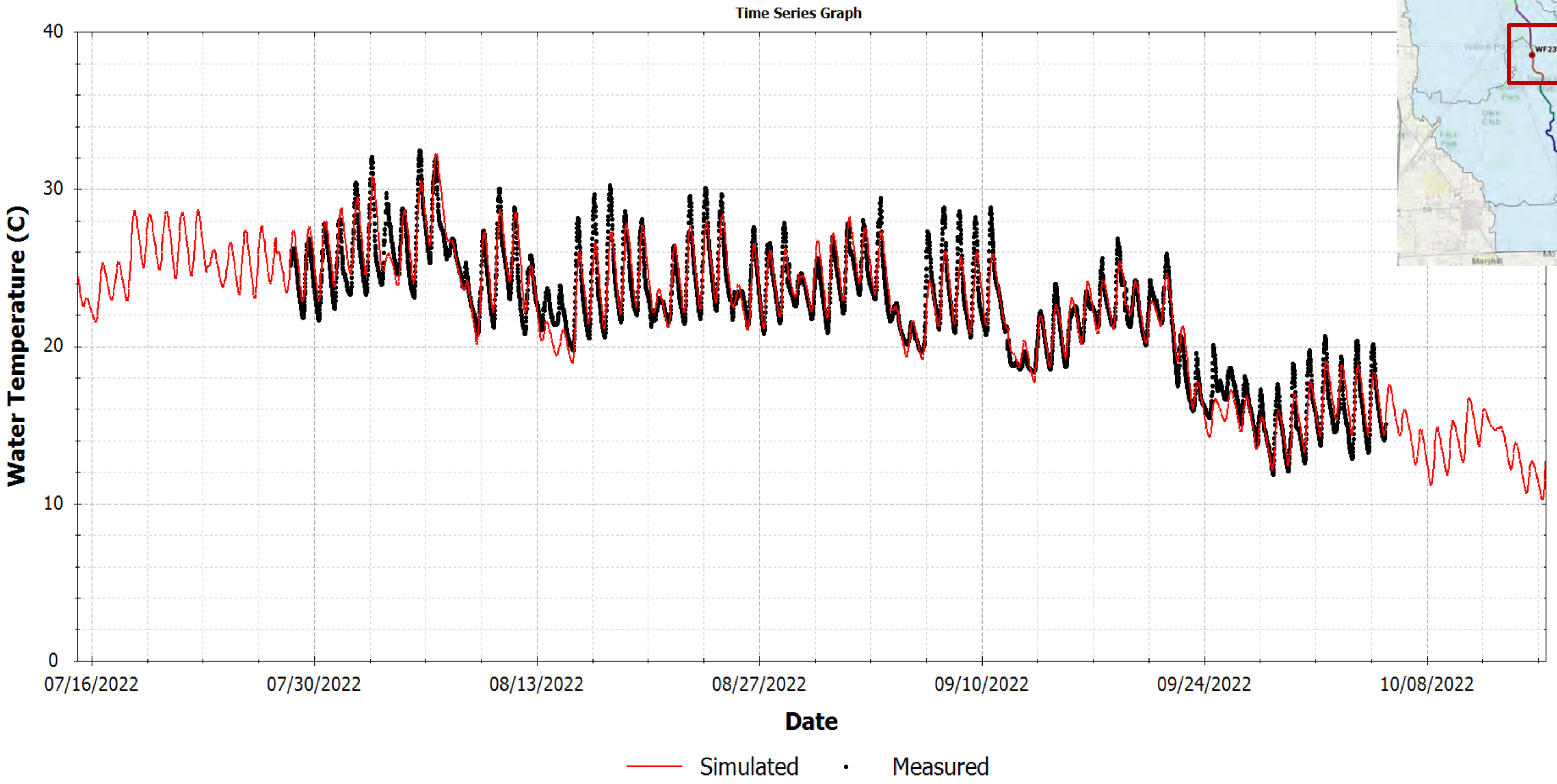
Questions

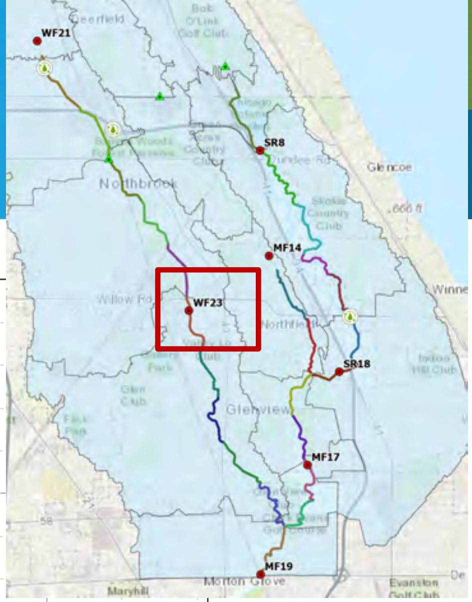
Yifan He, PhD, EIT

Yifan.He@Geosyntec.com

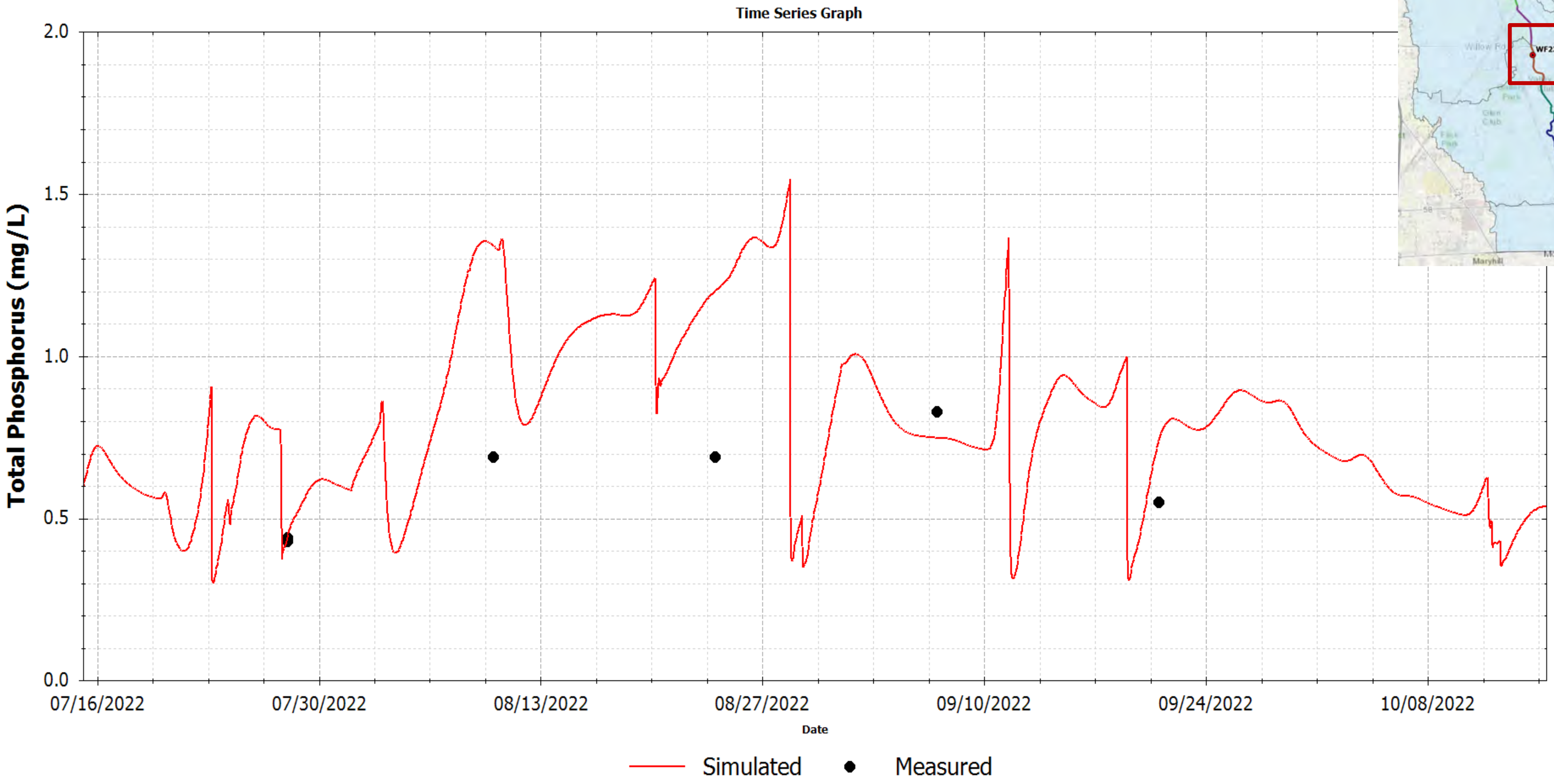
Phone: 630-481-5465

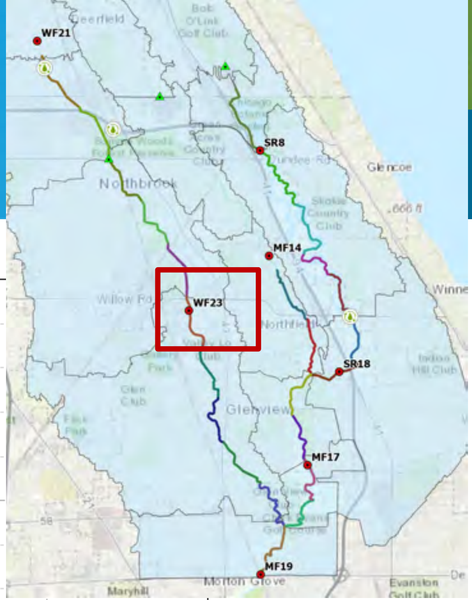
Calibration Results – WTMP WF23





Calibration Results – TP WF23





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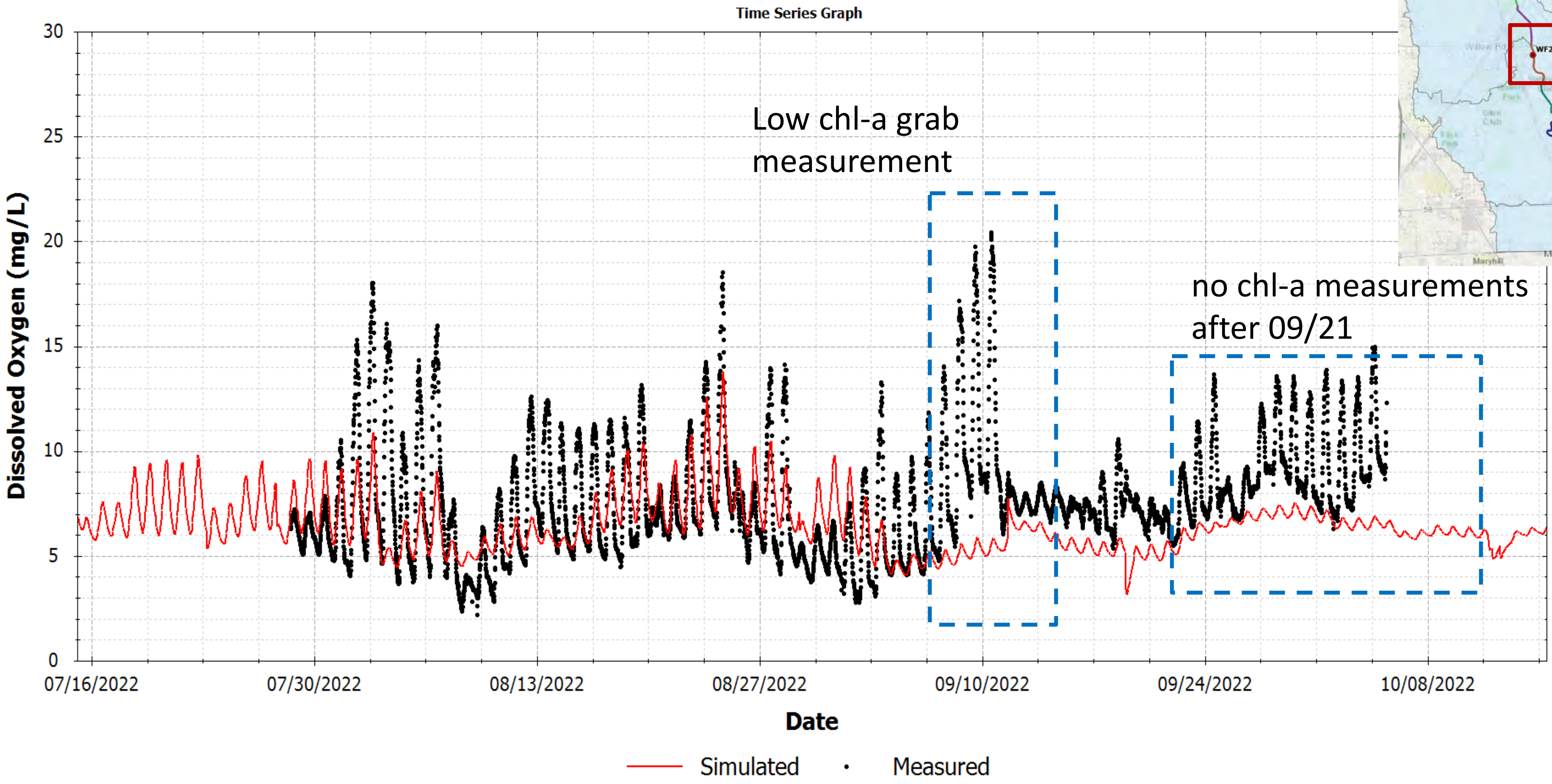
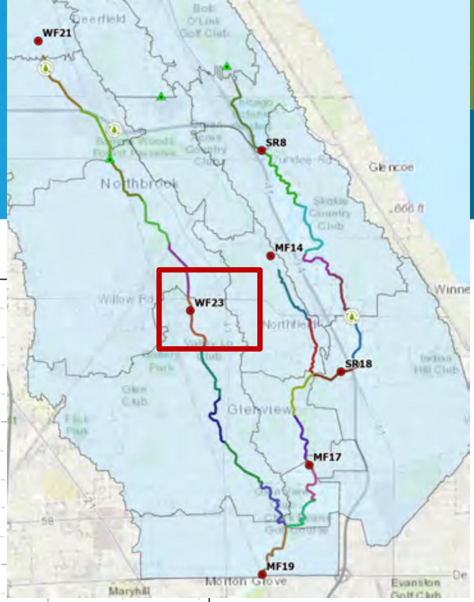
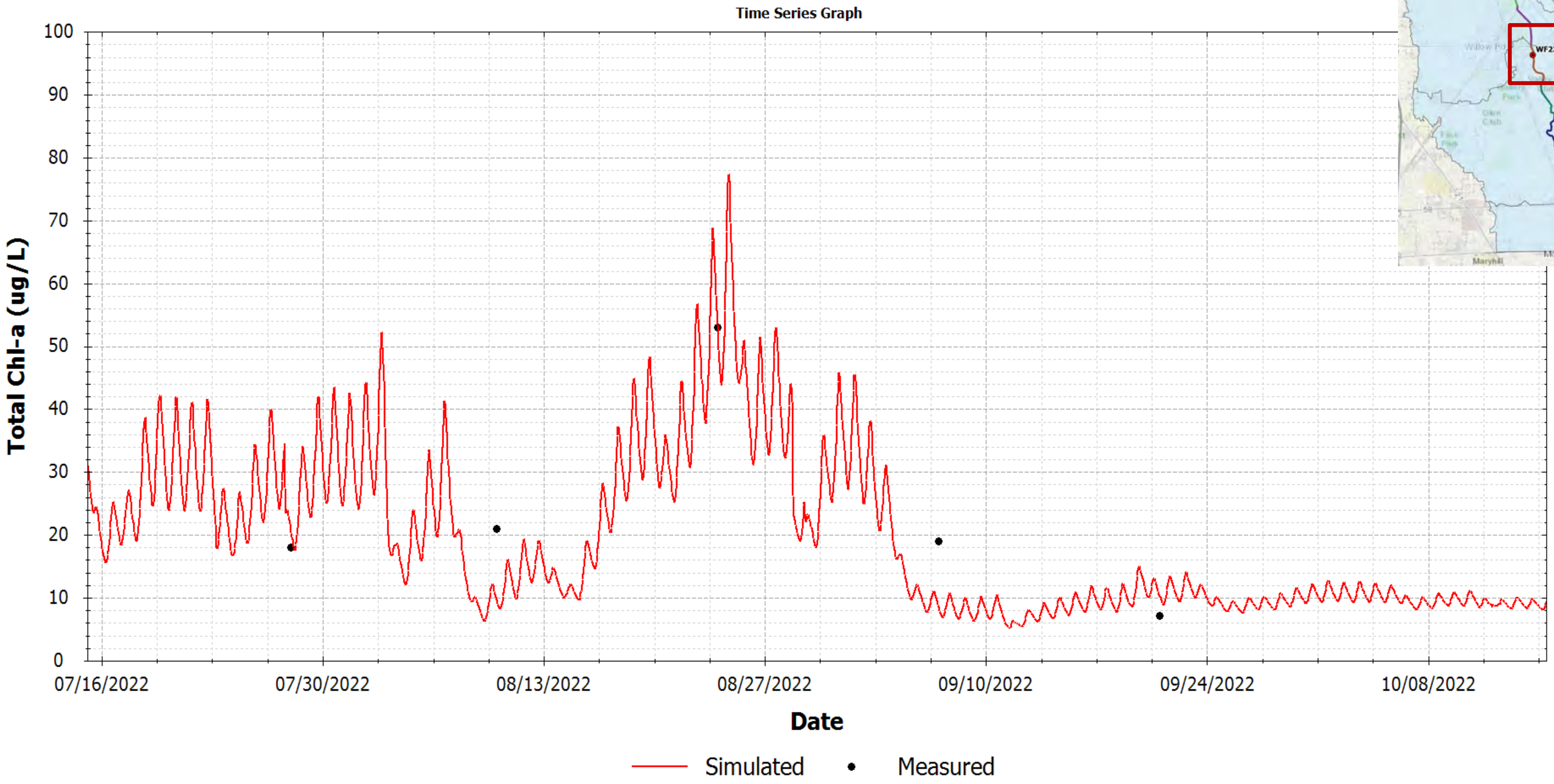
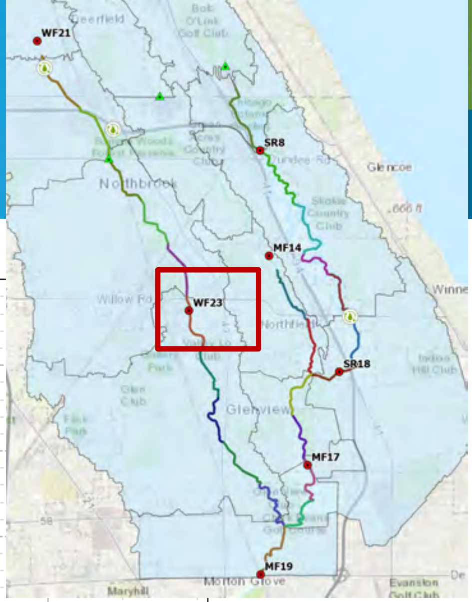
Calibration Results – DO WF23





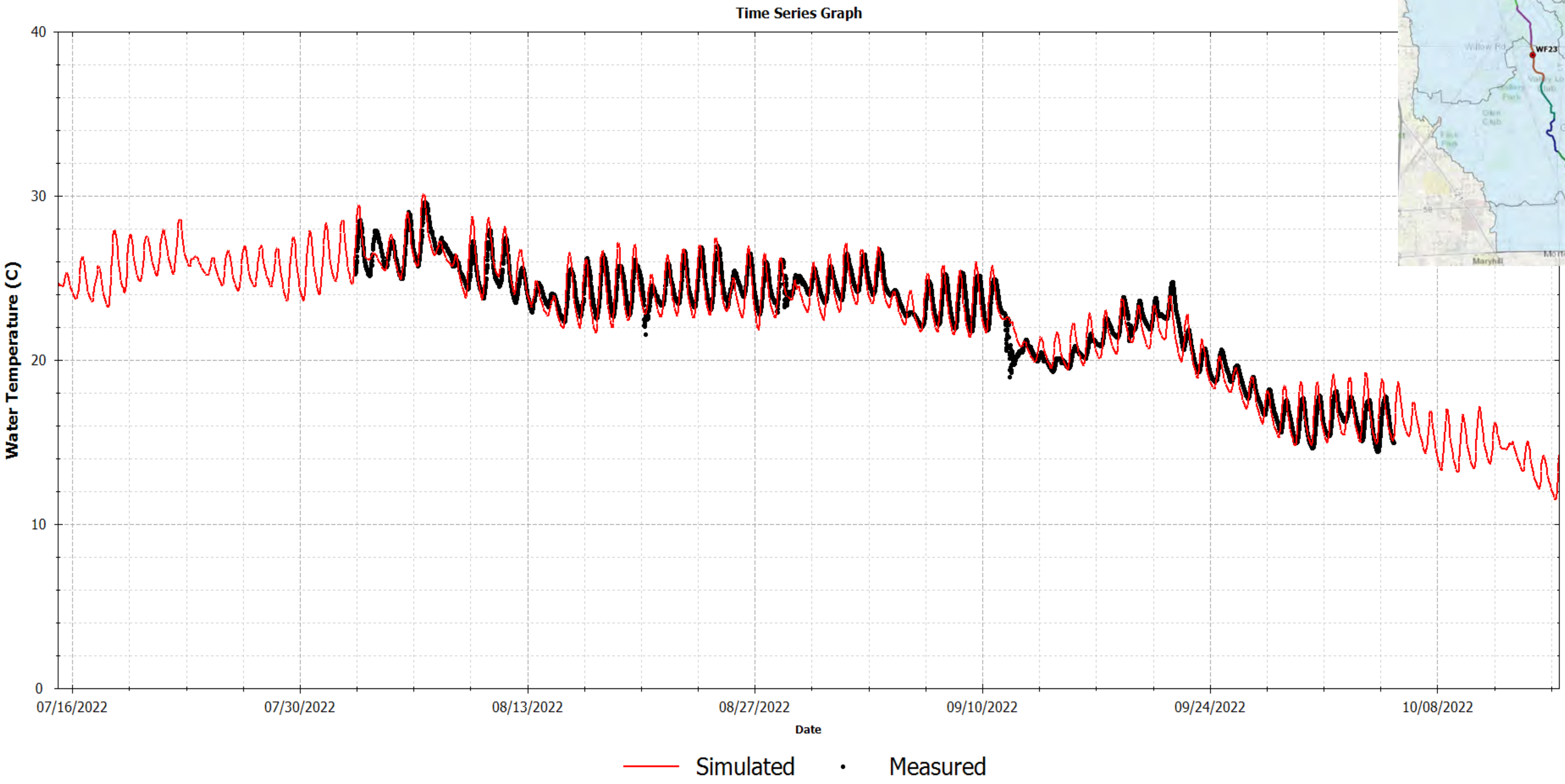
Calibration Results – CHLA WF23

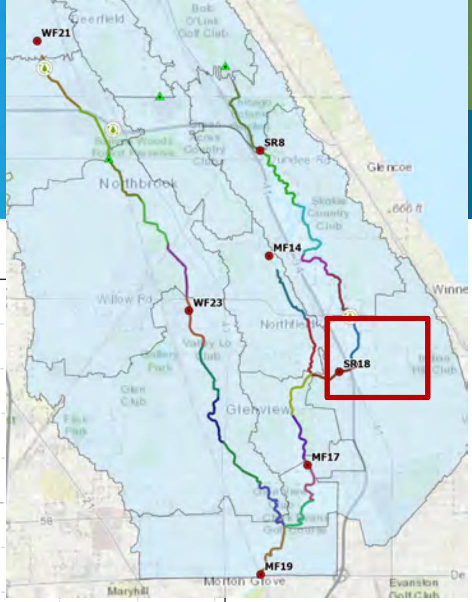




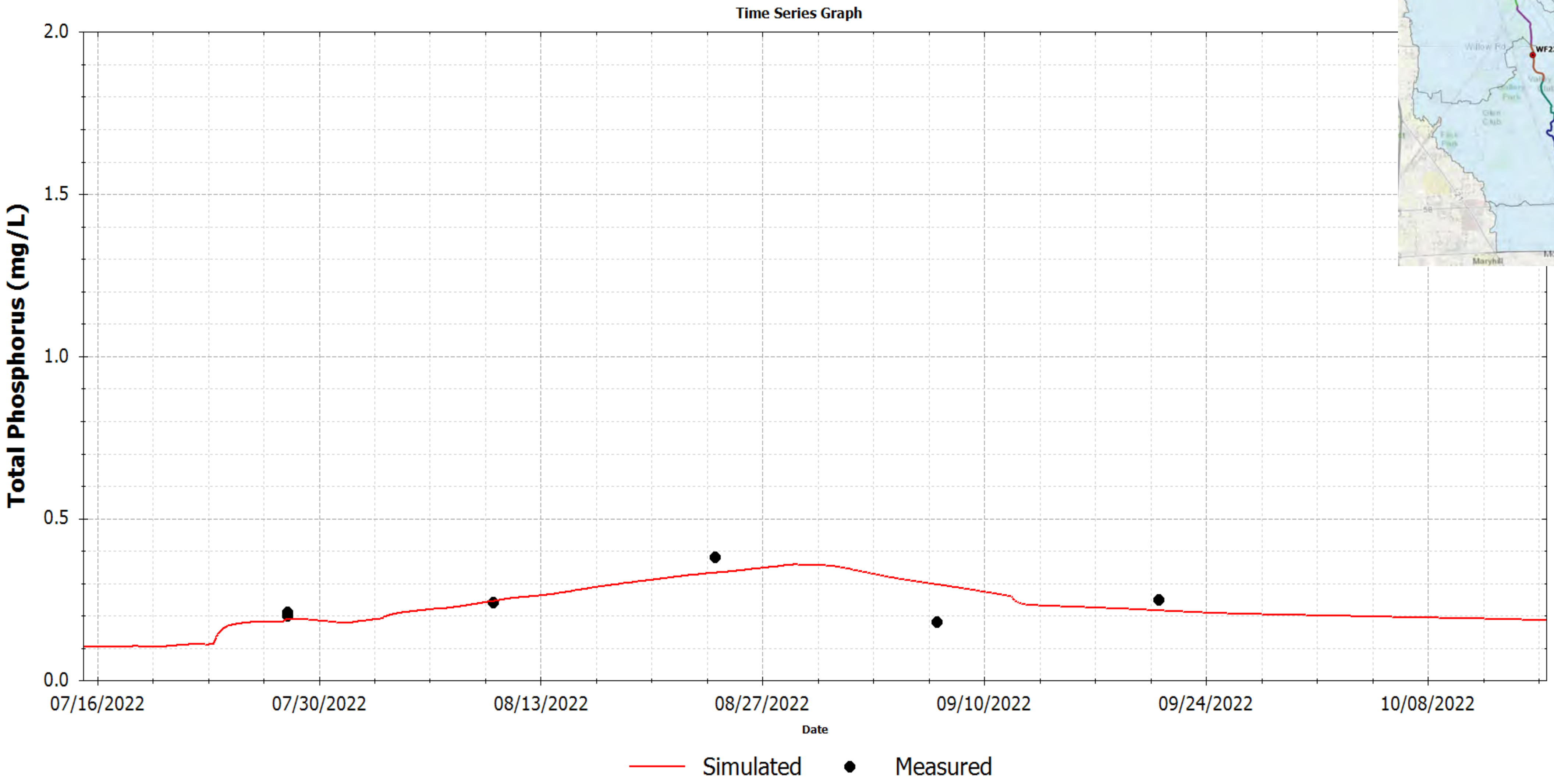
GEOSYNTEC CONSULTANTS

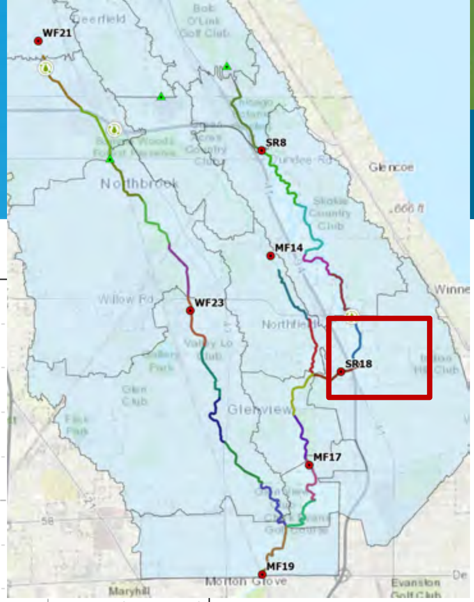
Calibration Results – WTMP SR18



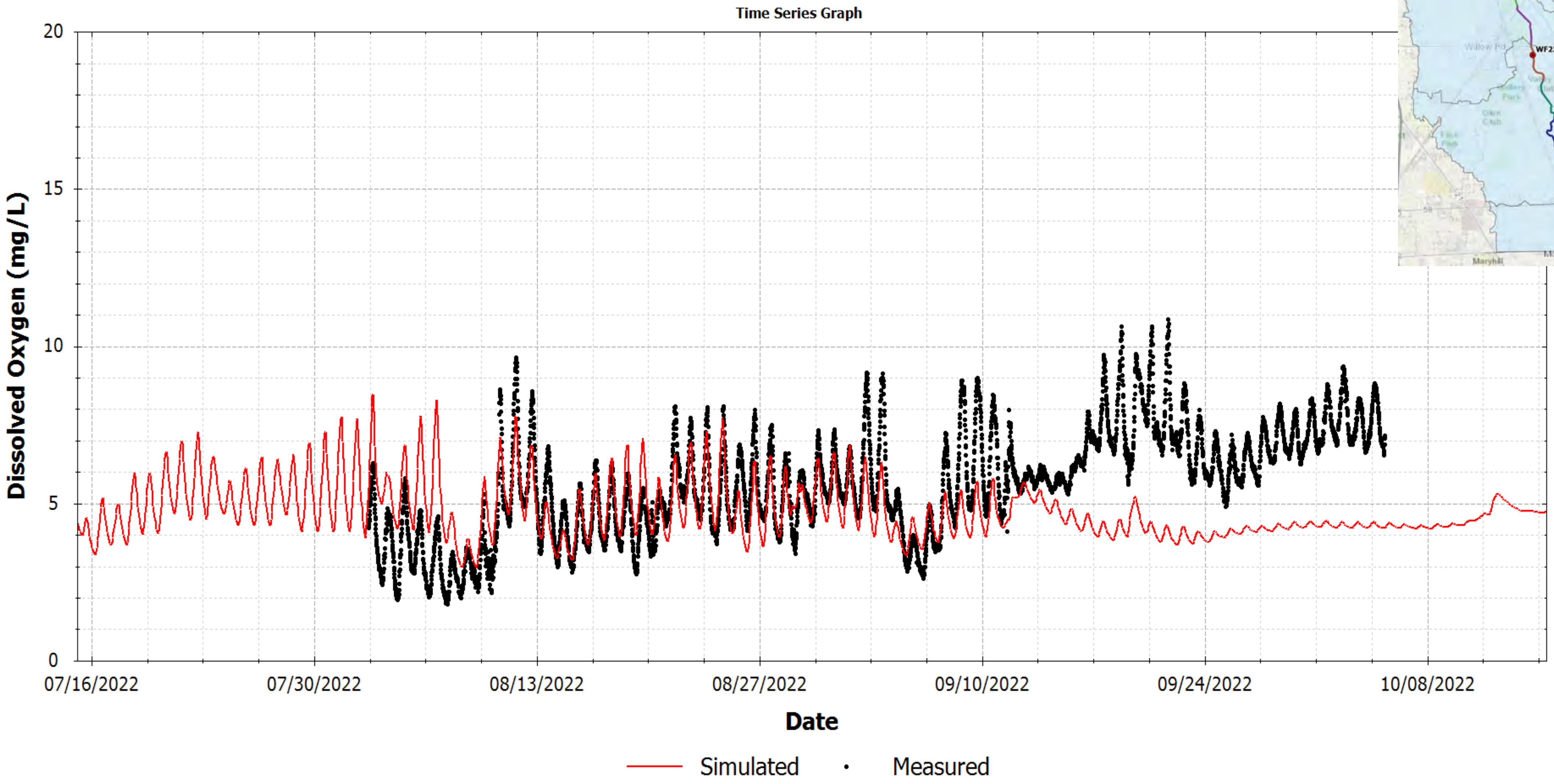


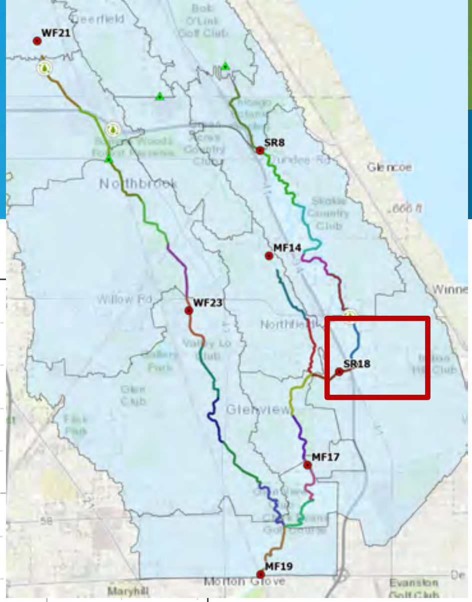
Calibration Results – TP SR18





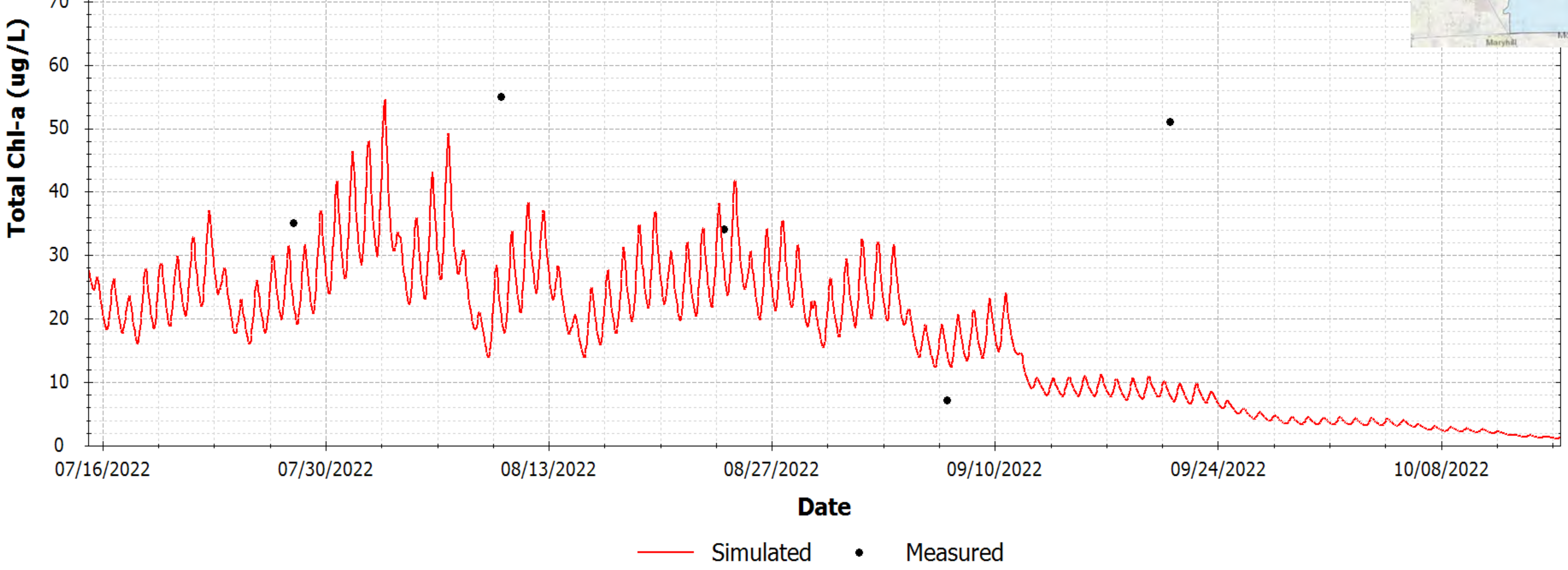
Calibration Results – DO SR18

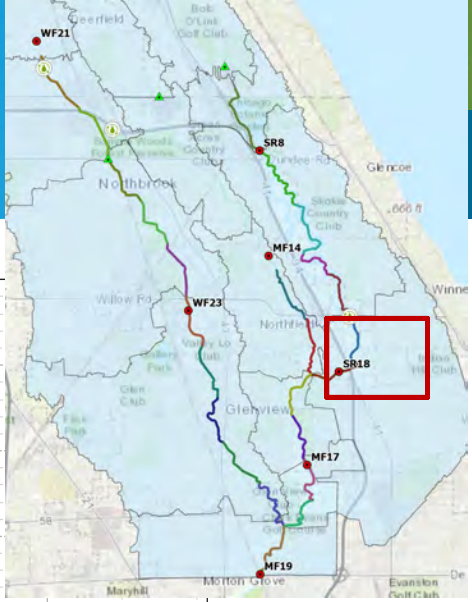




GEOSYNTEC CONSULTANTS

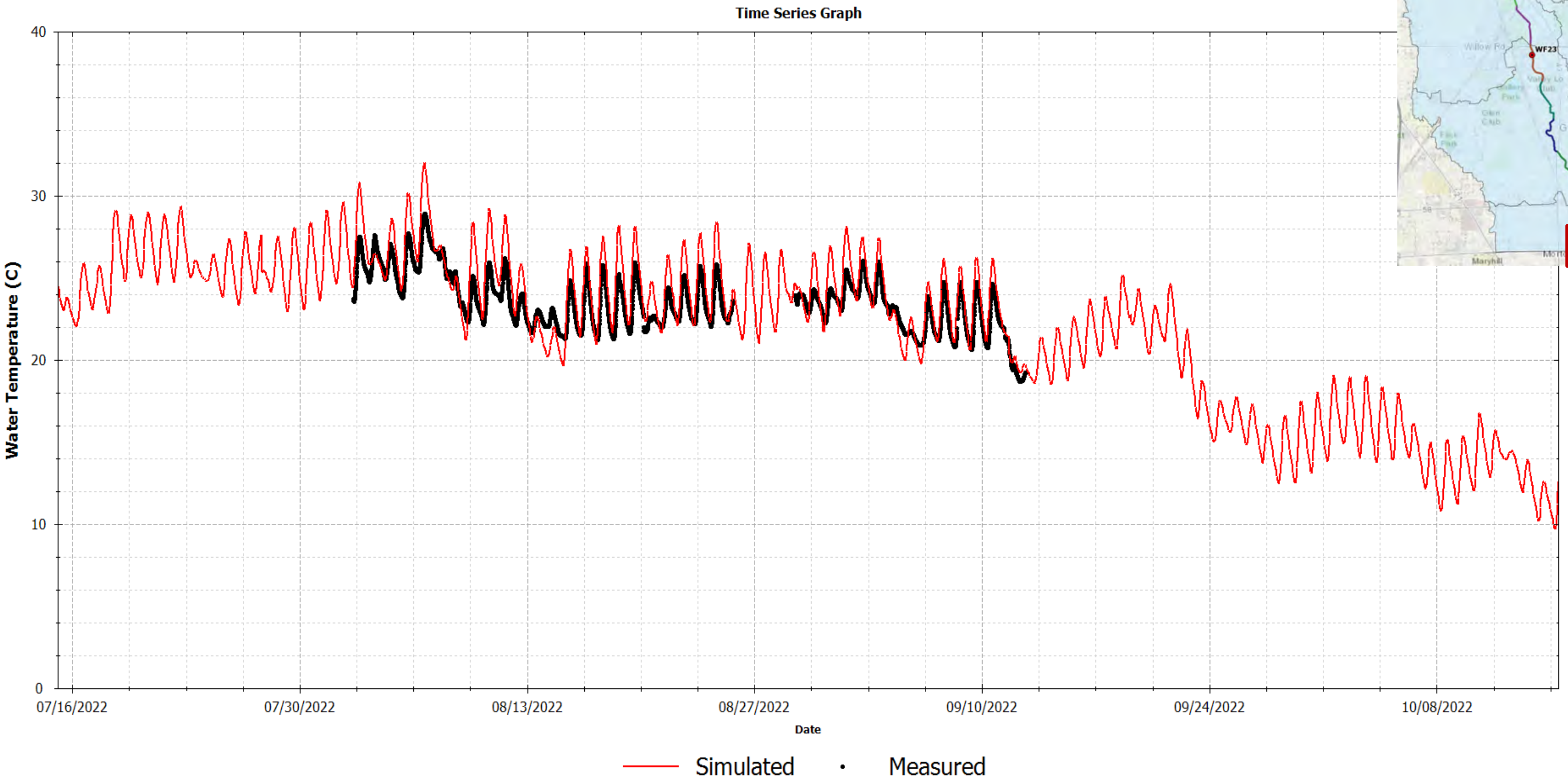
Calibration Results – CHLA SR18

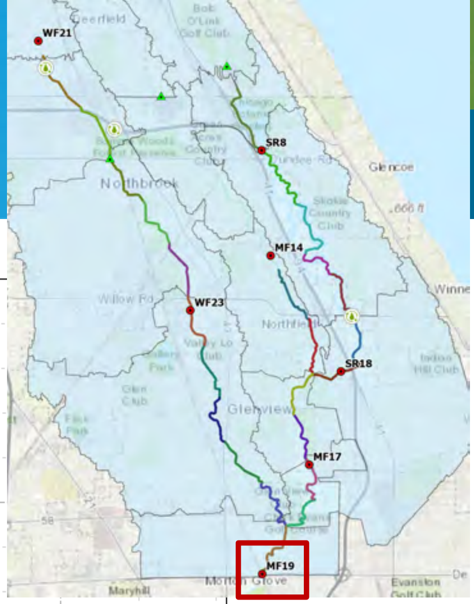




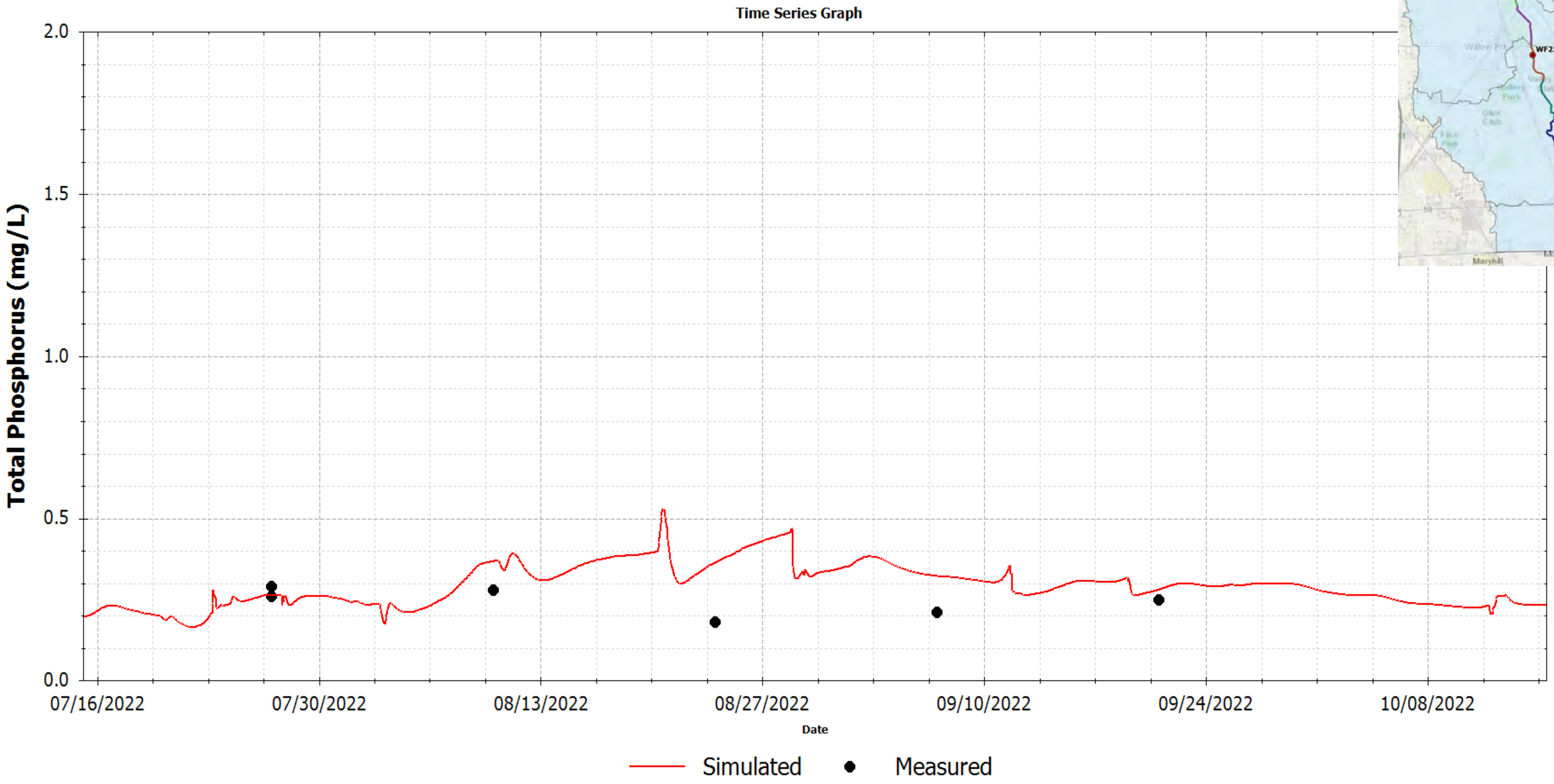
GEOSYNTEC CONSULTANTS

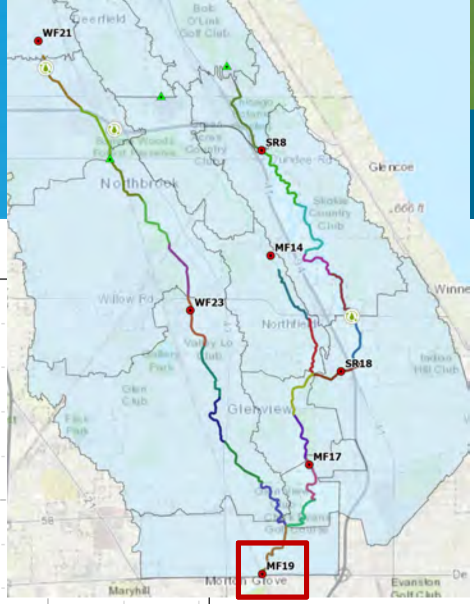
Calibration Results – WTMP MF19



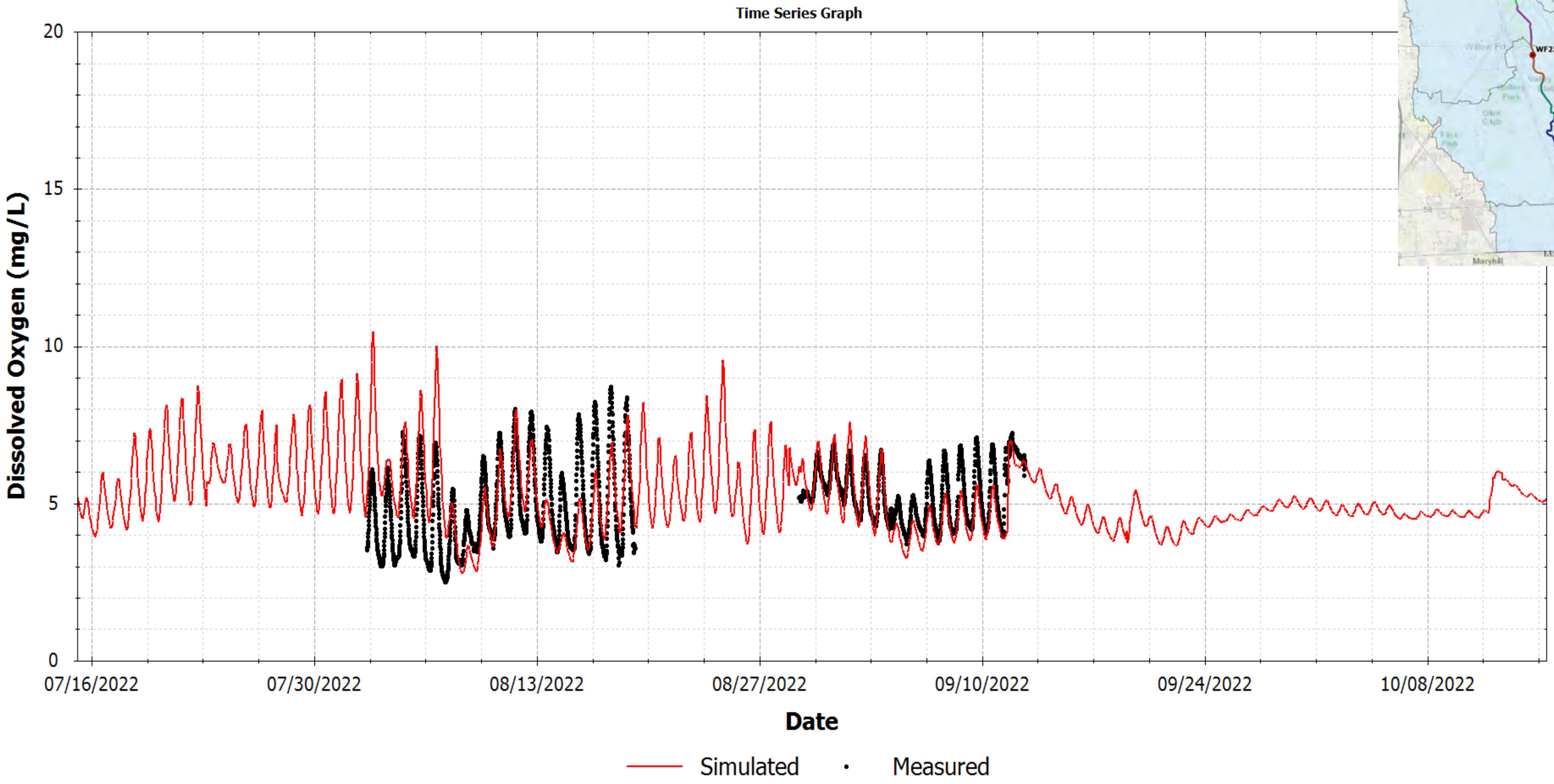


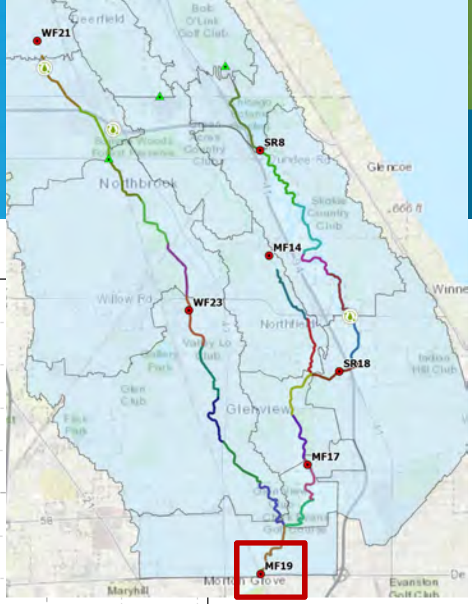
Calibration Results – TP MF19



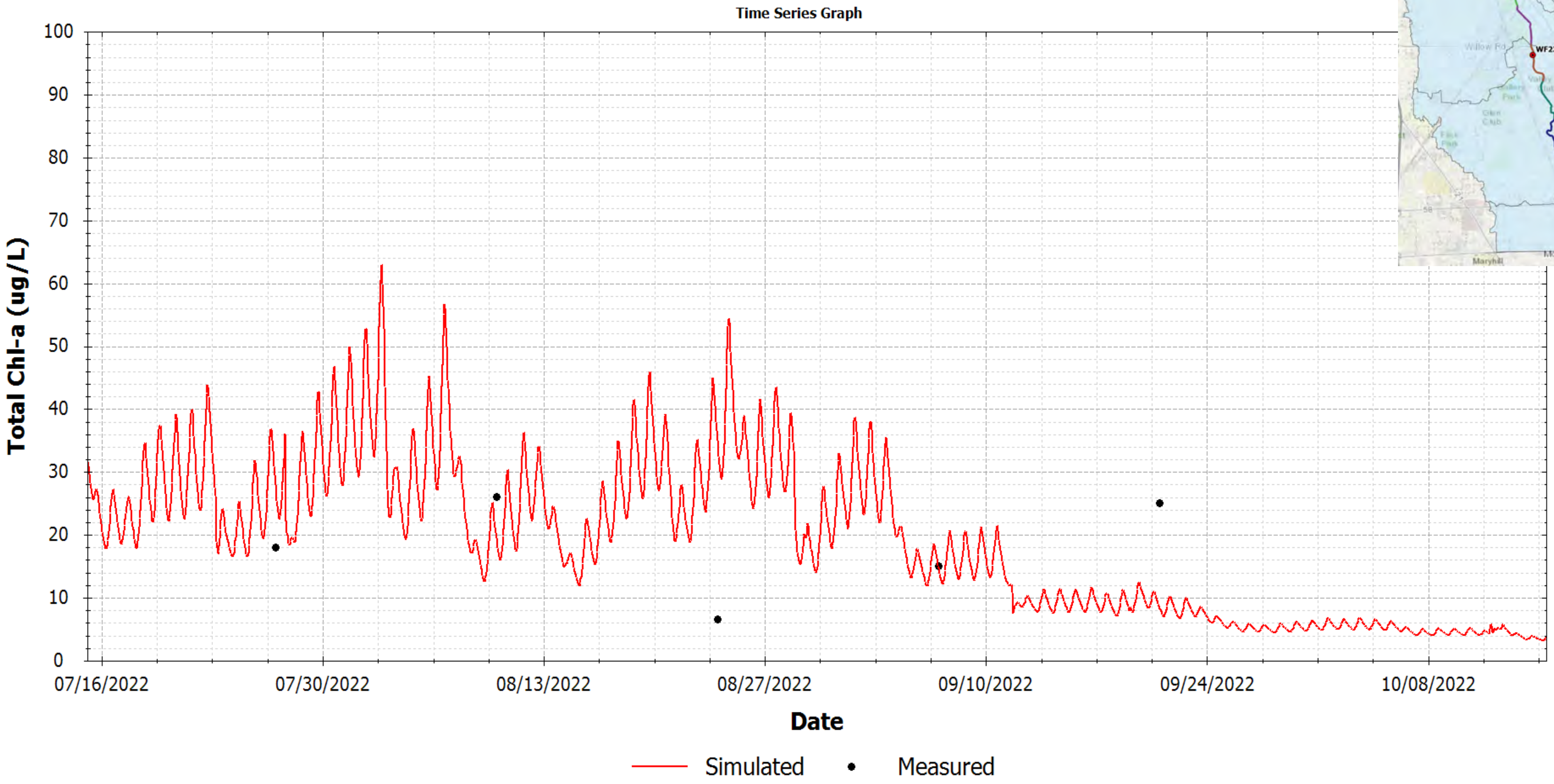


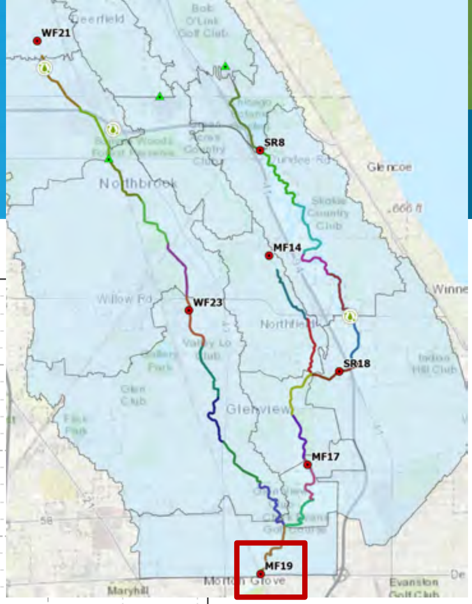
Calibration Results – DO MF19





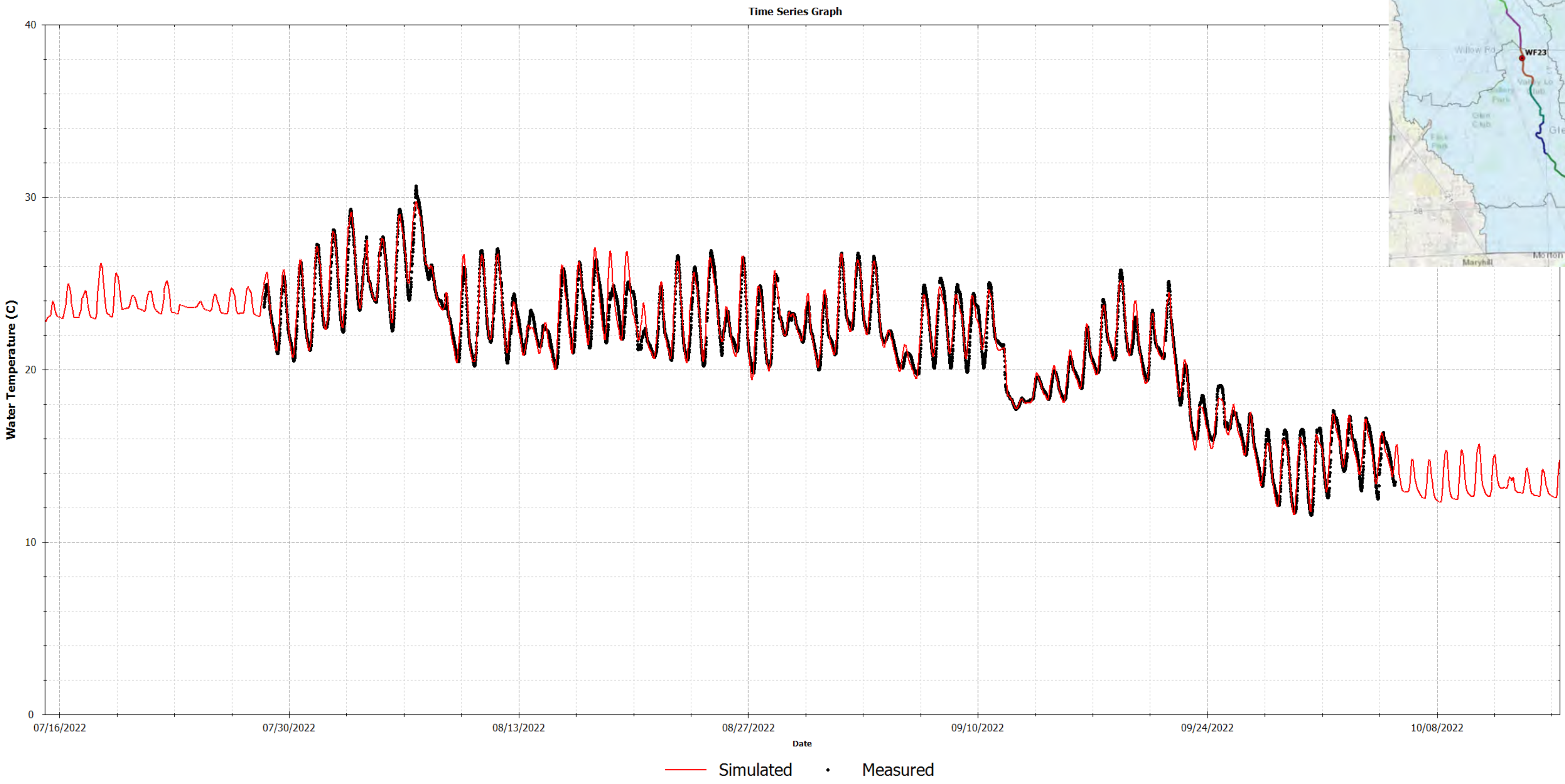
Calibration Results – CHLA MF19

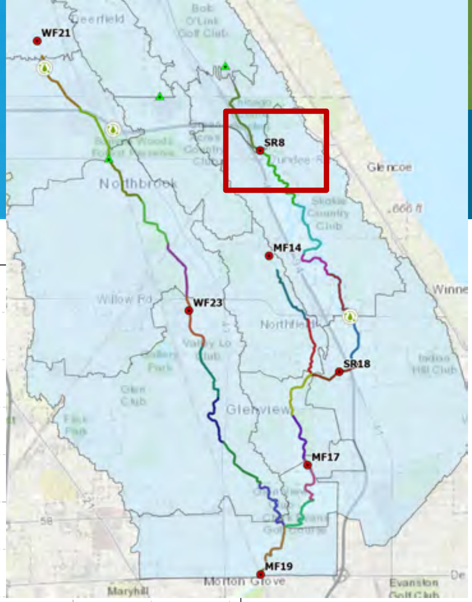




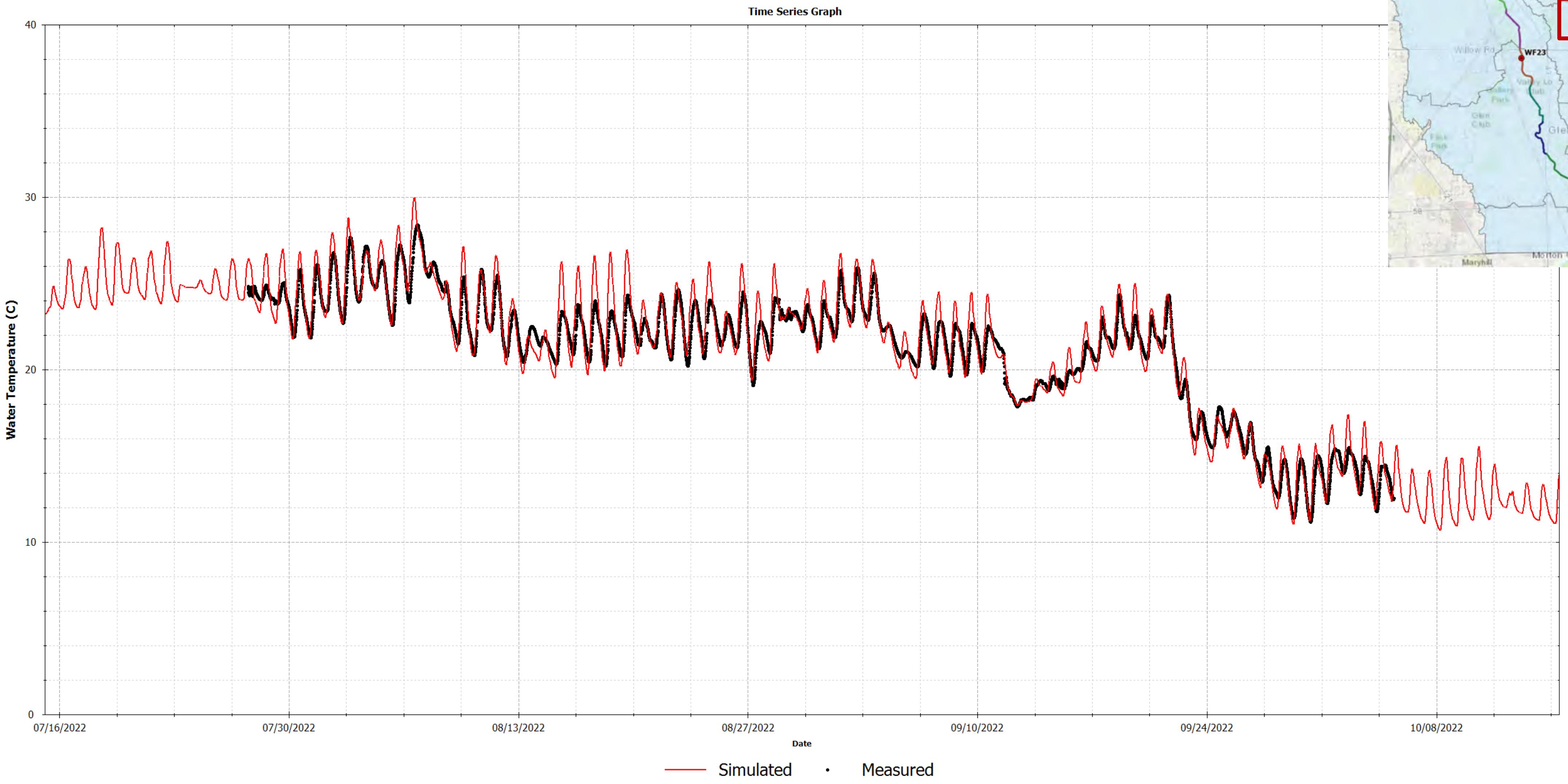
NBWW NARP: WATER TEMP Calibration

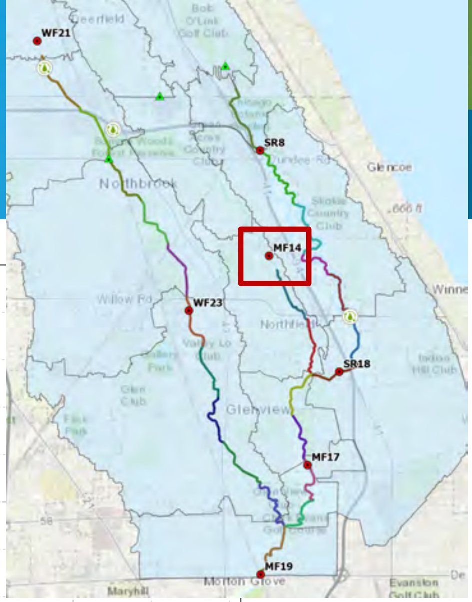
Calibration Results – WTMP SR8



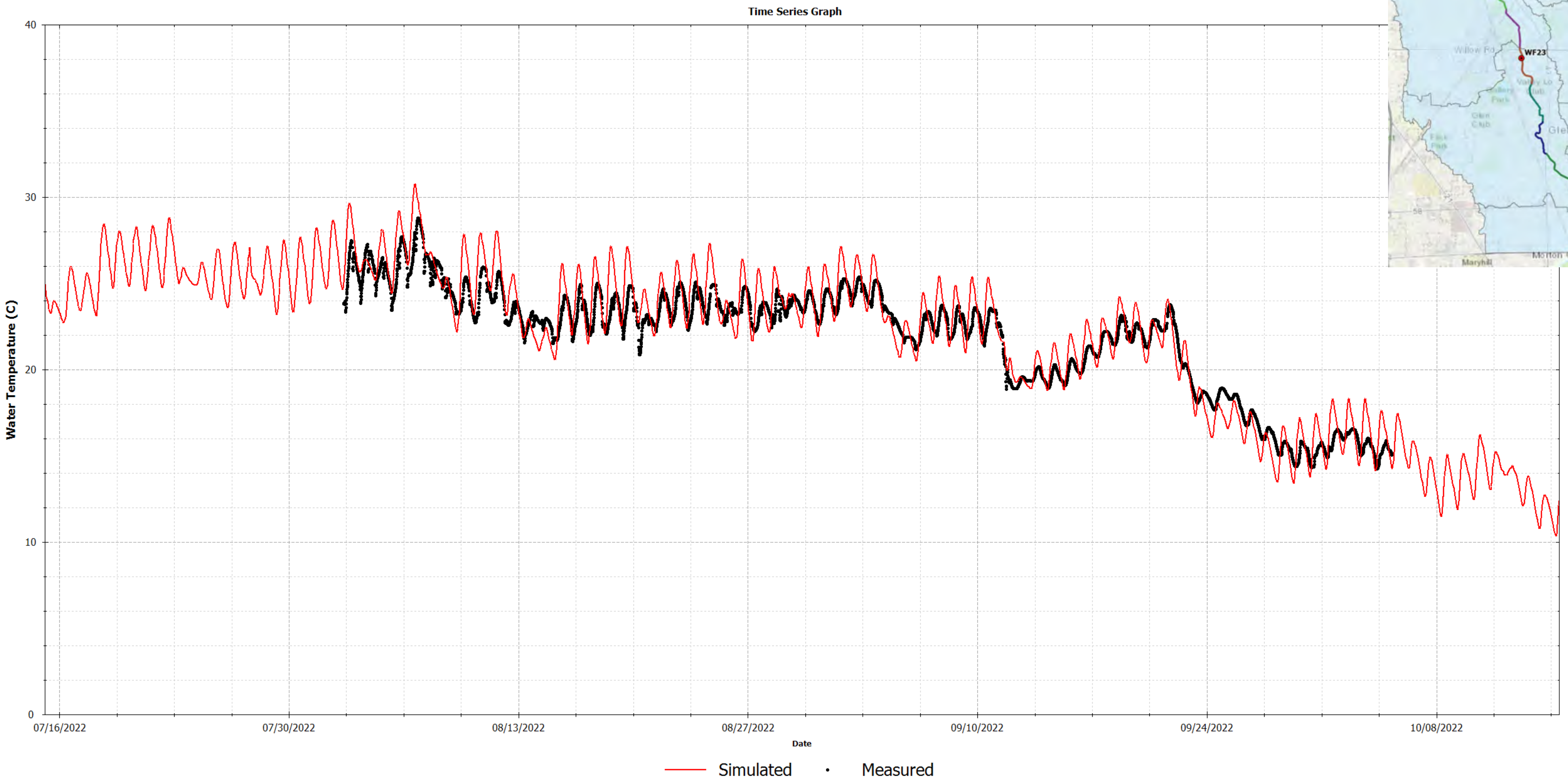


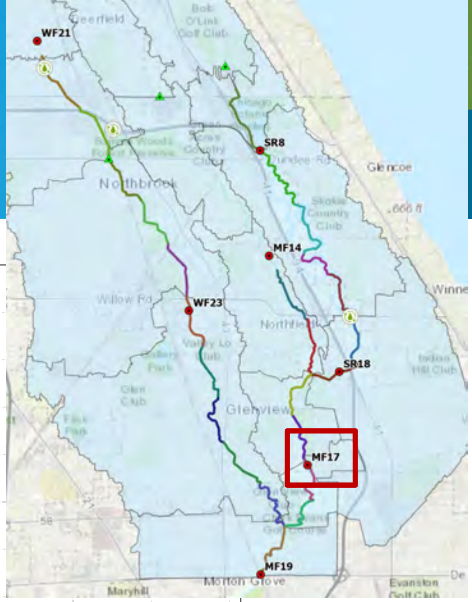
Calibration Results – WTMP MF14





Calibration Results – WTMP MF17





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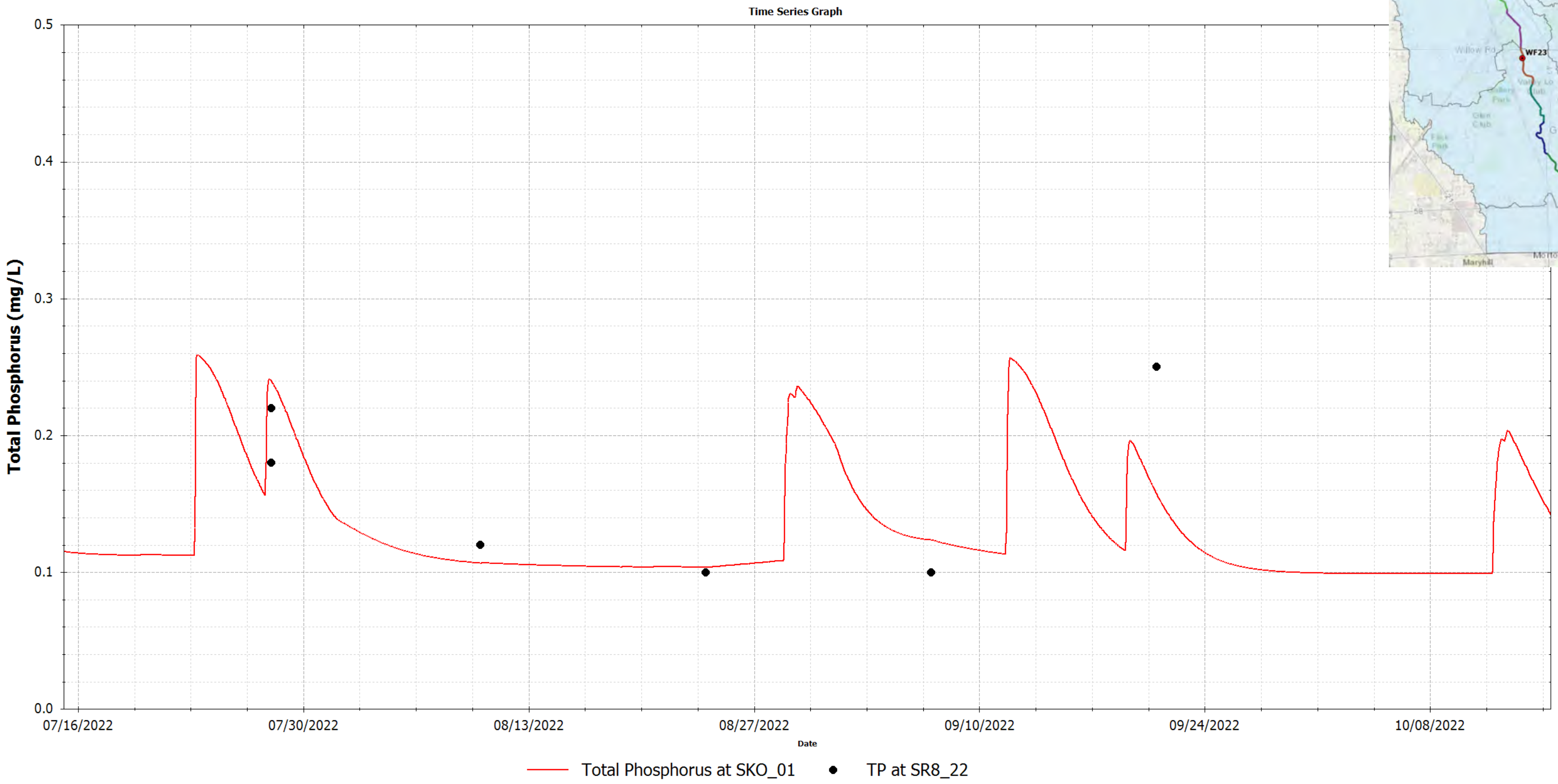
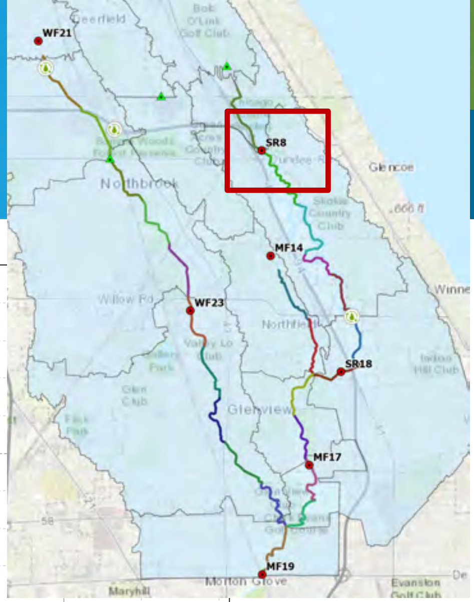
Geosyntec consultants

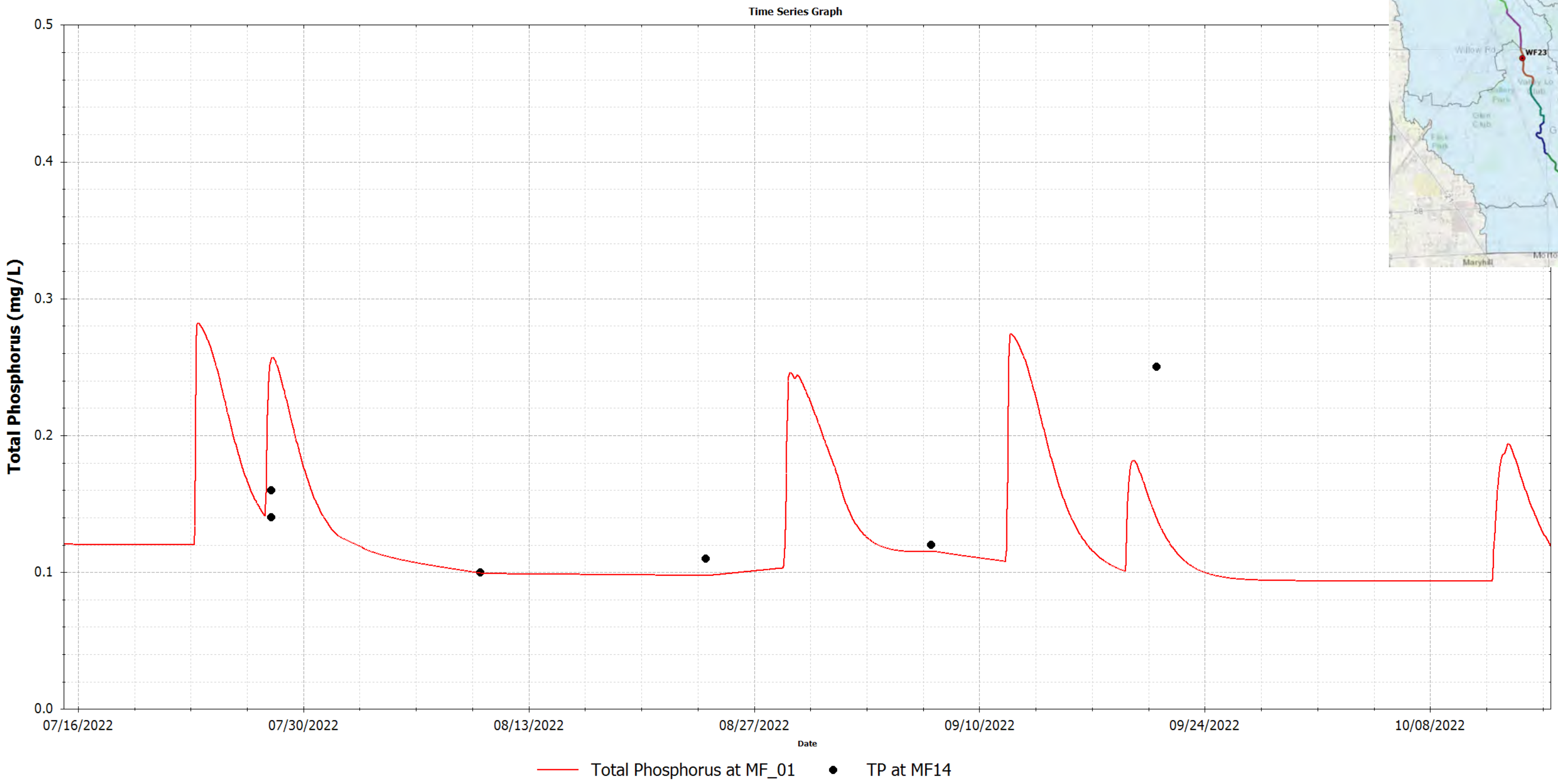
NBWW NARP: TP Calibration

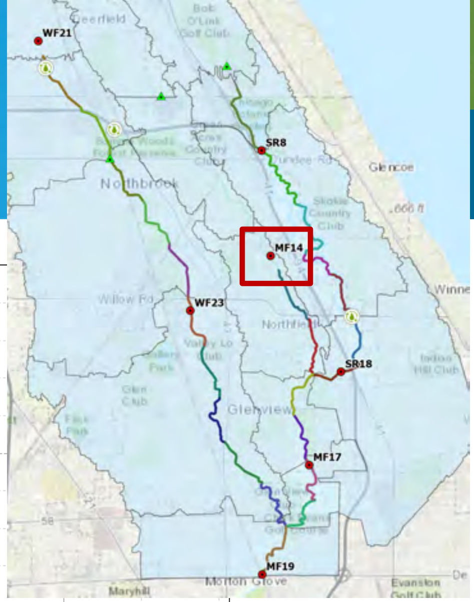
Calibration Results – TP SR8



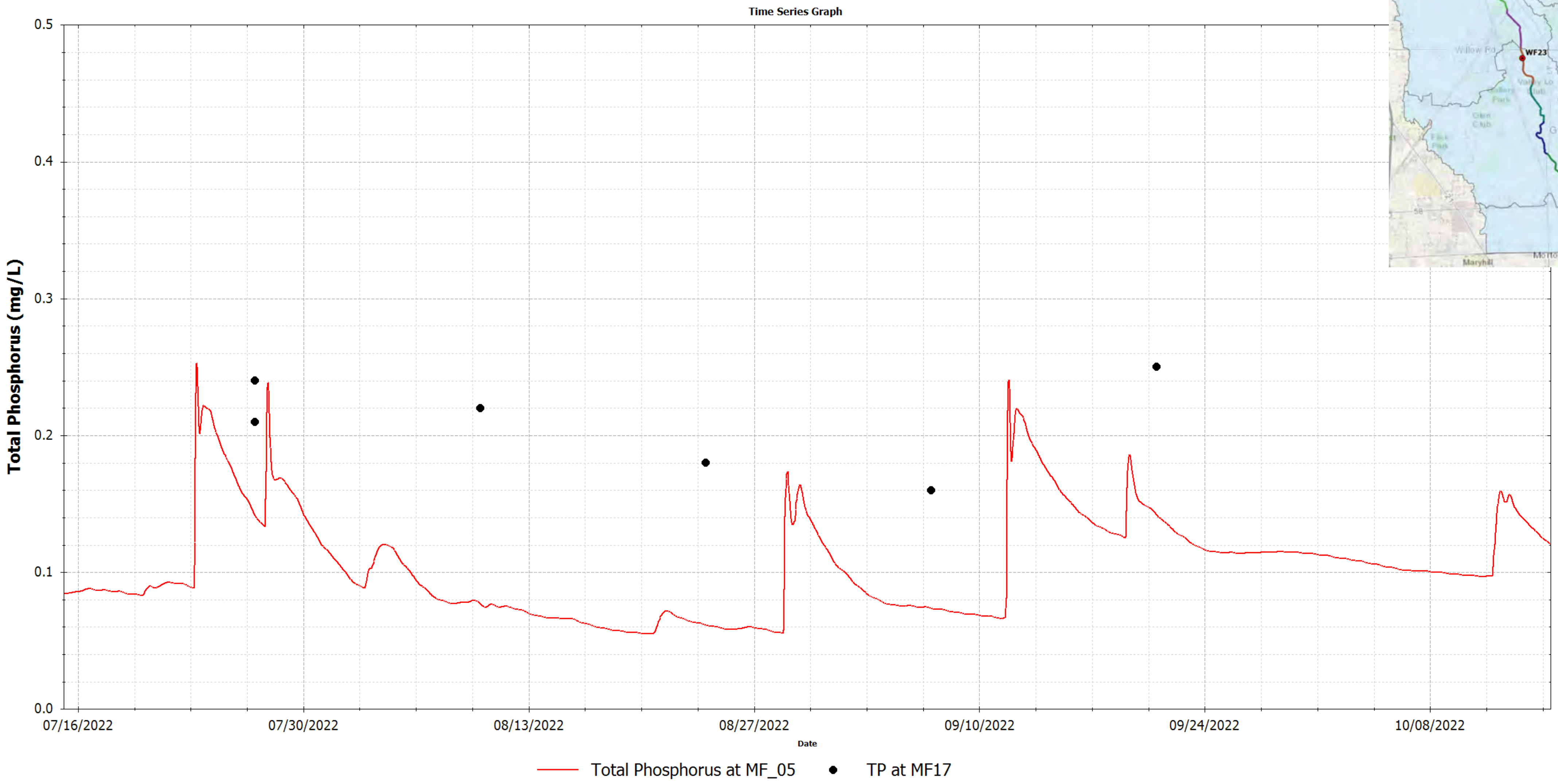


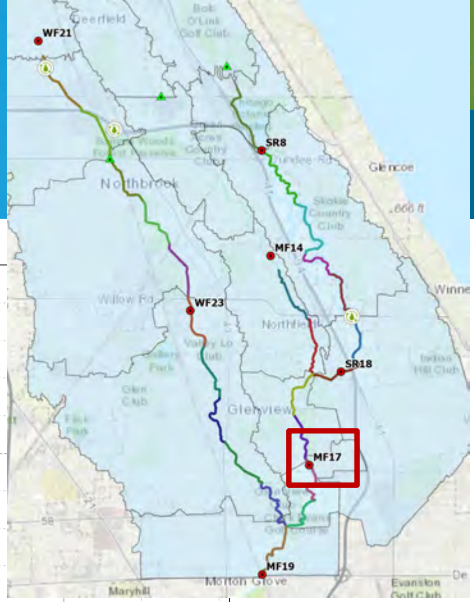
Calibration Results – TP MF14





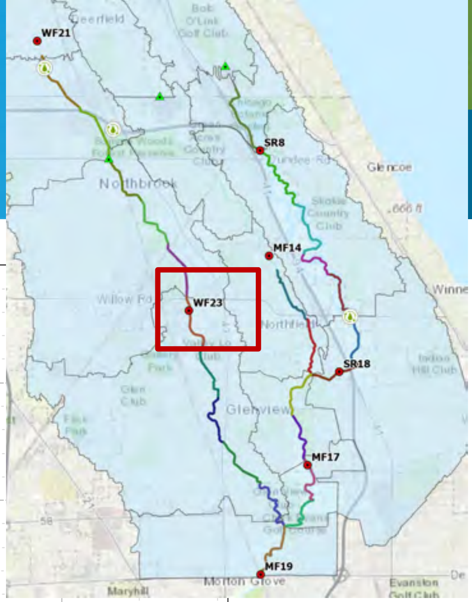
Calibration Results – TP MF17



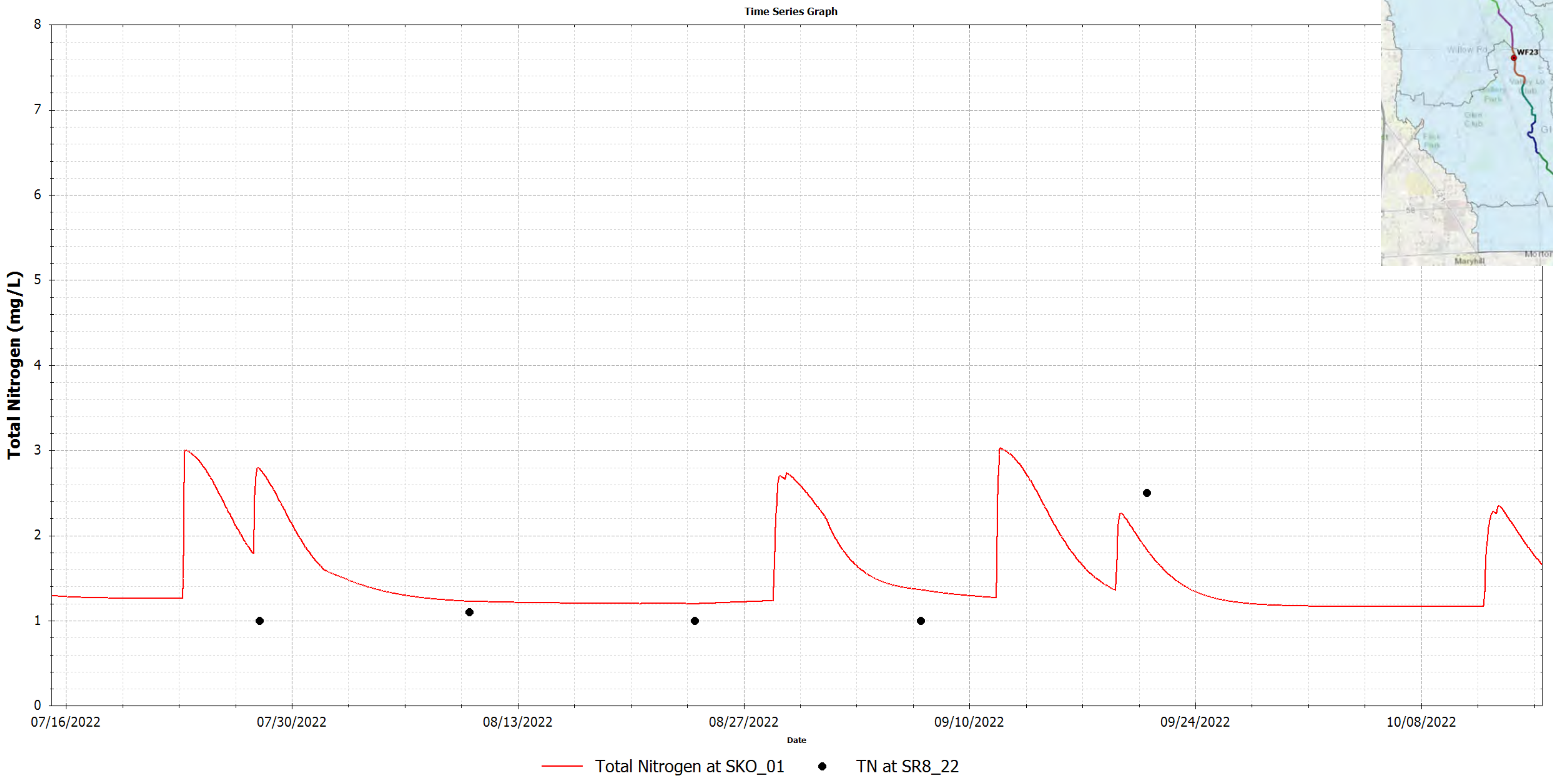


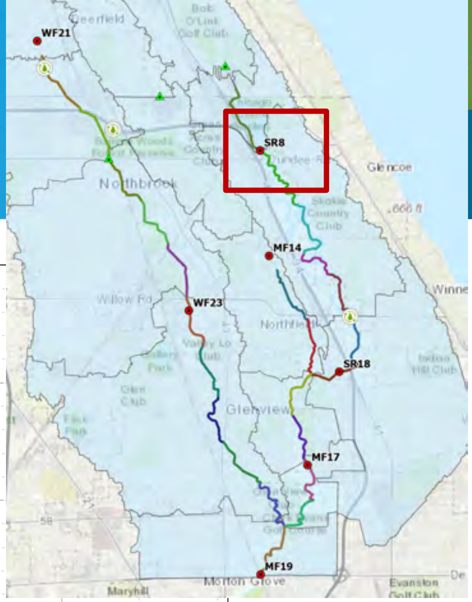
NBWW NARP: TN Calibration

Calibration Results – TN WF23

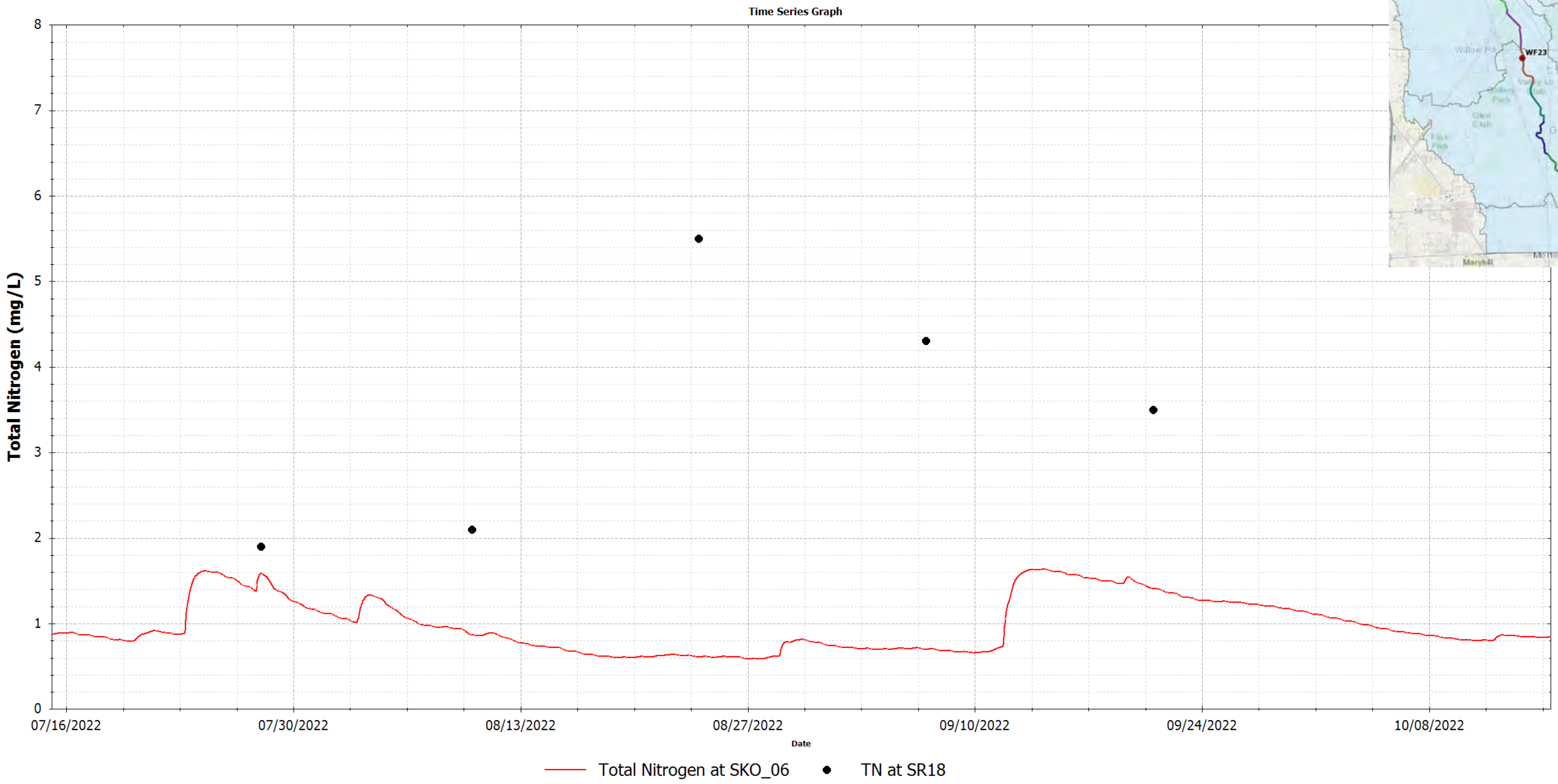


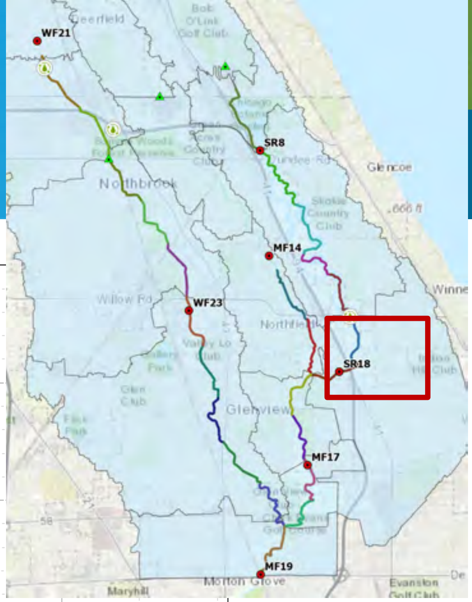
Calibration Results – TN SR8



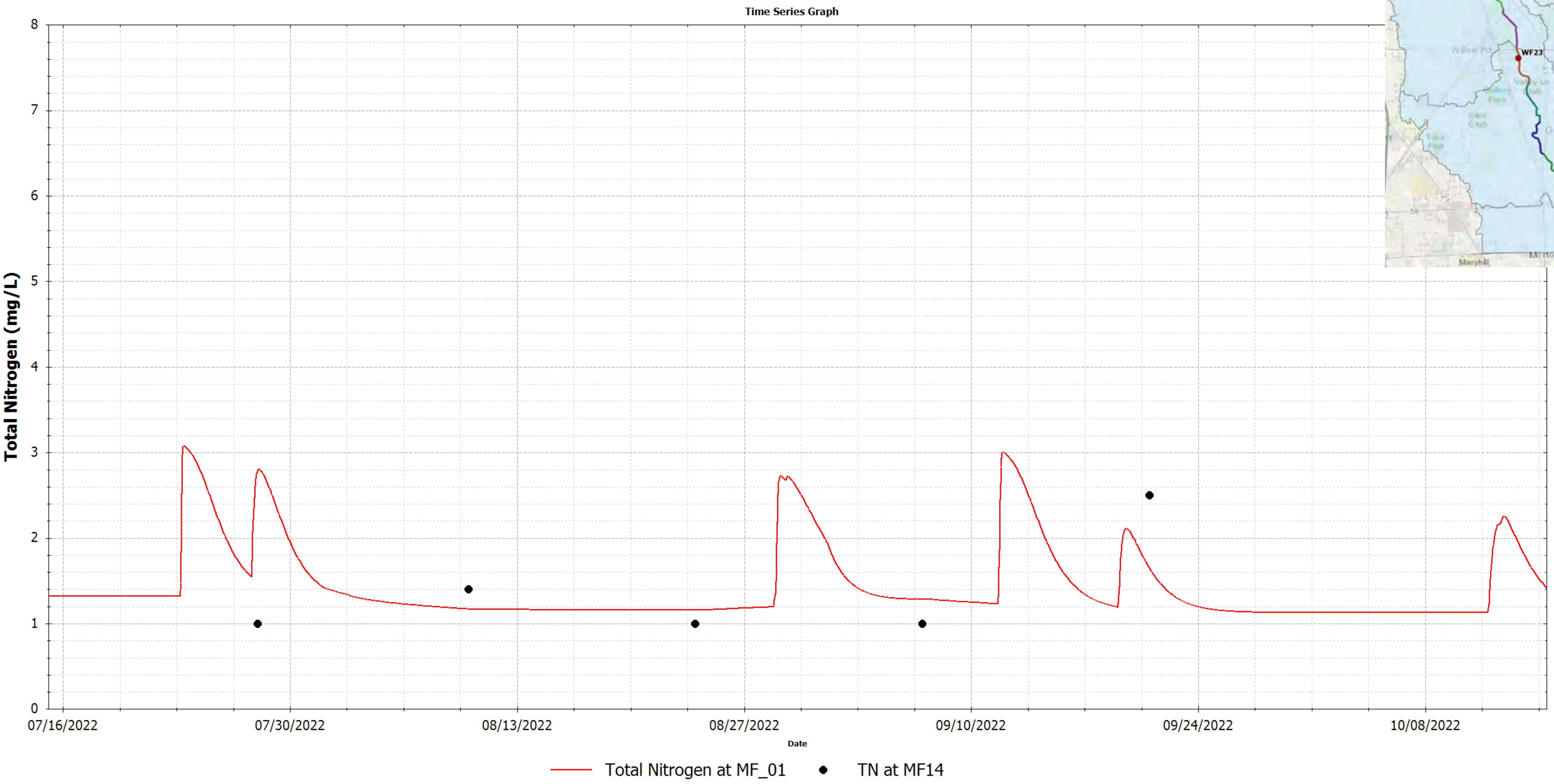


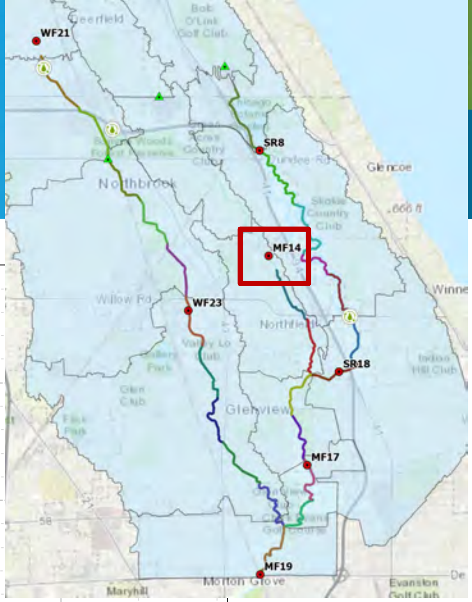
Calibration Results – TN SR18



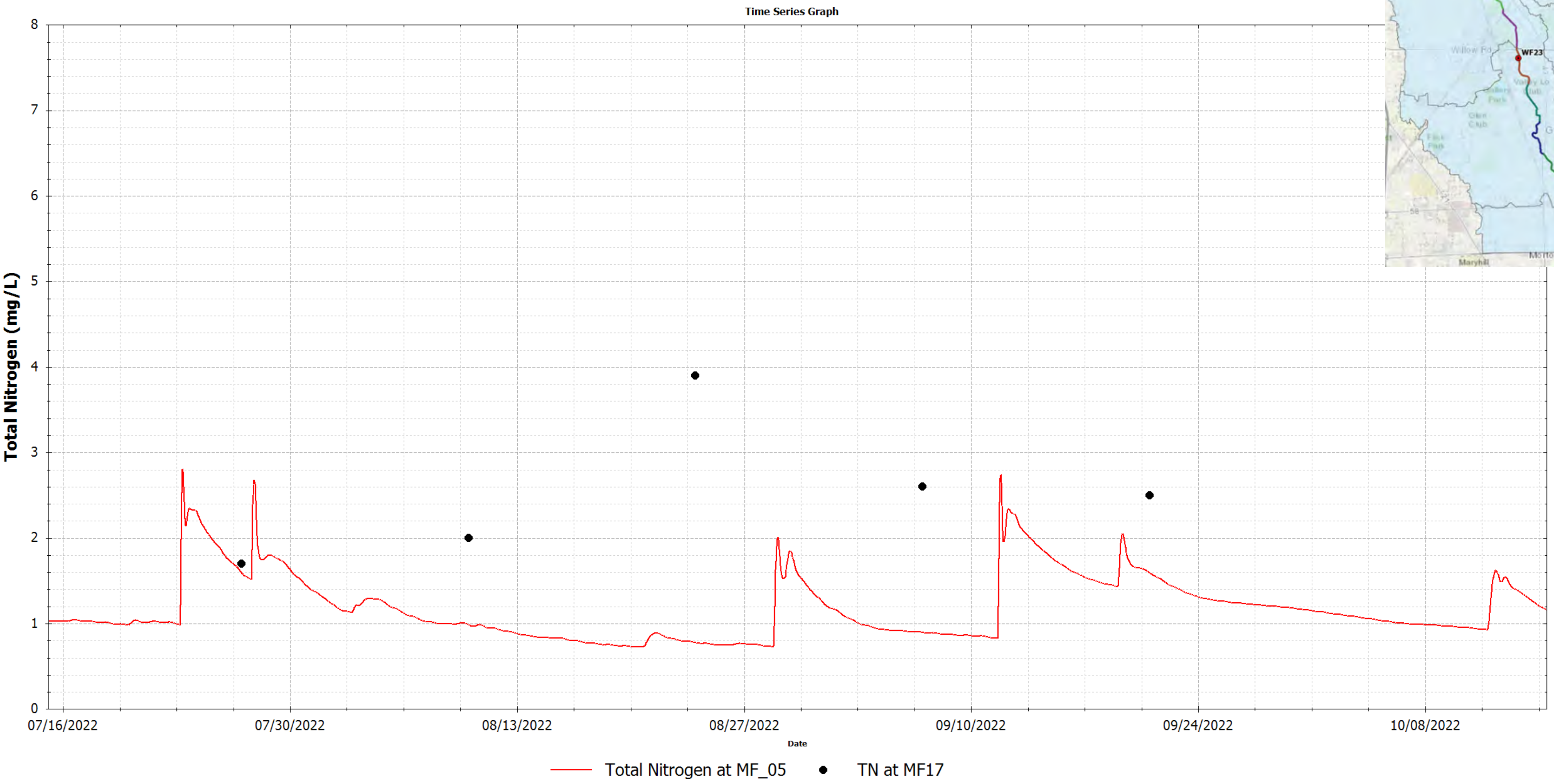


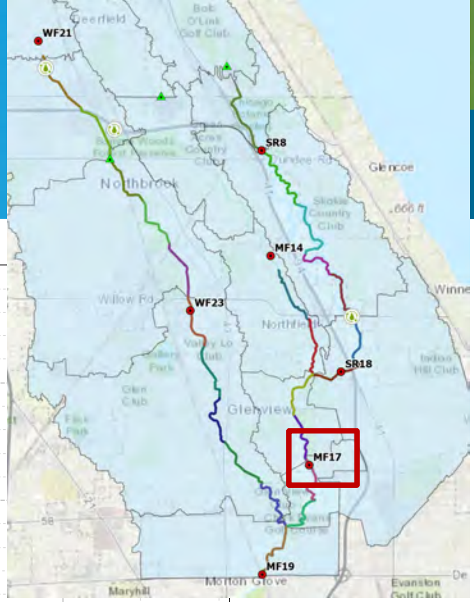
Calibration Results – TN MF14



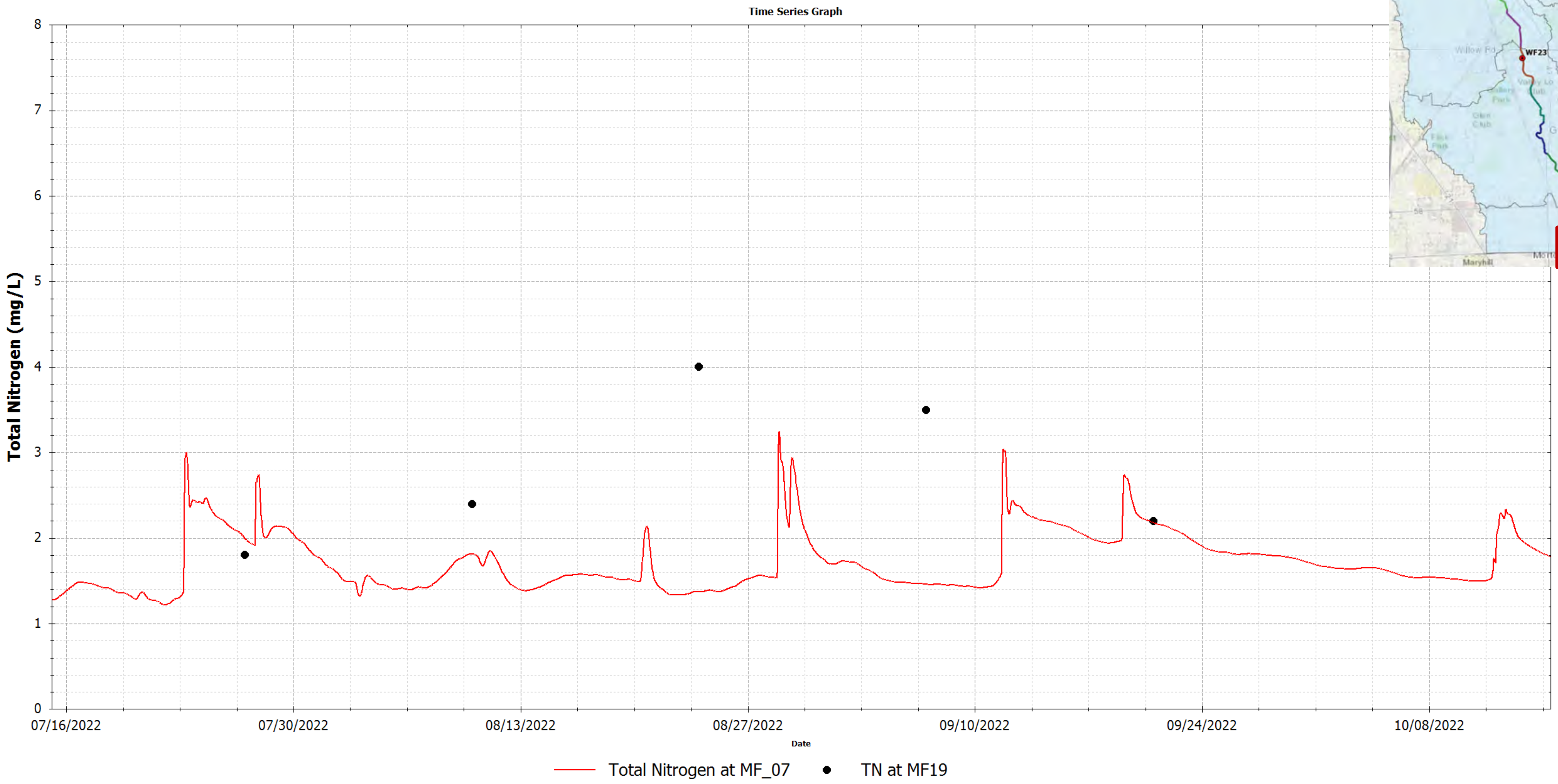


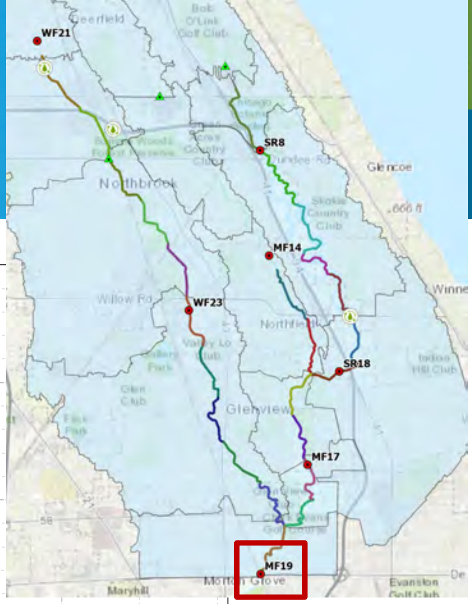
Calibration Results – TN MF17





Calibration Results – TN MF19





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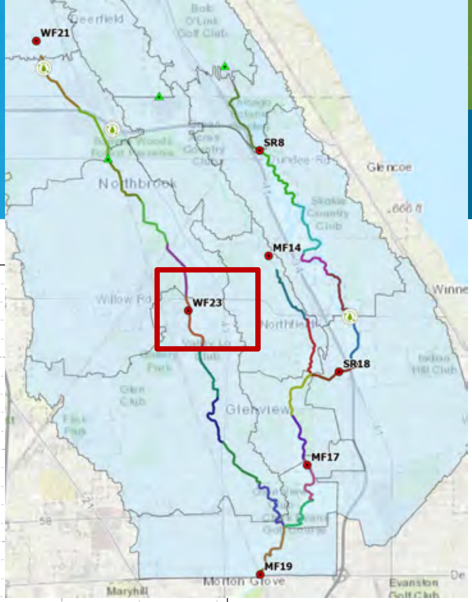
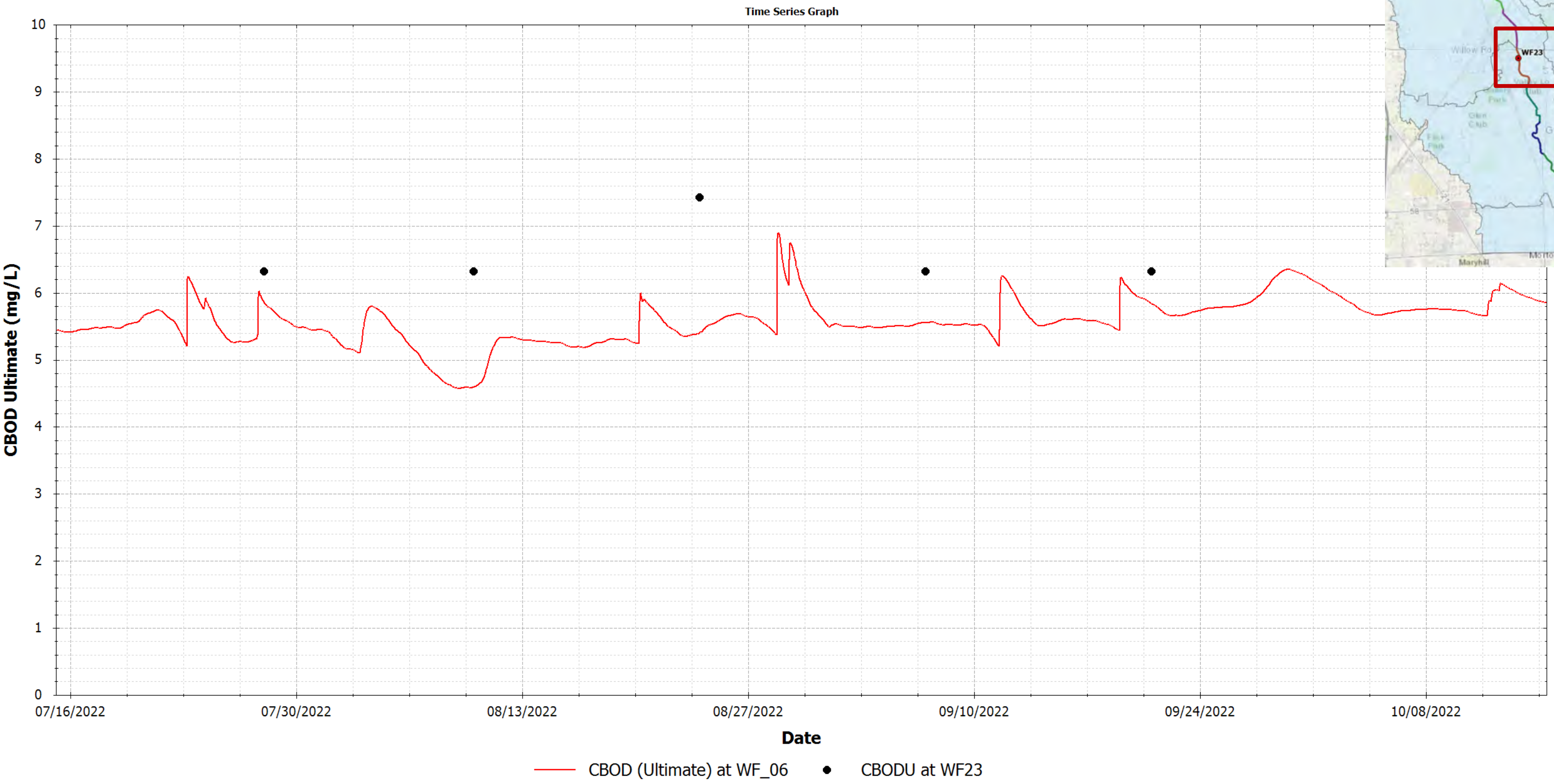
NBWW NARP: CBODU Calibration

Calibration Results – CBODU WF23

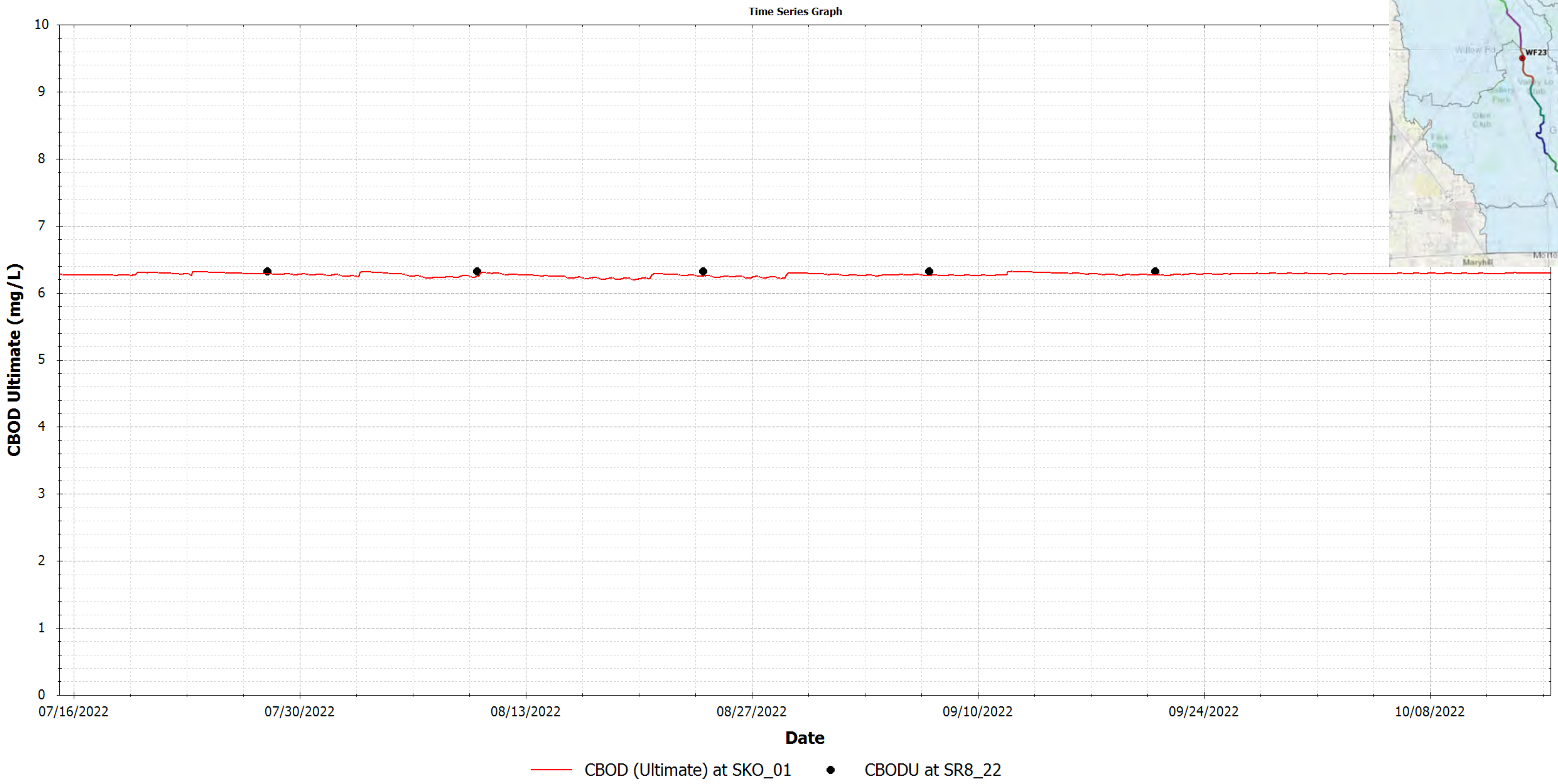
$$CBOD_U = \frac{CBOD_5}{1 - e^{-kt}}$$

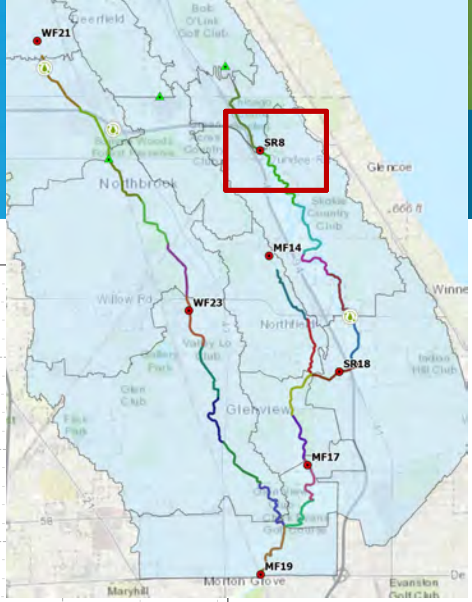
CBODU = CBOD5 * 1.58





Calibration Results – CBODU SR8





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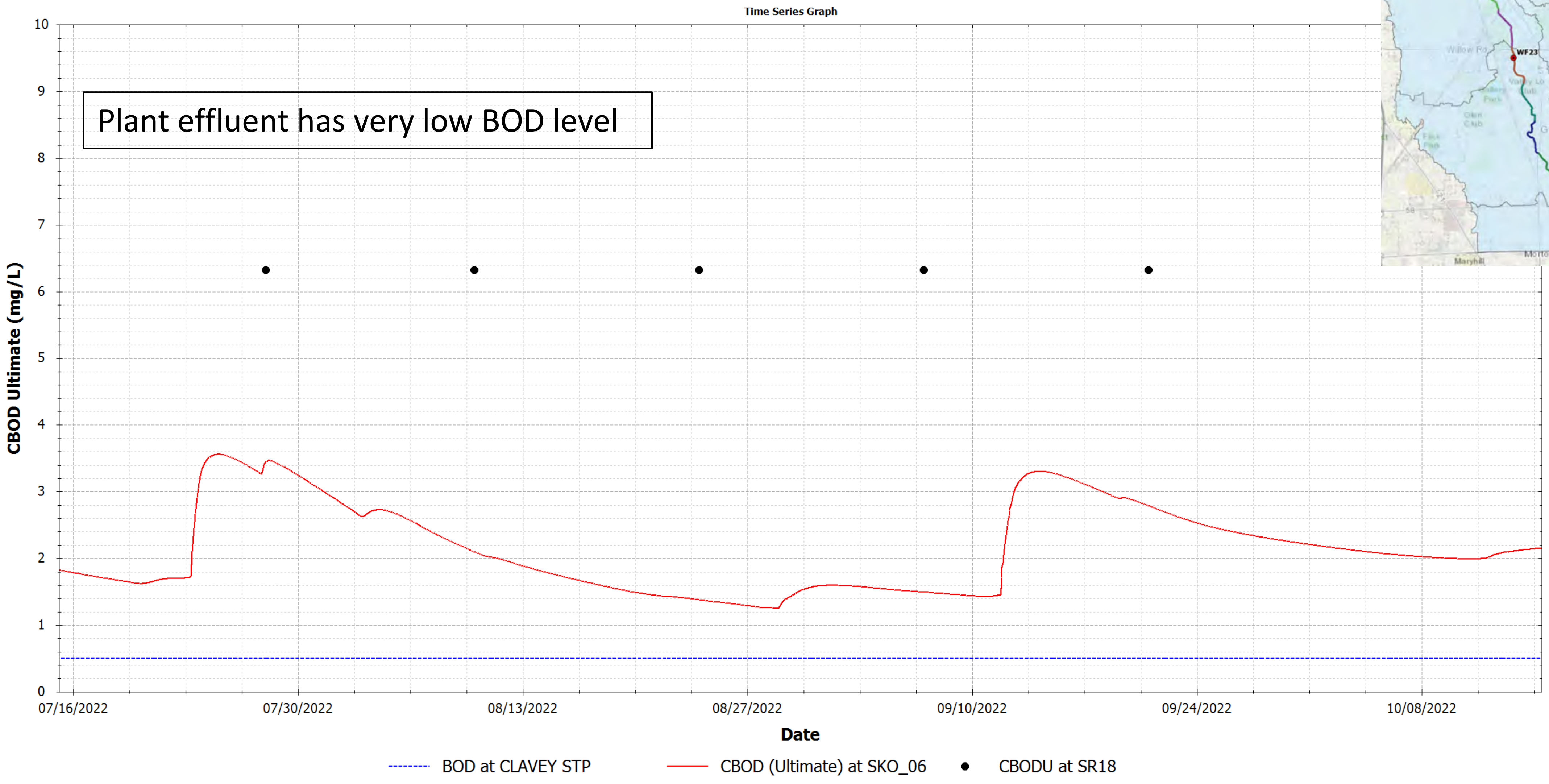
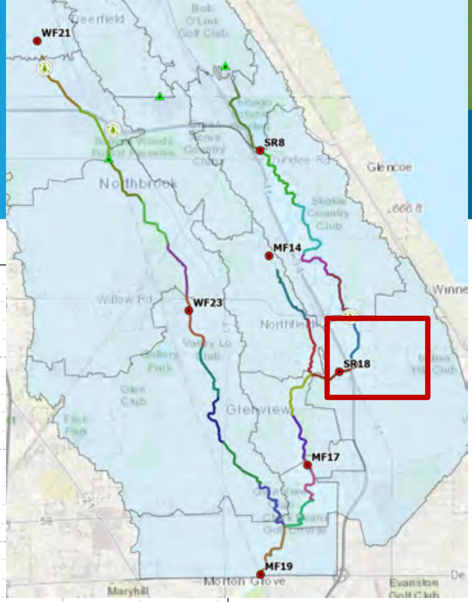
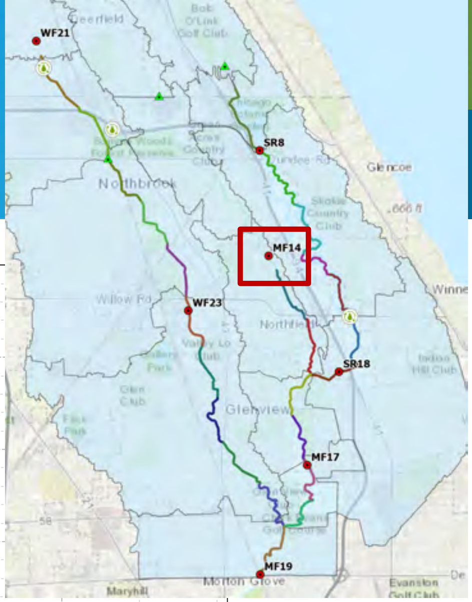
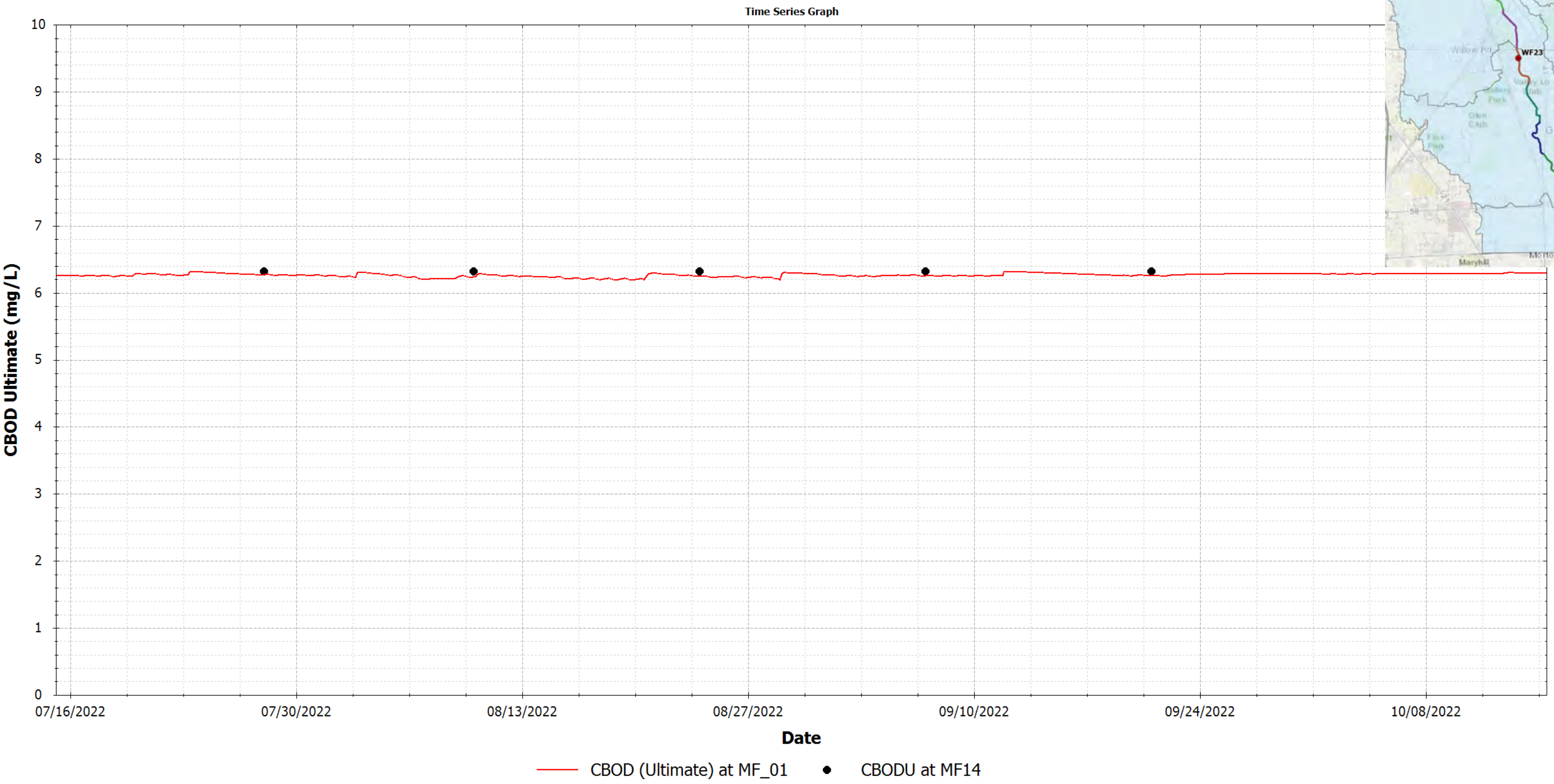


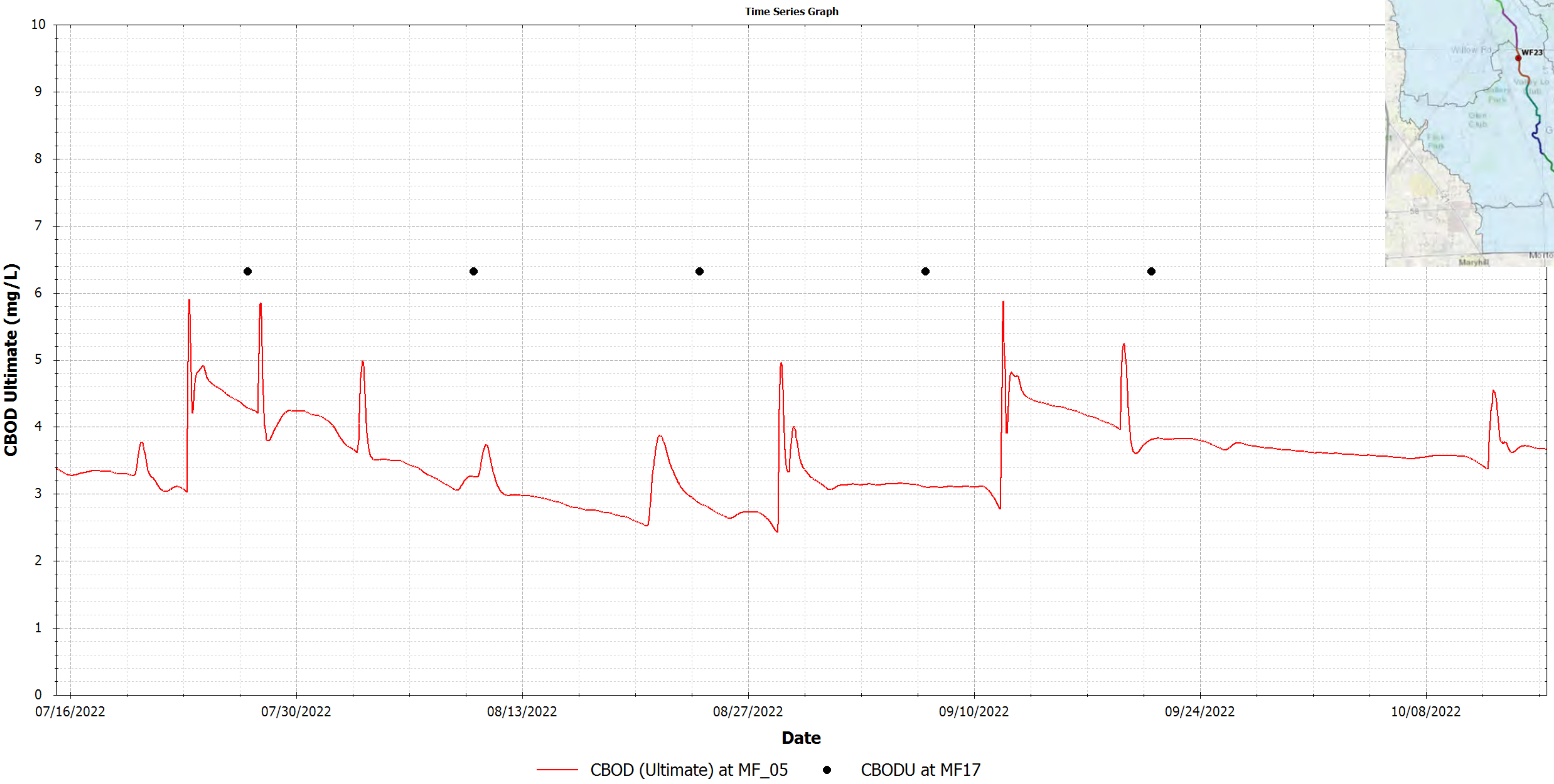


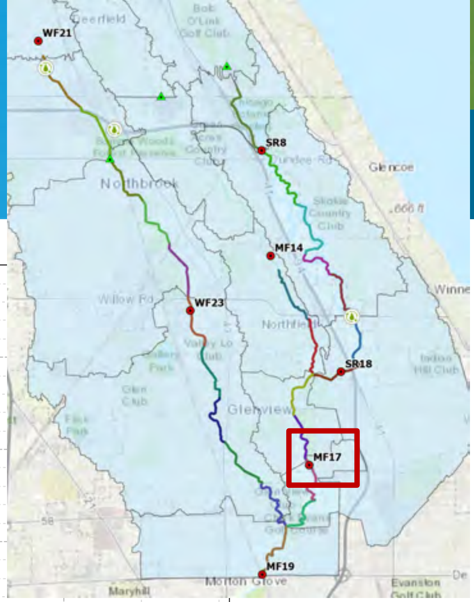
Calibration Results – CBOD MF14



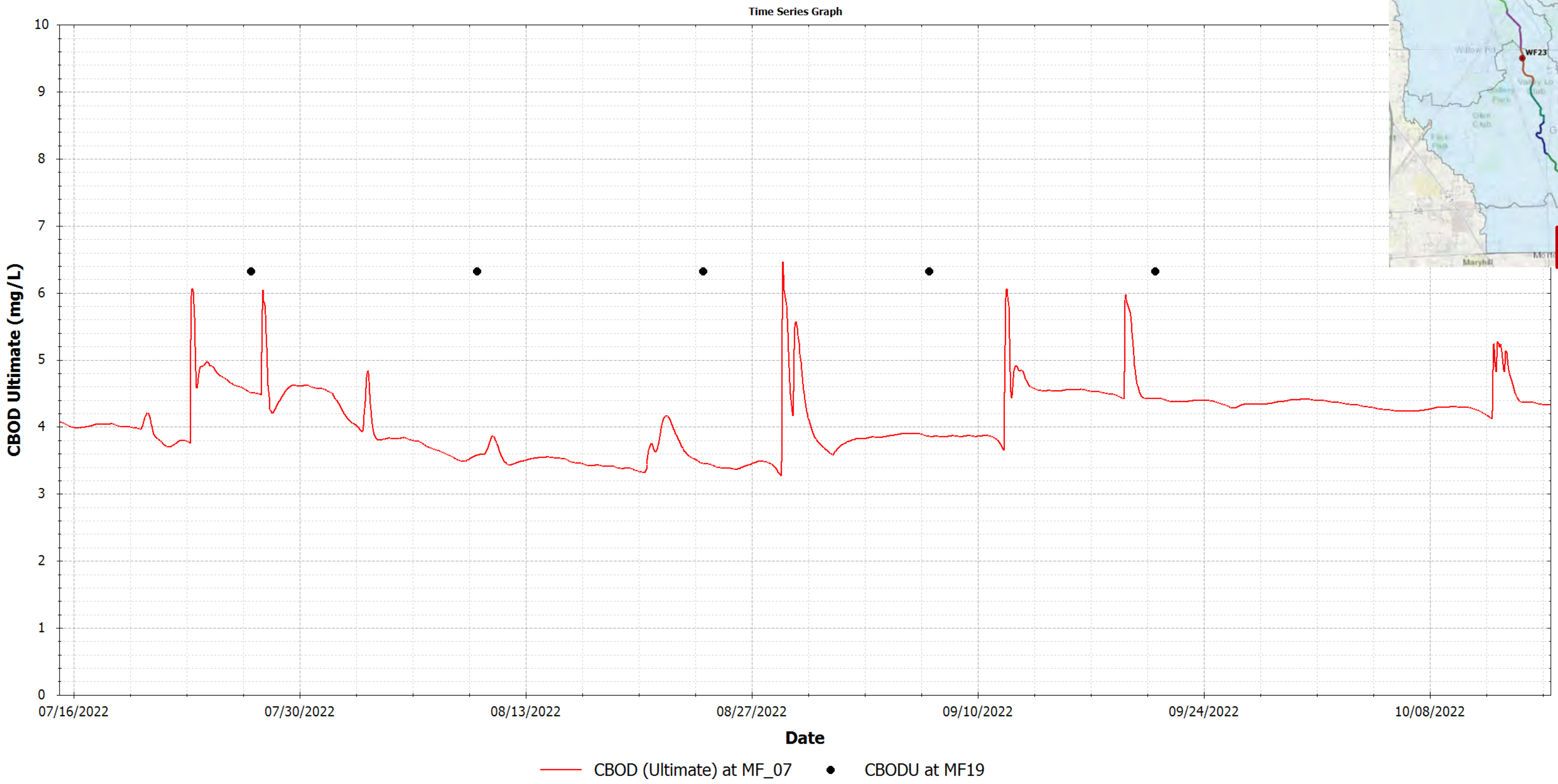


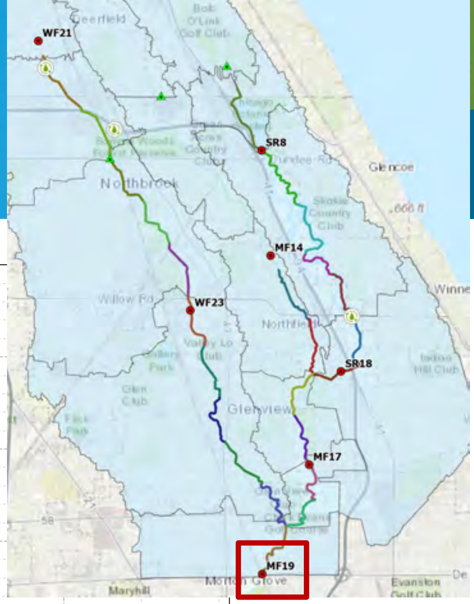
Calibration Results – CBODU MF17





Calibration Results – CBODU MF19





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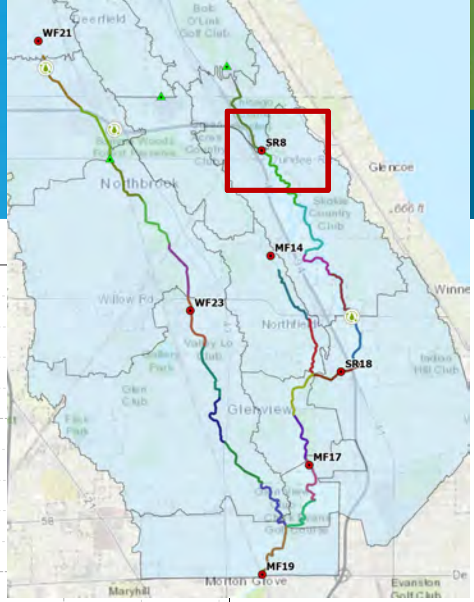
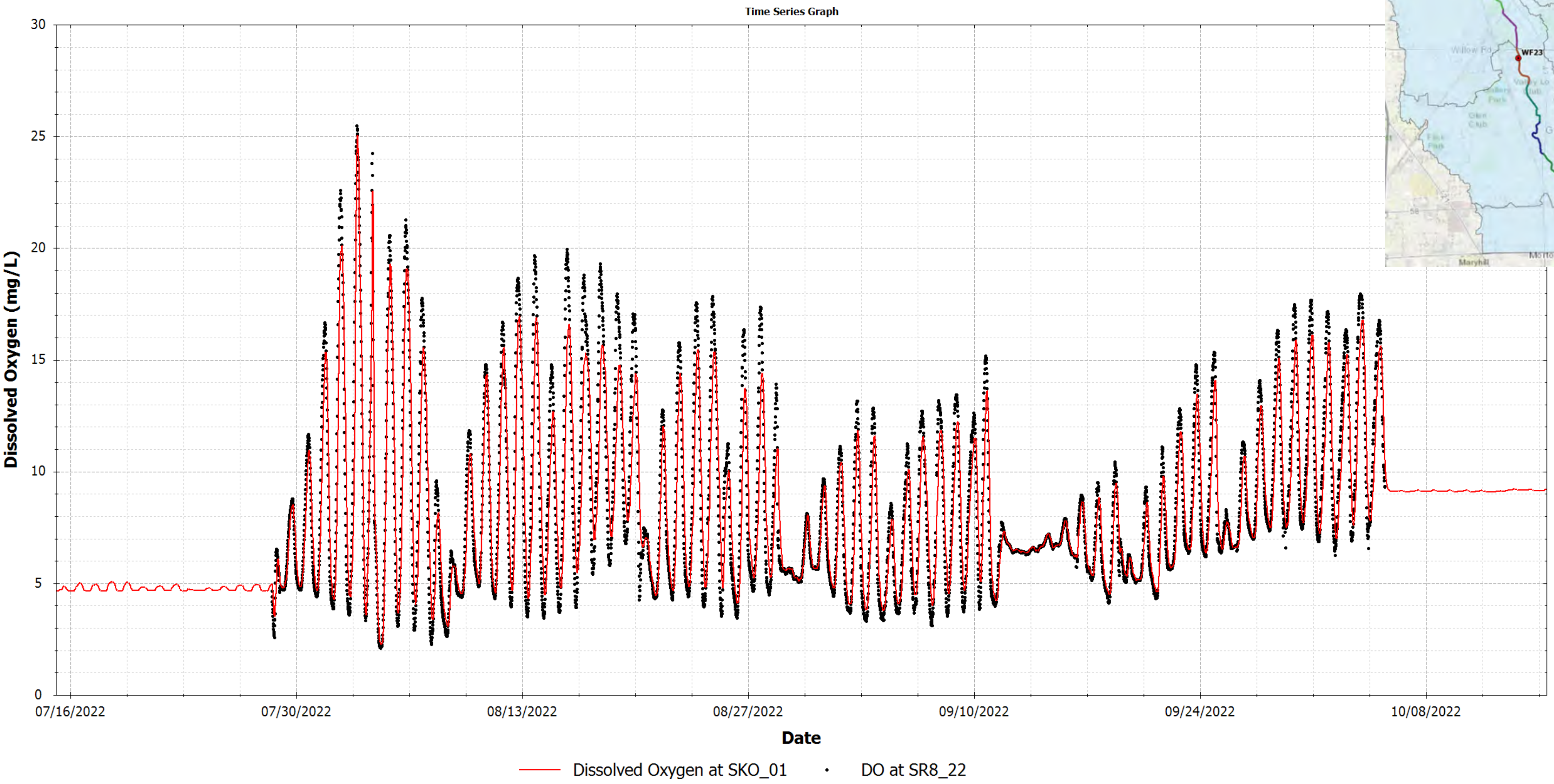
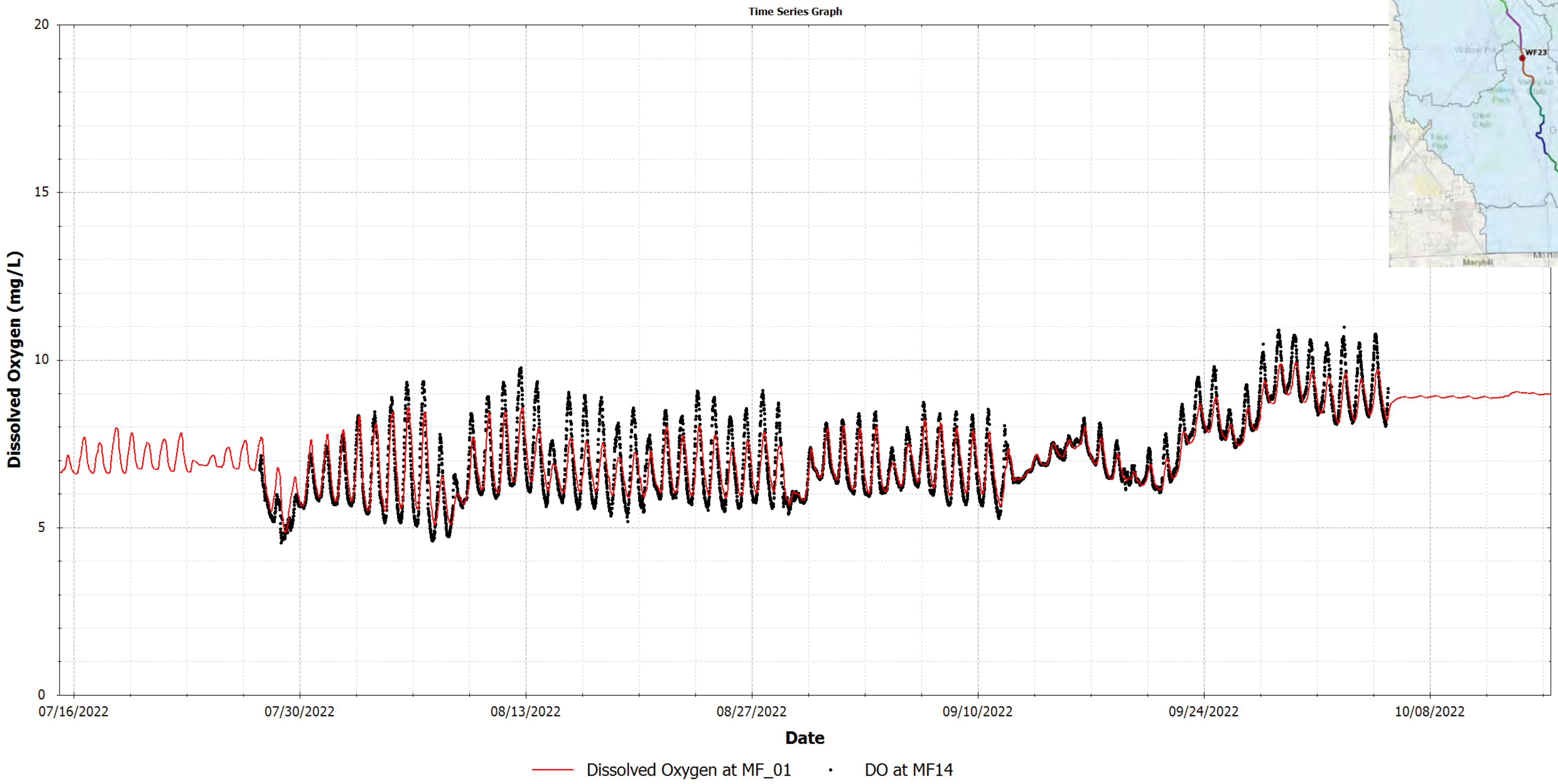
NBWW NARP: DO Calibration

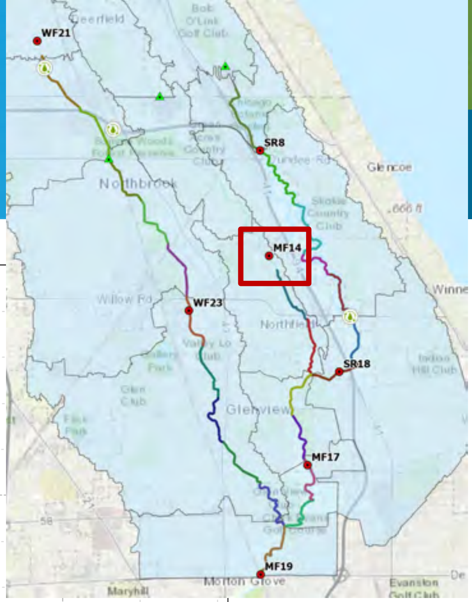
Calibration Results – DO SR8



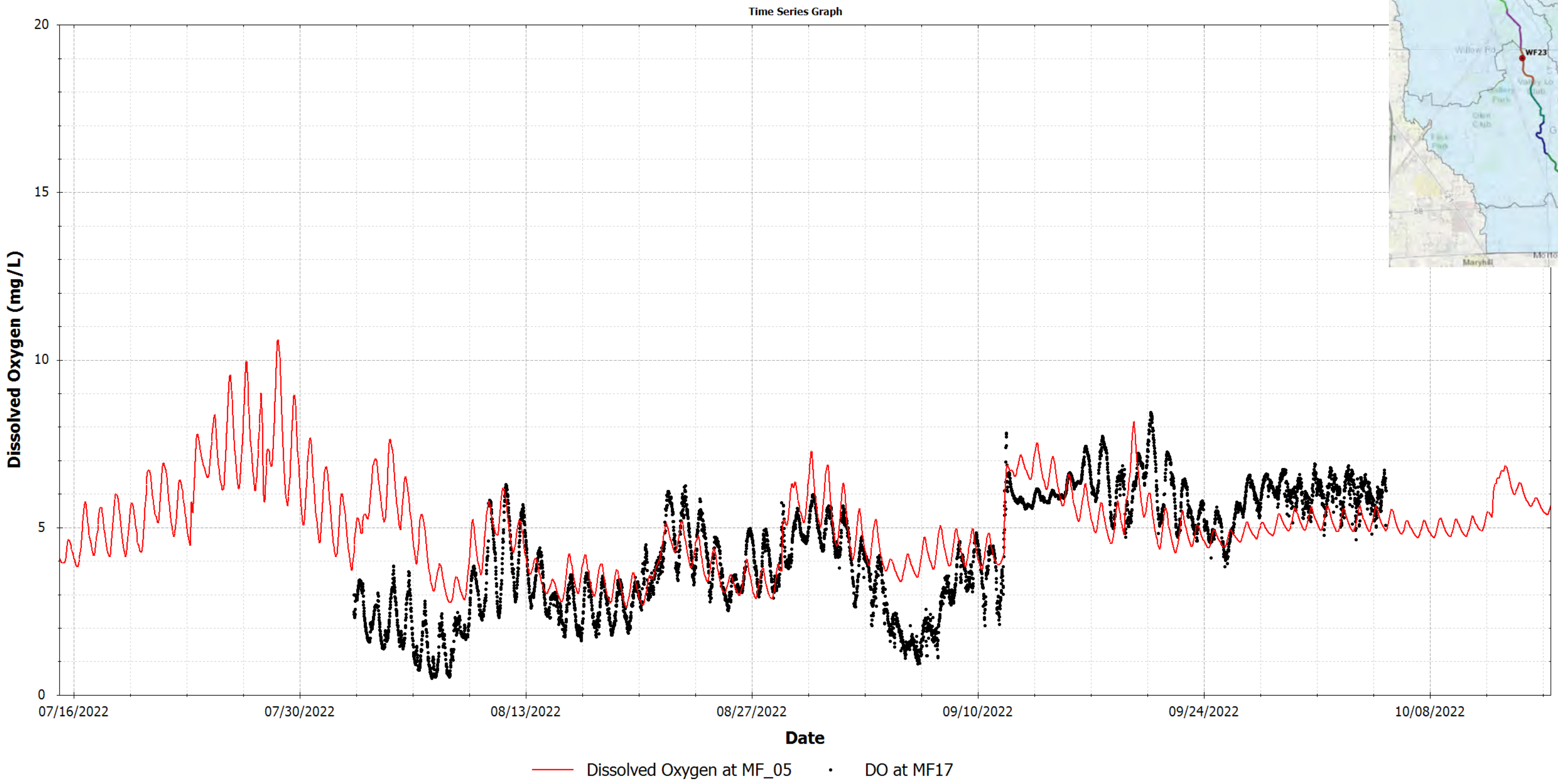


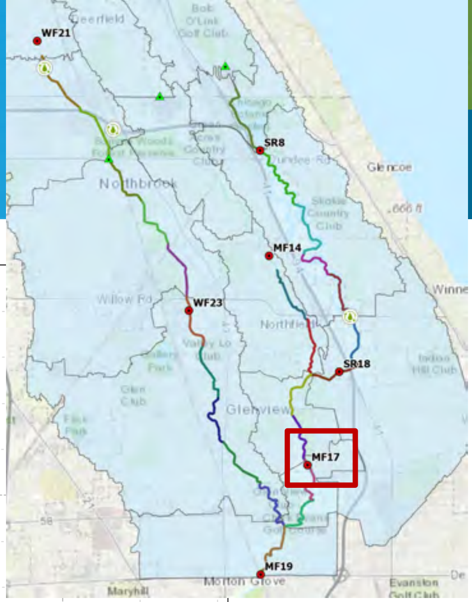
Calibration Results – DO MF14





Calibration Results – DO MF17





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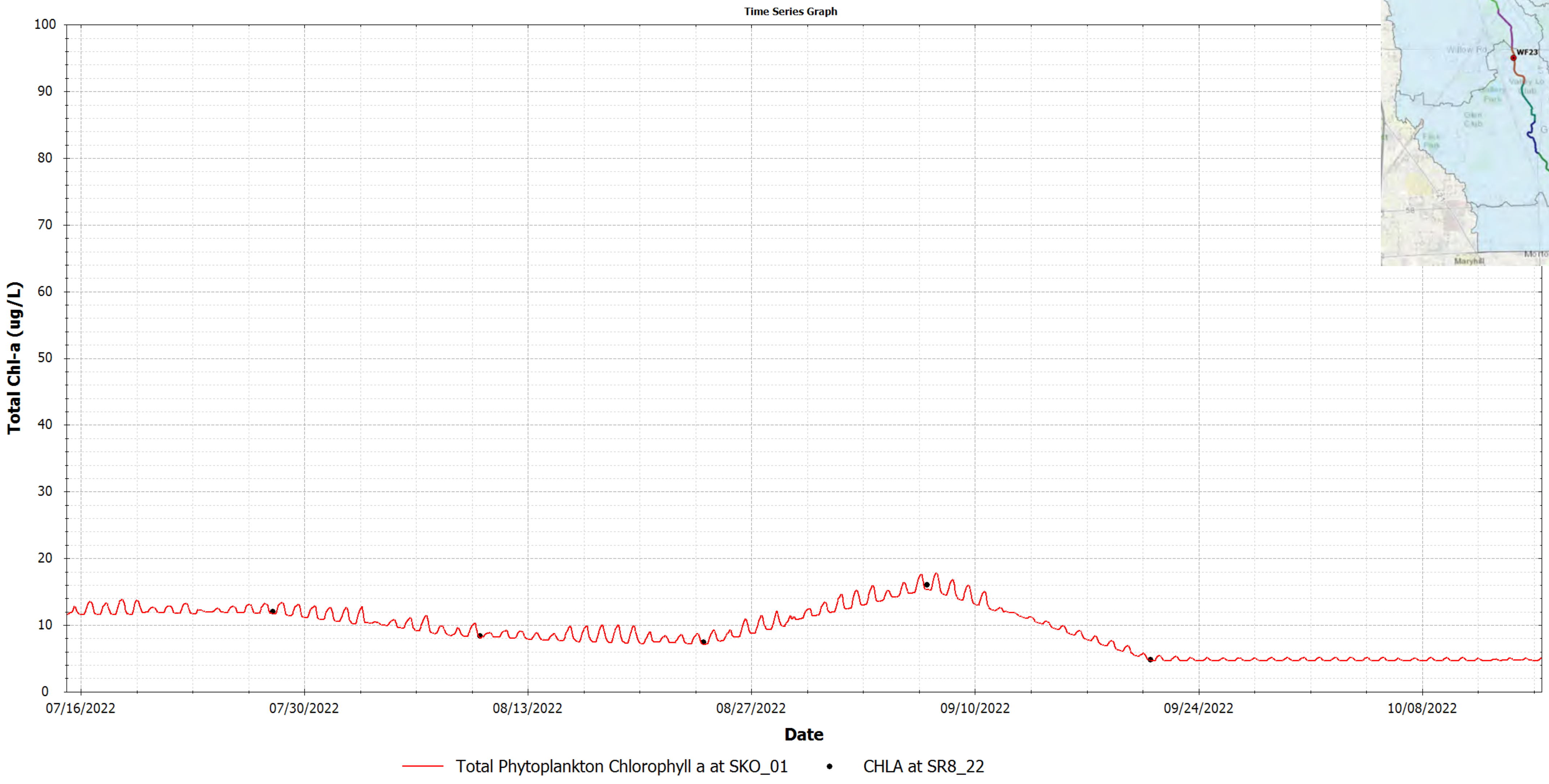
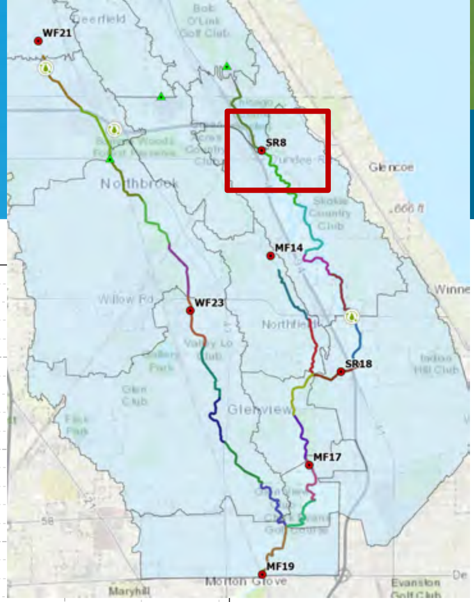
NBWW NARP: CHLA Calibration

Calibration Results – CHLA SR8





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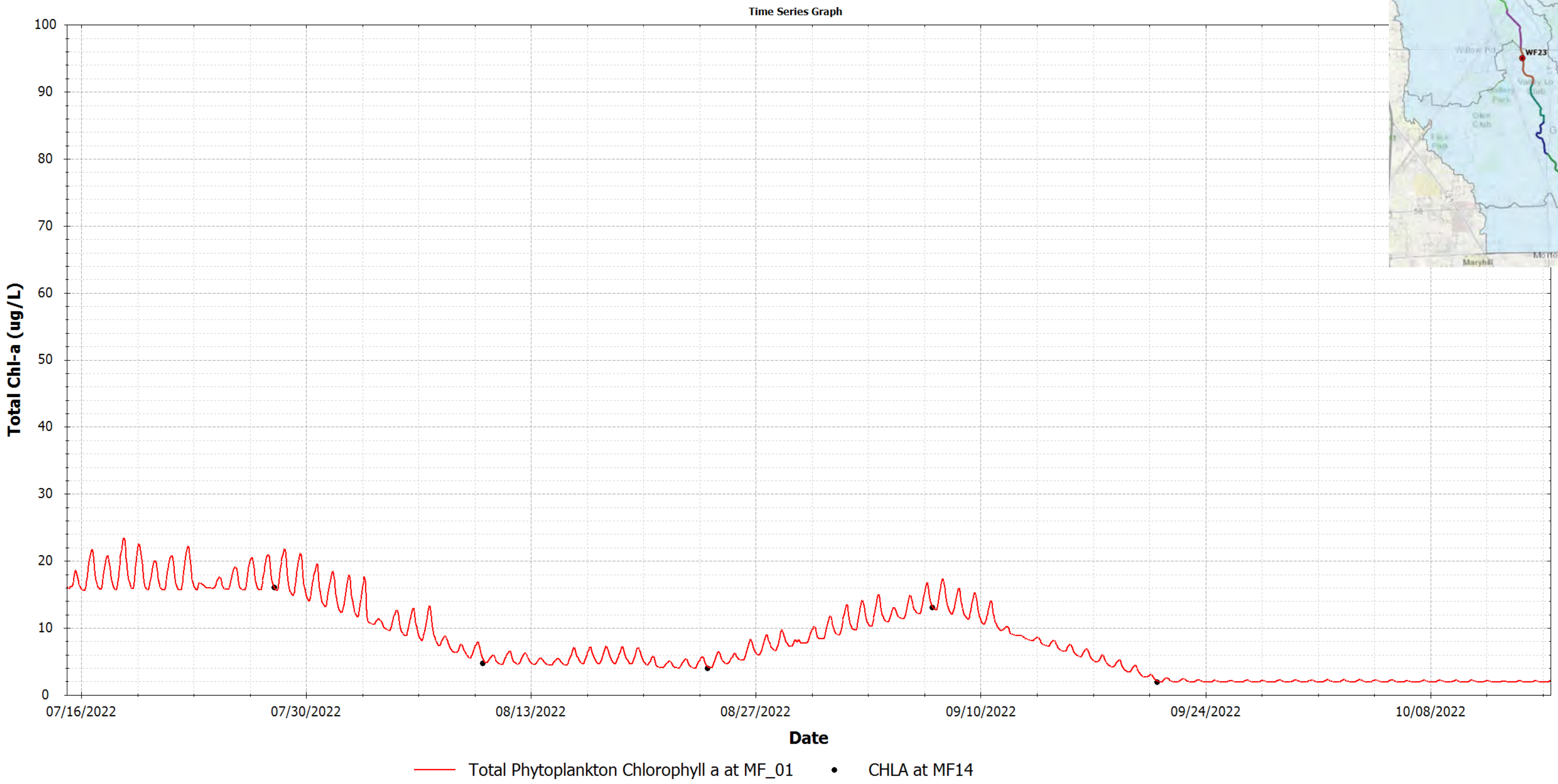
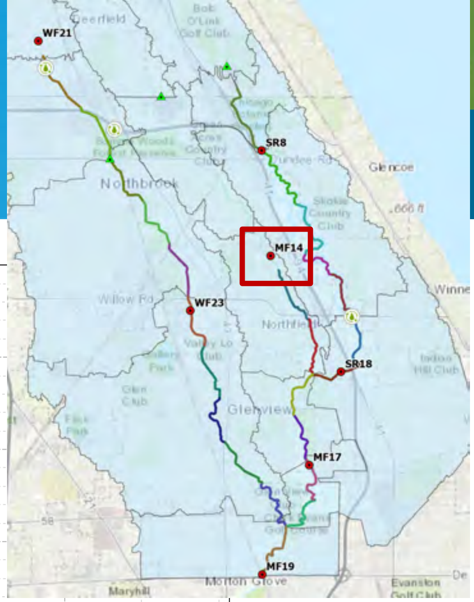
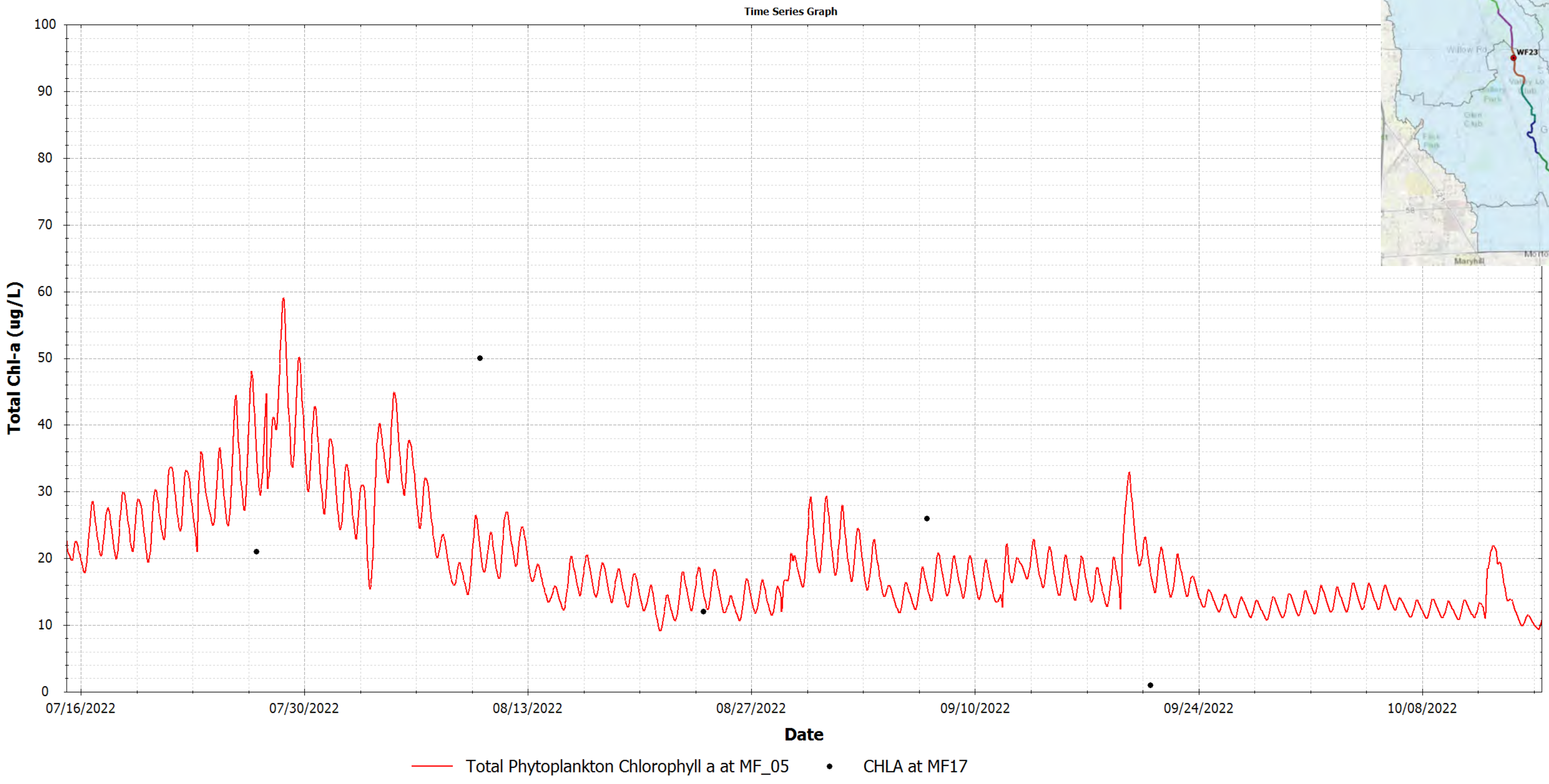
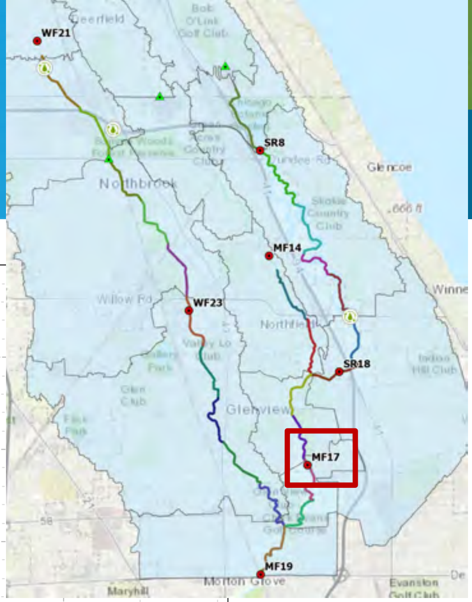




Calibration Results – CHLA MF17





Appendix C: Management Scenarios and Implementation Survey

NORTH BRANCH CHICAGO RIVER WATERSHED WORKGROUP

Geosyntec consultants

NBWW NARP: Management Scenarios & Implementation Survey

February 19, 2025

Annual Membership Meeting

Brian Valleskey, Project Manager
Yifan He, Water Resources Engineer
Geosyntec

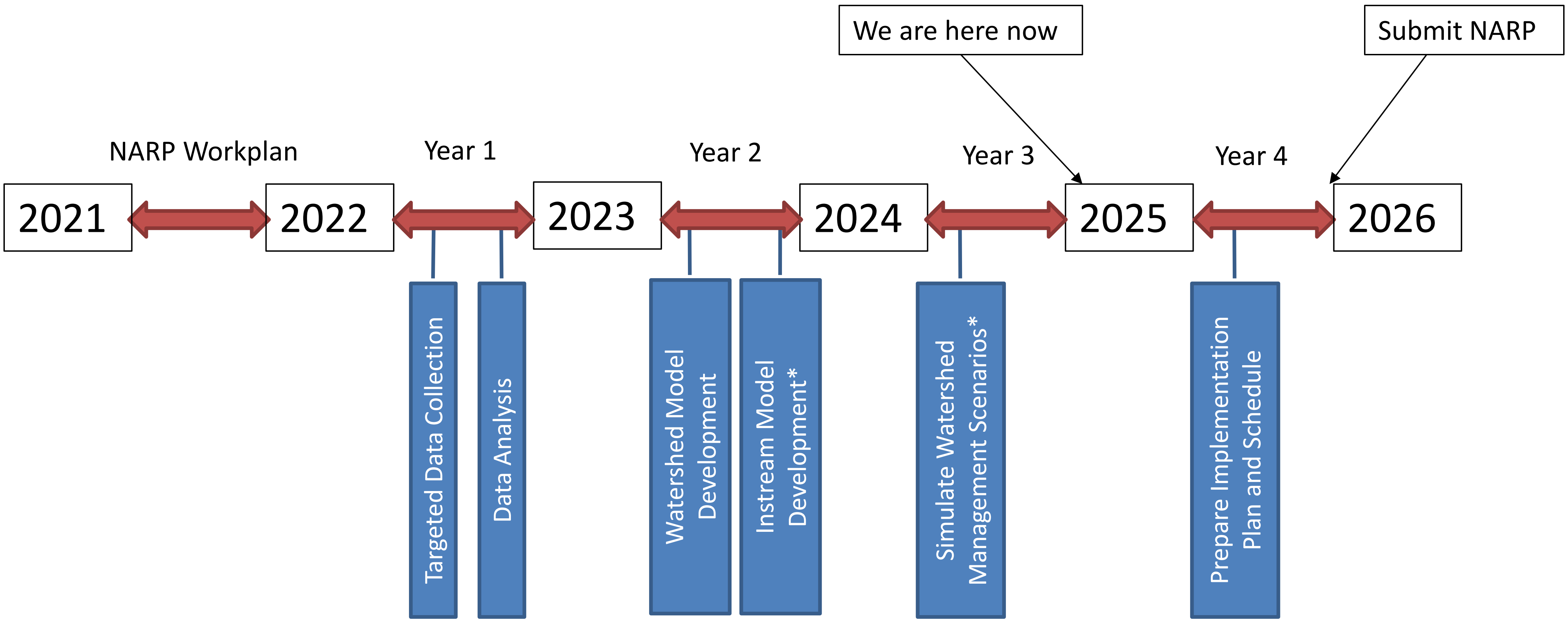
AGENDA

- Recap of progress from previous meeting (Aug ‘24)
- Recap of baseline scenarios completed to date (WWTF reductions only)
- Selected Scenarios (selected by monitoring and executive committees)
- Results of selected scenarios completed to date
- Survey to inform implementation

NSWRD Clayvey Rd WRF

Deerfield WRF

NBWW NARP General Timeline and Schedule



*Indicates task spans more than one fiscal year

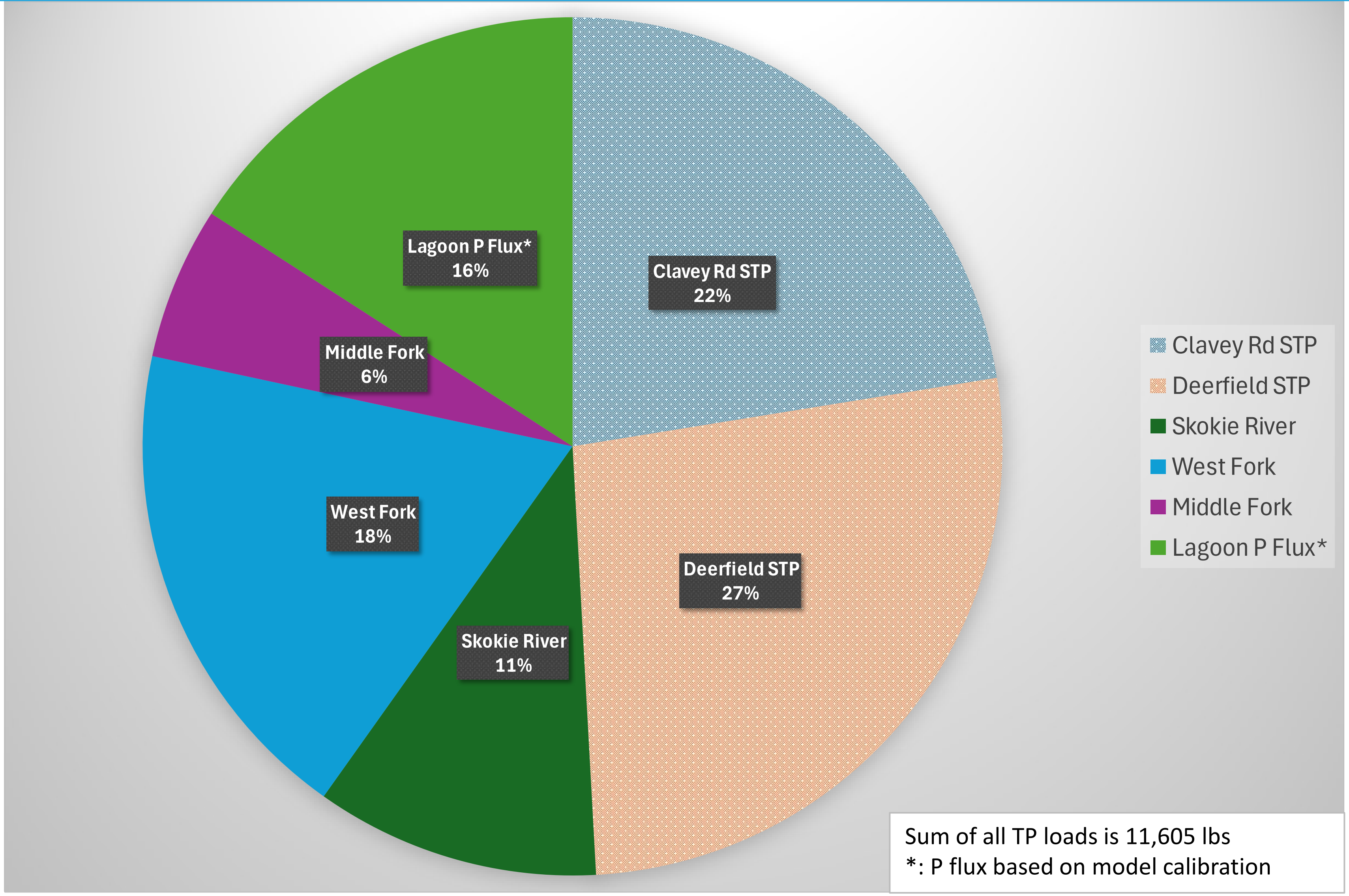
RECAP: Results from baseline scenarios (WWTF reductions)

Management Scenarios

The calibrated 2022 model was selected to be the baseline scenario. Additional management scenarios include:

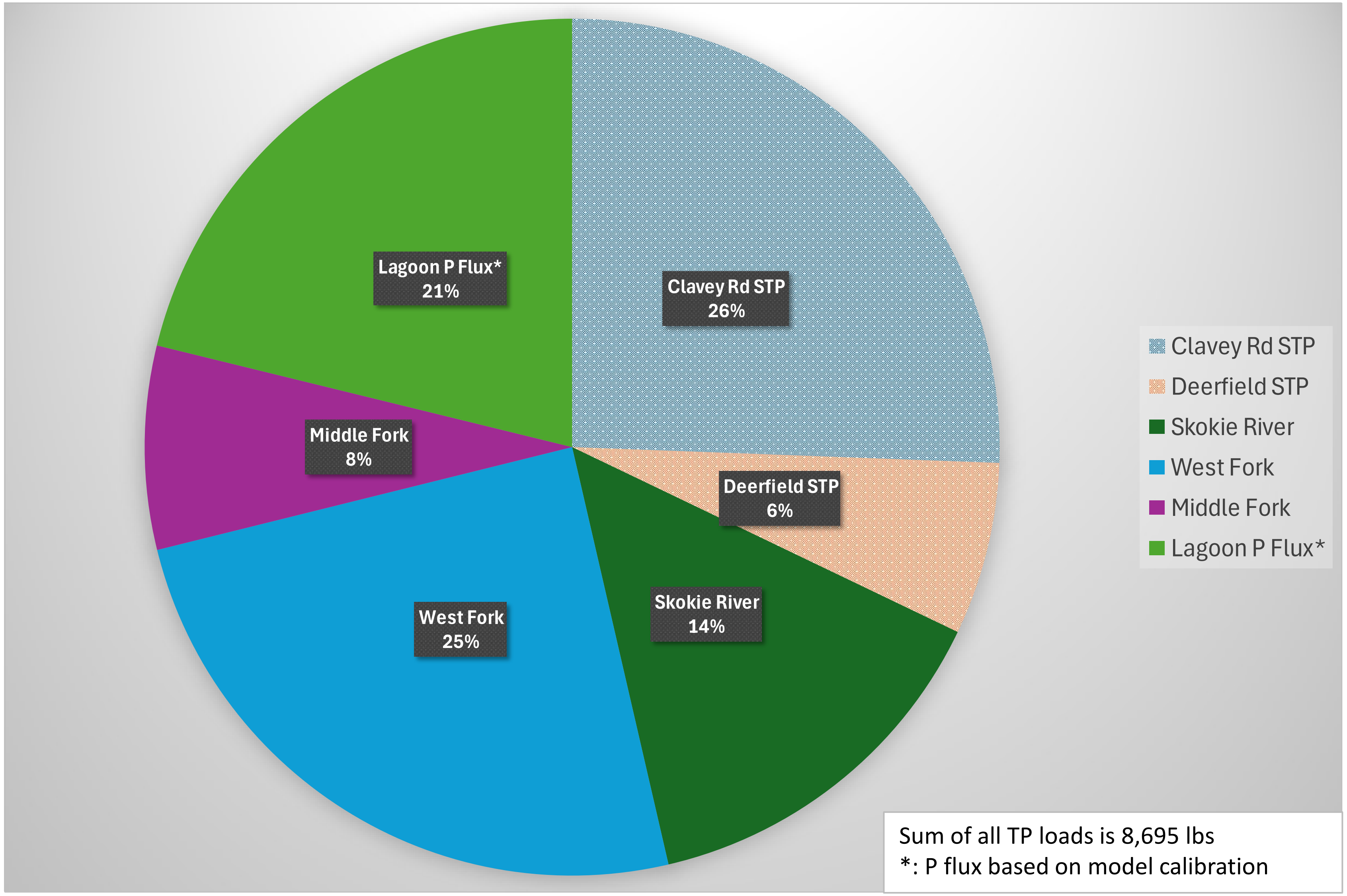
1. Impact to receiving streams if Clavey STP discharges downstream of the lagoon instead of upstream in 2022
2. Impact to receiving streams when POTWs cap effluent TP concentrations to 0.5 mg/L
3. Impact to receiving streams when POTWs cap effluent TP concentrations to 0.1 mg/L

Baseline - TP Loads in lbs from Jul 28 to Oct 5, 2022



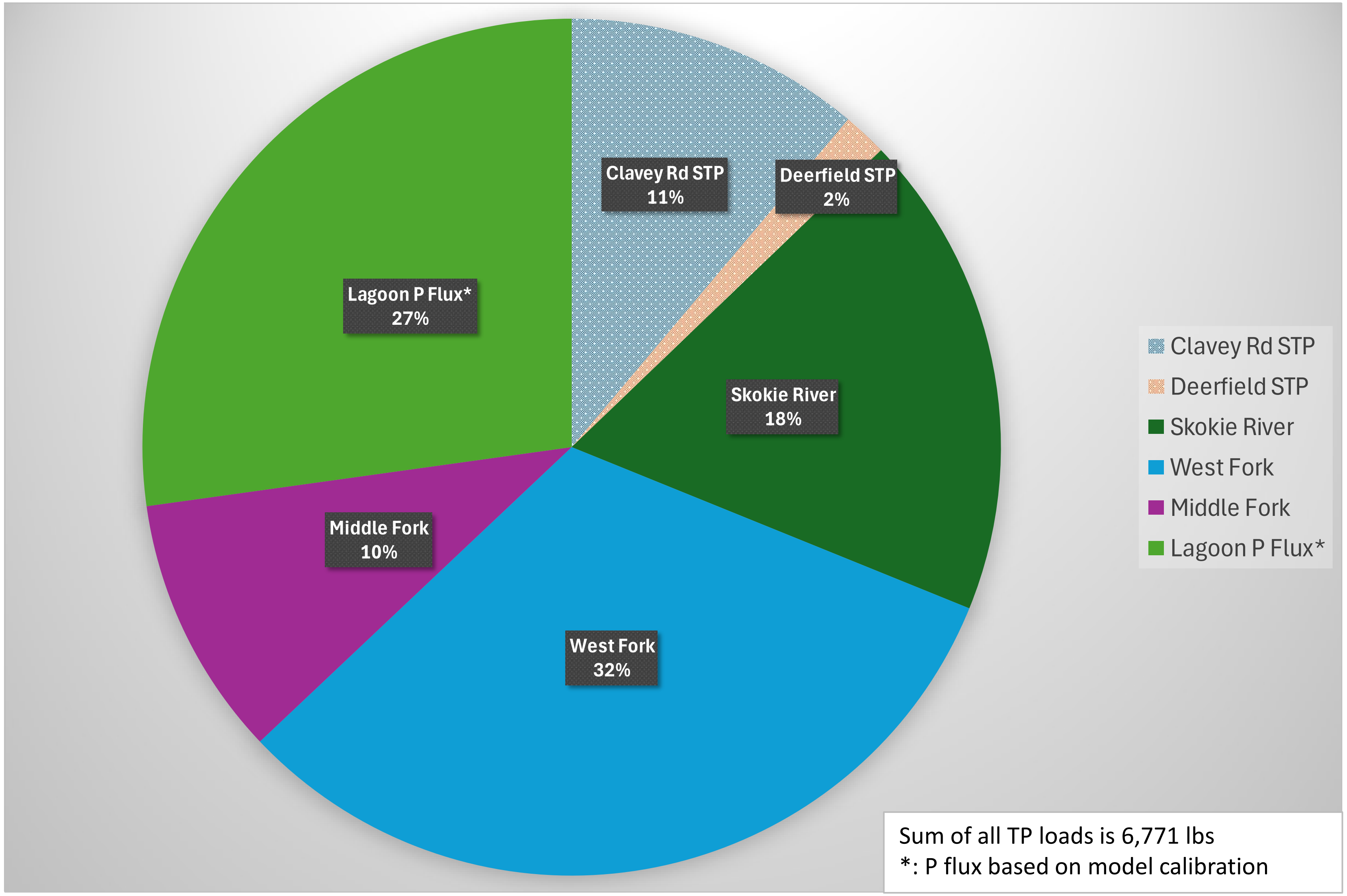
Sum of all TP loads is 11,605 lbs
*: P flux based on model calibration

Capped to 0.5 mg/L - TP Loads in lbs from Jul 28 to Oct 5, 2022



Sum of all TP loads is 8,695 lbs
*: P flux based on model calibration

Capped to 0.1 mg/L - TP Loads in lbs from Jul 28 to Oct 5, 2022



Sum of all TP loads is 6,771 lbs
*: P flux based on model calibration

Takeaways

- Moving the Clavey STP discharge outfall from upstream of the lagoon to downstream of the lagoon will lead to:
  - Reduced chl-*a* concentration downstream of the lagoon due to dilution but increased chl-*a* concentration upstream of the lagoon
  - Improved DO condition downstream of the lagoon (reduced %time DO below minimum standards)

Takeaways

- For 2022 baseline condition, most of the Clavey STP effluent TP measurements were already below 0.5mg/L, so capping TP to 0.5 mg/L does not show much difference
- Capping effluent TP to 0.1 mg/L improves downstream chl-*a* and TP conditions very slightly. However, due to uncertainties associated with the sediment flux and model limitations, it may be difficult to justify the additional costs for the limited benefits

Takeaways

- The West Fork sees a much more significant improvements in terms of DO, chl-*a*, and TP for 2022.
- Capping Deerfield WRF effluent TP to 0.5 mg/L makes significant improvements compared to the baseline condition. Additional improvements by further reducing effluent TP to 0.1 mg/L are less significant.

Selected Scenarios

Selected Management Scenarios (listed by rank) – selected by Monitoring and Executive Committees

1. **MS4 Reduction (50%)**
2. **100 lb TP reduction (to represent watershed plan implementation)**
3. Increased baseline aeration
4. Combination metrics to eliminate Risk of Eutrophication
5. Impervious Area Reduction
6. Lagoon Offline

MS4 Reduction

Geosyntec consultants

NBWW NARP Scenario Development

1. 50% Urban Runoff Reduction (~2000 lbs)

1.1. Baseline & 50% TP Reduction in Urban Runoff

1.2. WWTP TP Capped at 0.5 mg/L & 50% TP Reduction in Urban Runoff

1.3. WWTP TP Capped at 0.1 mg/L & 50% TP Reduction in Urban Runoff

NBWW NARP Scenario Development

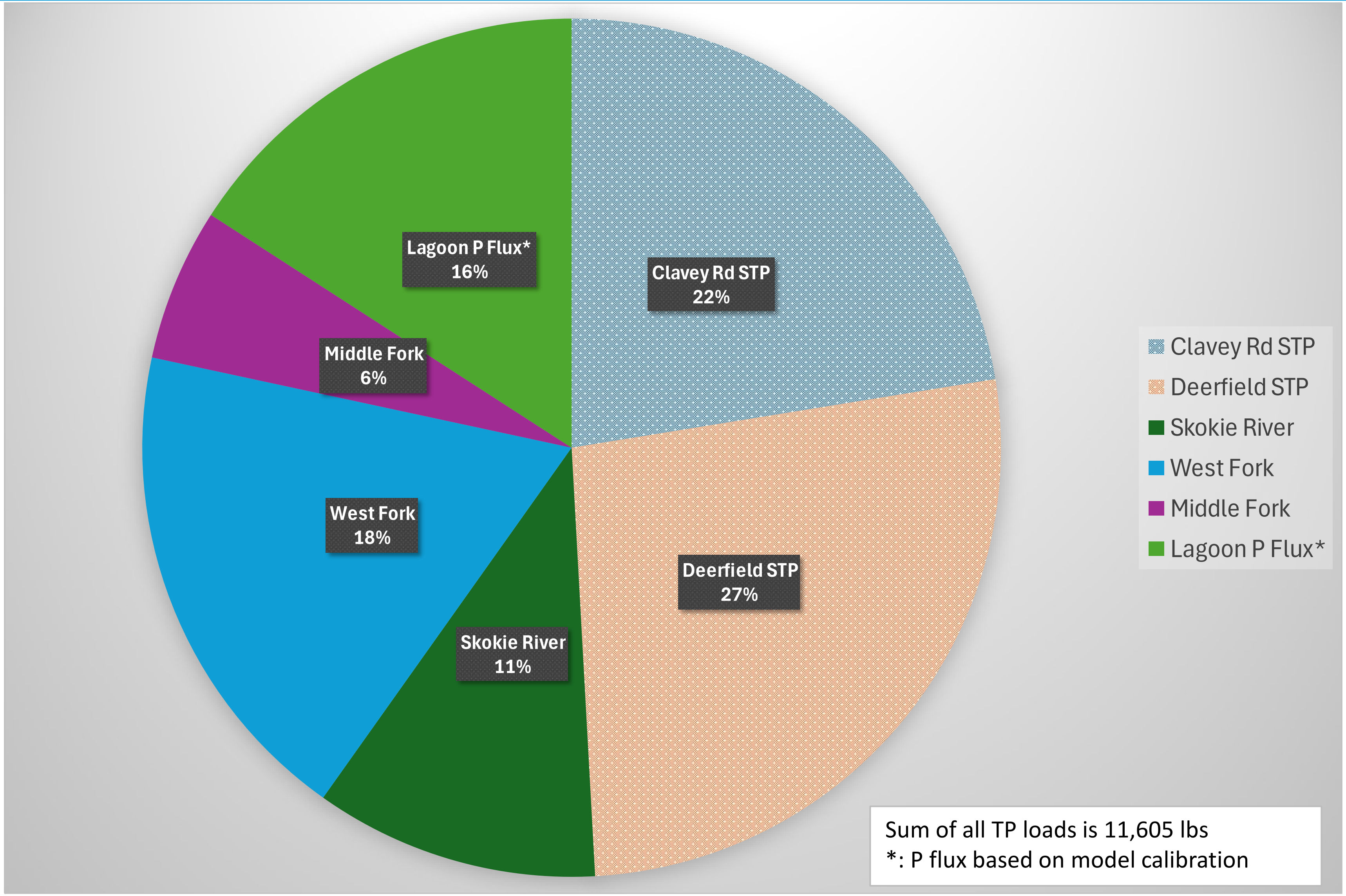
1. 50% Urban Runoff Reduction (~2000 lbs)

1.1. Baseline & 50% TP Reduction in Urban Runoff

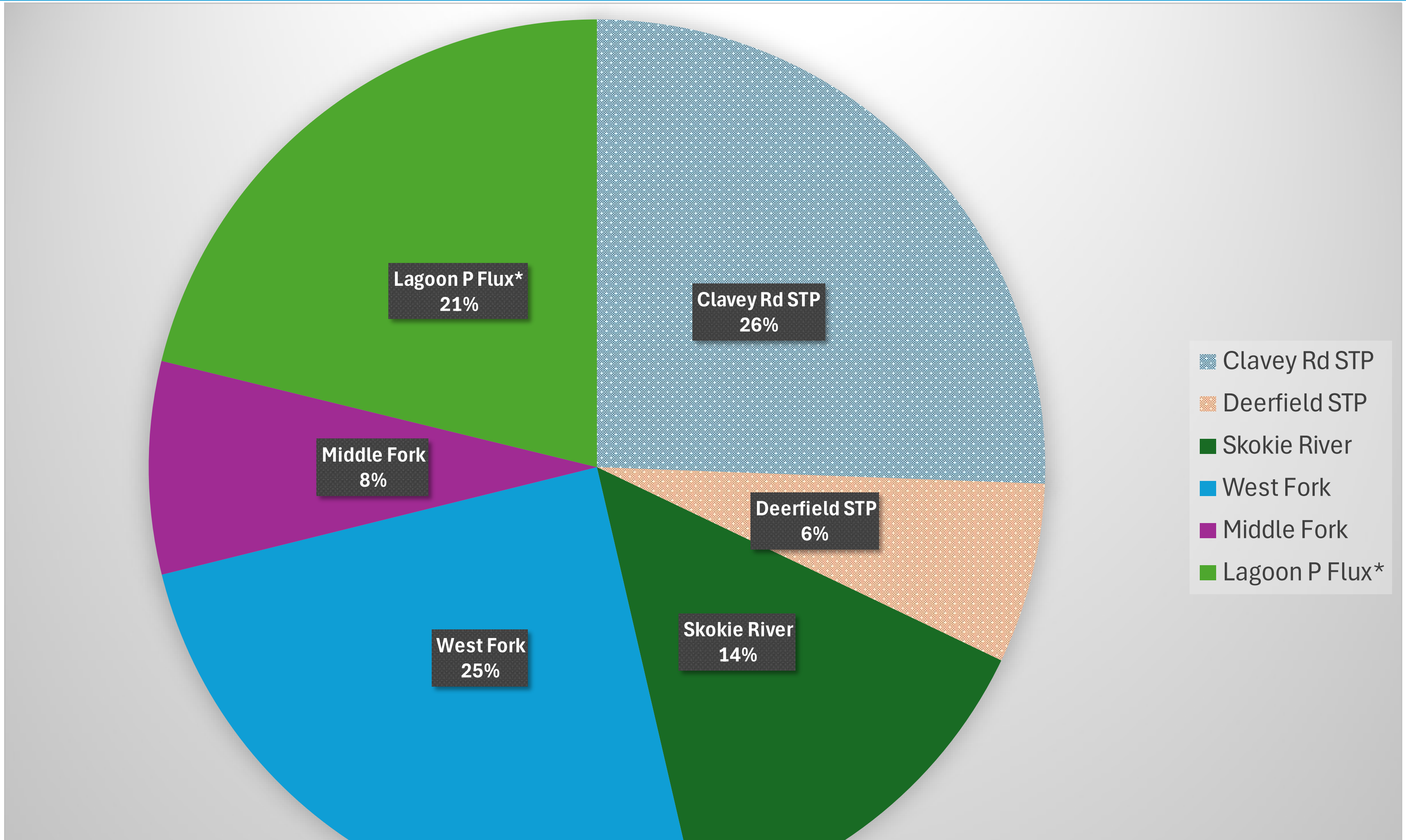
1.2. WWTP TP Capped at 0.5 mg/L & 50% TP Reduction in Urban Runoff

1.3. WWTP TP Capped at 0.1 mg/L & 50% TP Reduction in Urban Runoff

Baseline - TP Loads in lbs from Jul 28 to Oct 5, 2022

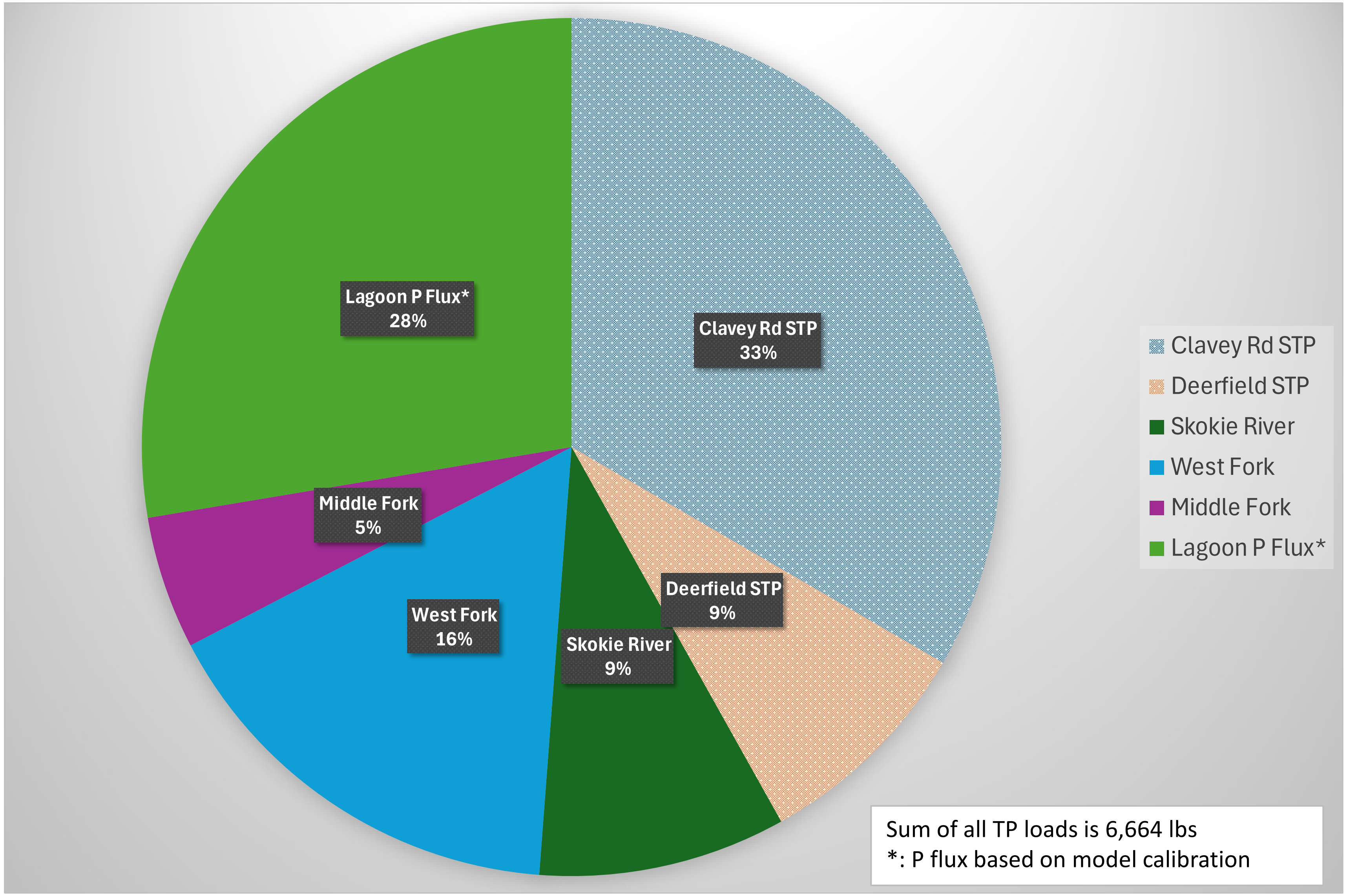


Capped to 0.5 mg/L - TP Loads in lbs from Jul 28 to Oct 5, 2022



Sum of all TP loads is 8,695 lbs
*: P flux based on model calibration

WWTP Capped to 0.5 mg/L & 50% TP Loads Reduction in lbs in Urban Runoff from Jul 28 to Oct 5, 2022



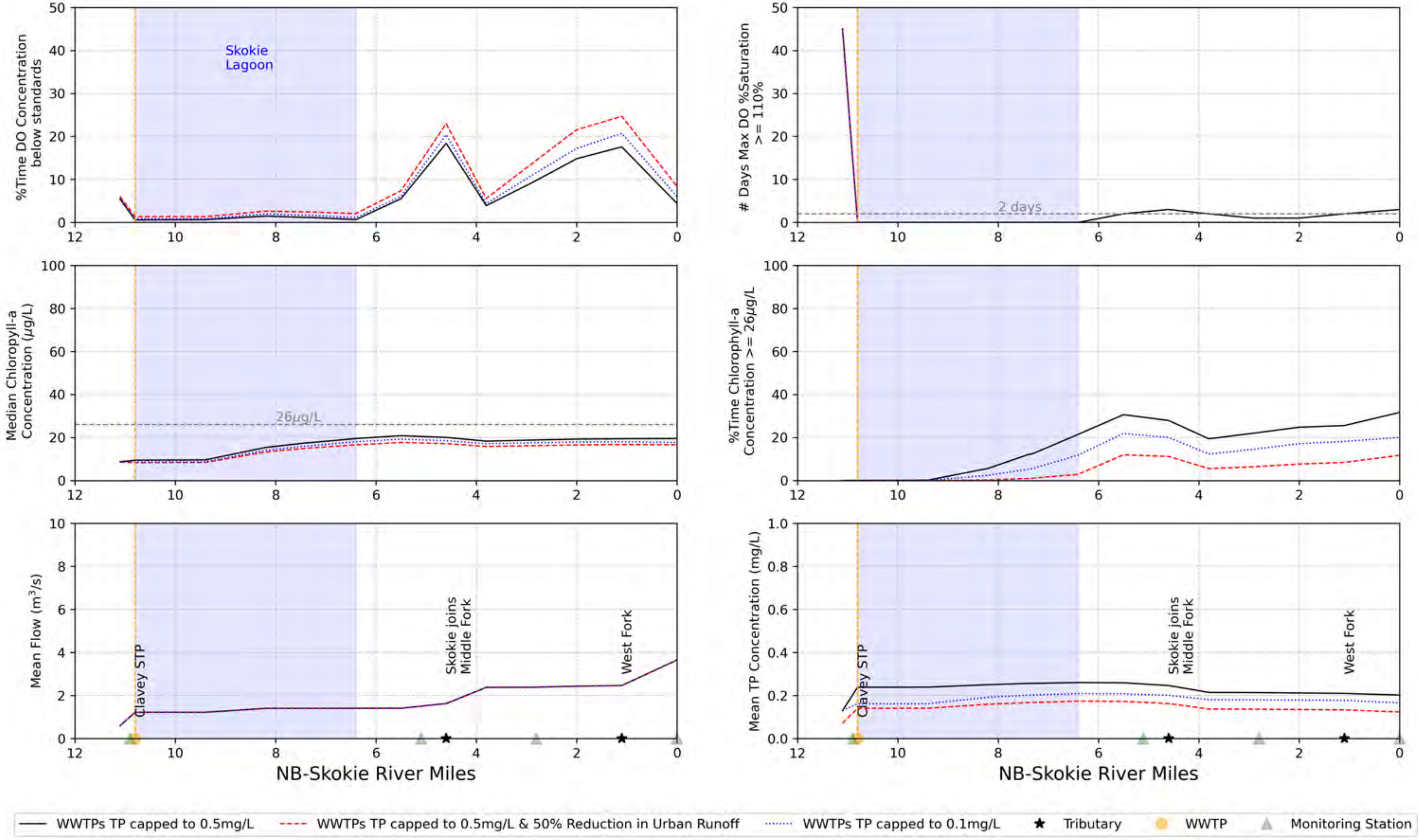
Sum of all TP loads is 6,664 lbs
*: P flux based on model calibration

How we analyze the results

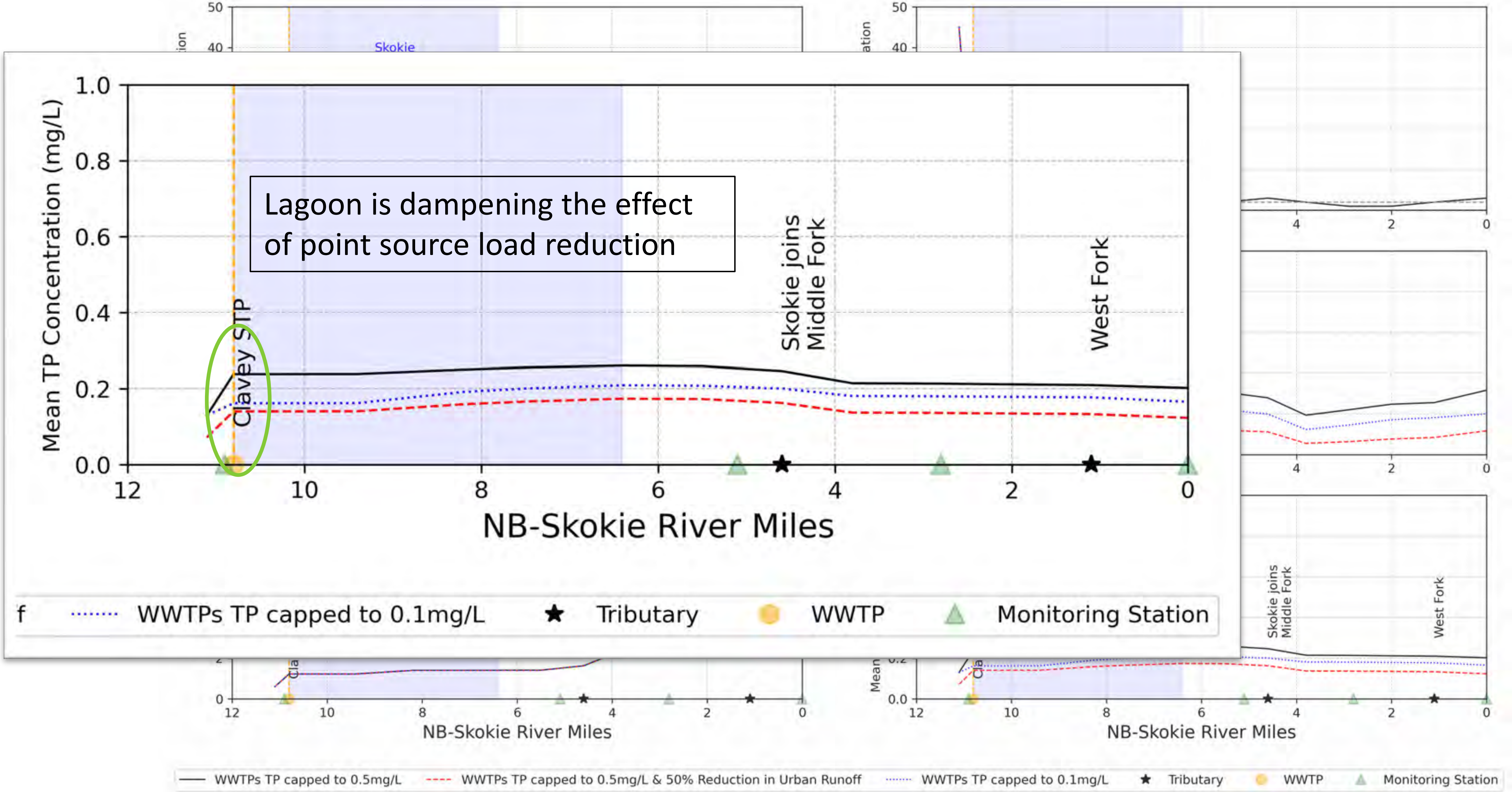
Percentage of time when DO concentrations are below minimum standards (5mg/L for March through July and 3.5mg/L for August through Feb)	Number of days in which the daily maximum %DO Saturation is greater than 110%
Median sestonic chlorophyll *a* concentration	Percentage of time when chlorophyll *a* concentrations exceed 26µg/L
Mean flow	Mean TP concentration

River Miles

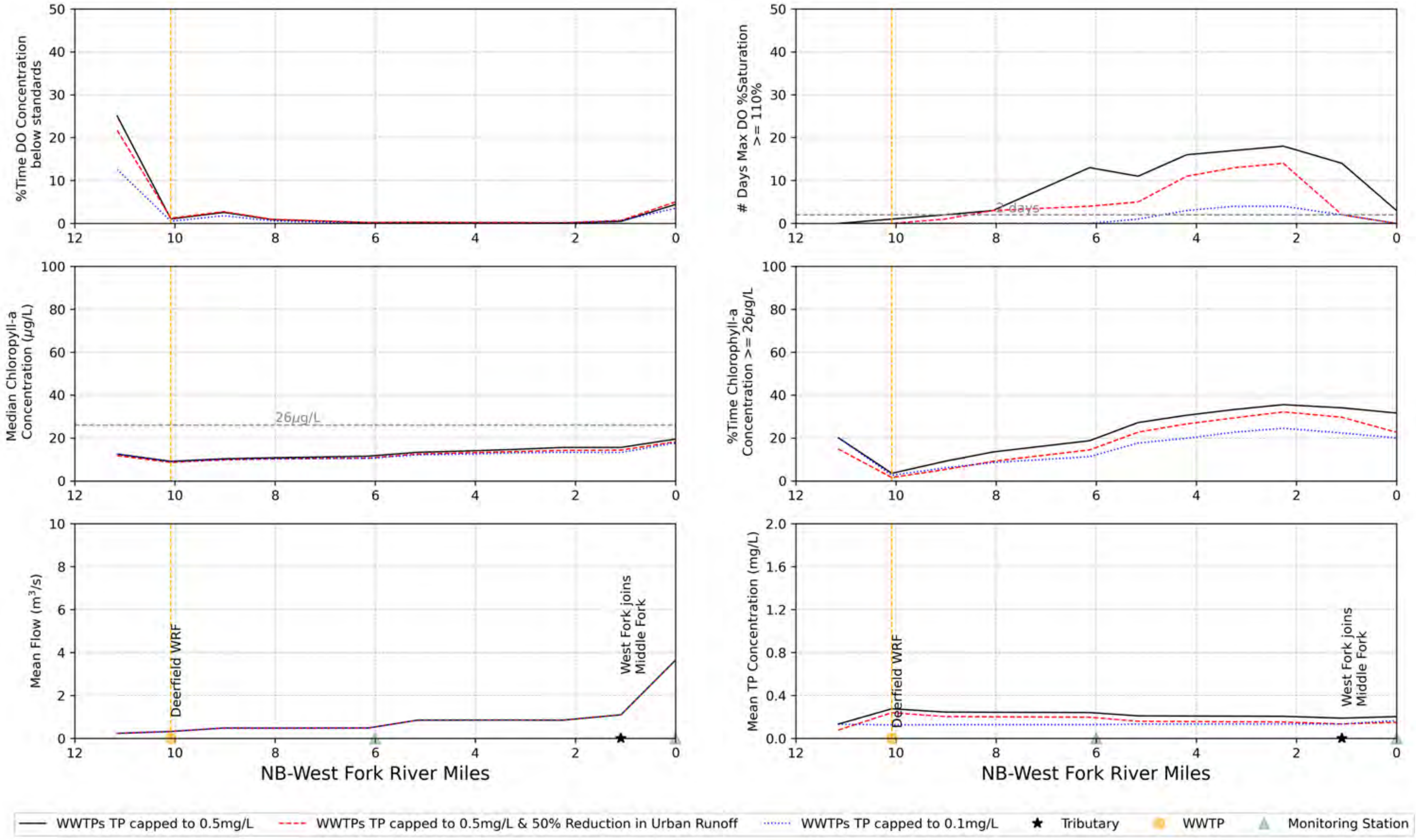
TP=0.5 mg/L vs. TP=0.5 mg/L & 50% Reduction in Urban Runoff vs. TP=0.1 mg/L



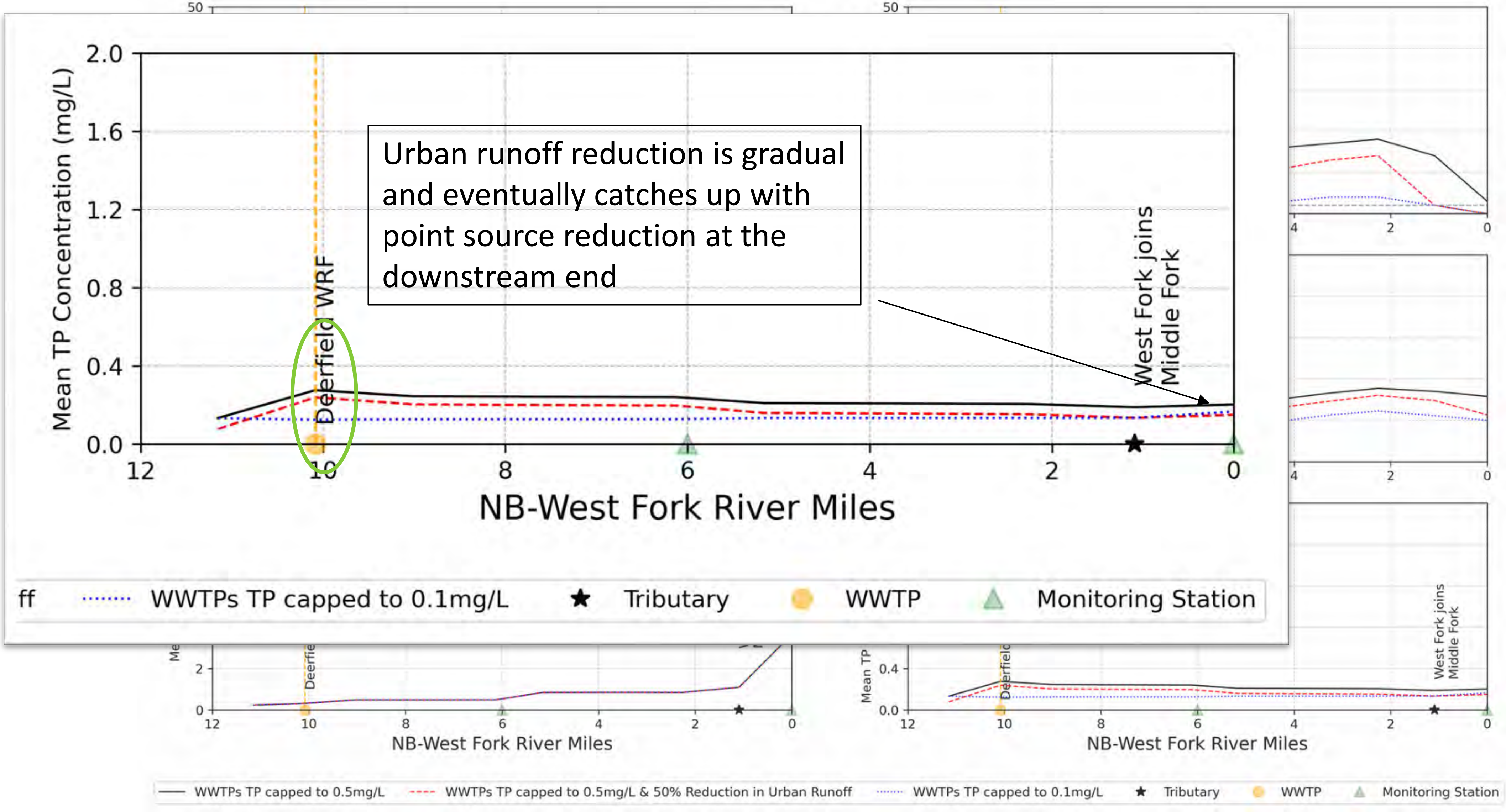
TP=0.5 mg/L vs. TP=0.5 mg/L & 50% Reduction in Urban Runoff vs. TP=0.1 mg/L



WF - TP=0.5 mg/L vs. TP=0.5 mg/L & 50% Reduction in Urban Runoff vs. TP=0.1 mg/L



WF - TP=0.5 mg/L vs. TP=0.5 mg/L & 50% Reduction in Urban Runoff vs. TP=0.1 mg/L



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Key Takeaways

- MS4s are major contributors to watershed TP loads
- After POTWs have achieved 0.5mg/L effluent limit
  - Skokie: 50% urban runoff TP reduction can lead to better water quality conditions compared to further limiting POTW effluent limit to 0.1mg/L
  - West Fork: Limiting POTW effluent limit to 0.1 mg/L provides better improvement compared to 50% urban runoff TP reduction even though the urban runoff reduction removes more TP load
  - Potential causes:
    - most urban runoffs are high volume low concentration stormwater runoffs
    - most of P in stormwater runoffs is non-reactive
    - lagoon dampens the effect of POTW load reduction

Watershed Plan TP reduction Implementation

Geosyntec consultants

2. Watershed TP Reductions

2.1. 100 lbs TP Reduction in Baseline

2.2. 500 lbs TP Reduction in Baseline

2.3. 1000 lbs TP Reduction in Baseline

2.4. WWTP TP Capped at 0.5 mg/L & 100 lbs Reduction in TP

2.5. WWTP TP Capped at 0.5 mg/L & 500 lbs Reduction in TP

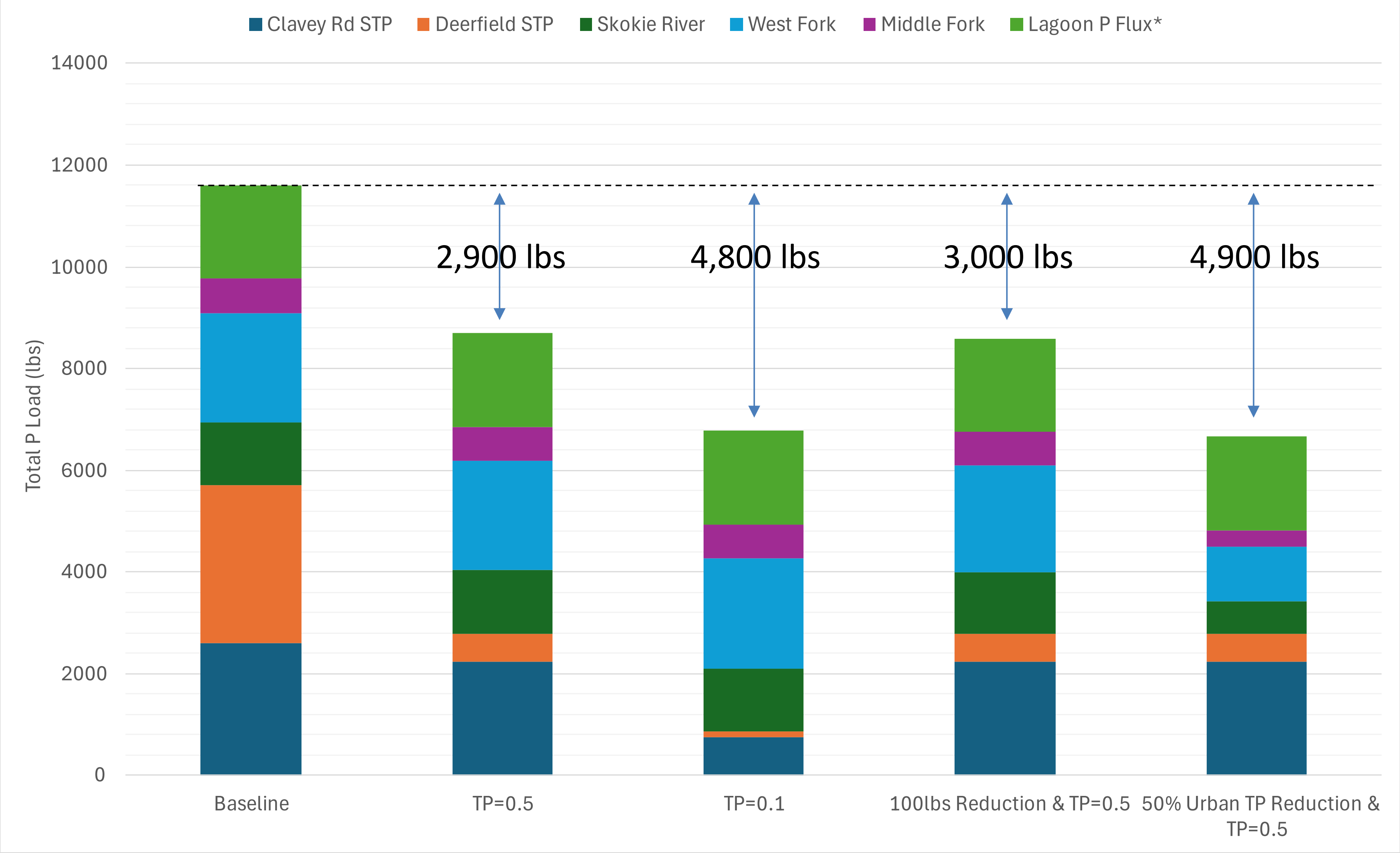
2.6. WWTP TP Capped at 0.5 mg/L & 1000 lbs Reduction in TP

2.7. WWTP TP Capped at 0.1 mg/L & 100 lbs Reduction in TP

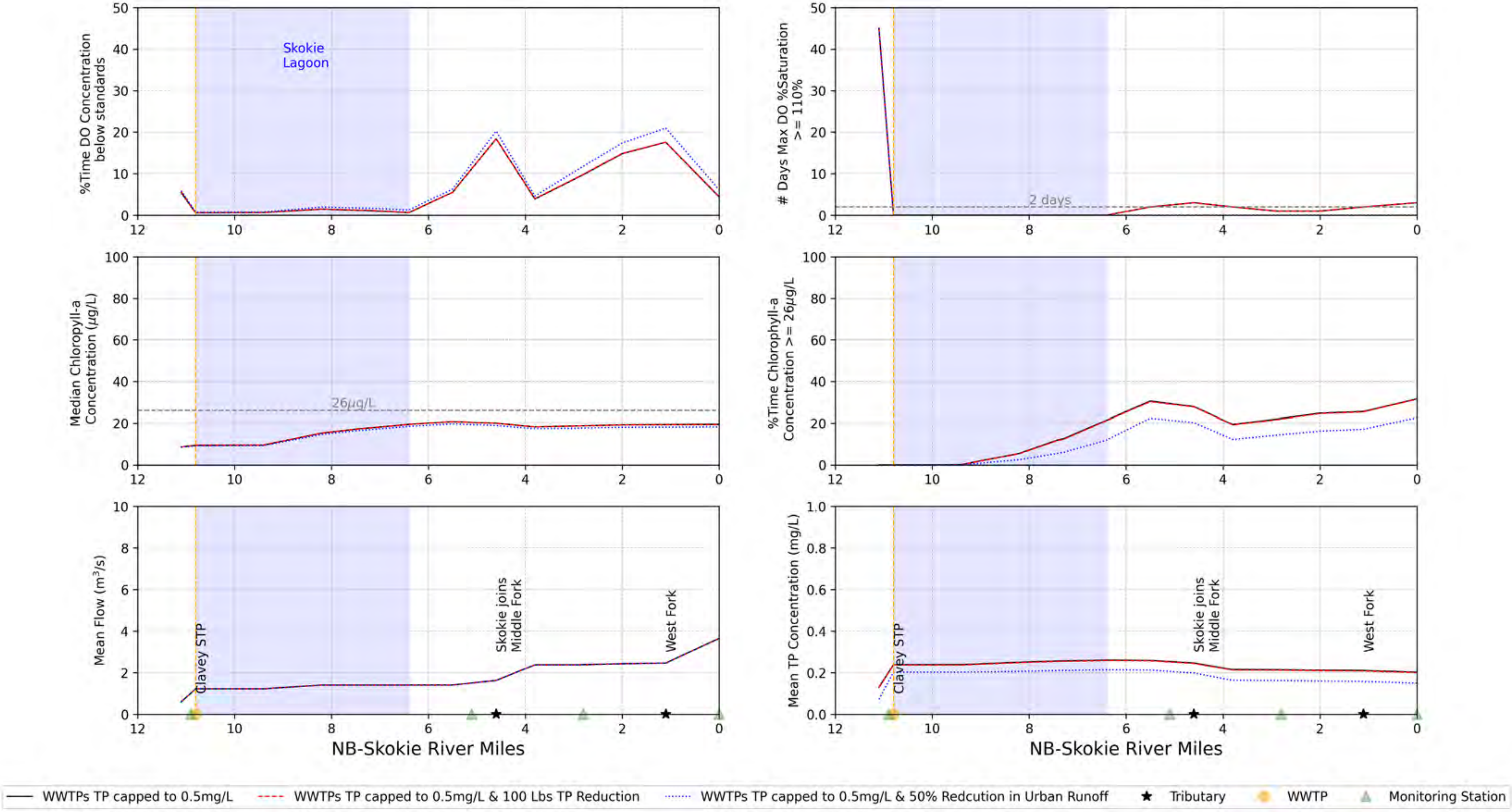
2.8. WWTP TP Capped at 0.1 mg/L & 500 lbs Reduction in TP

2.9. WWTP TP Capped at 0.1 mg/L & 1000 lbs Reduction in TP

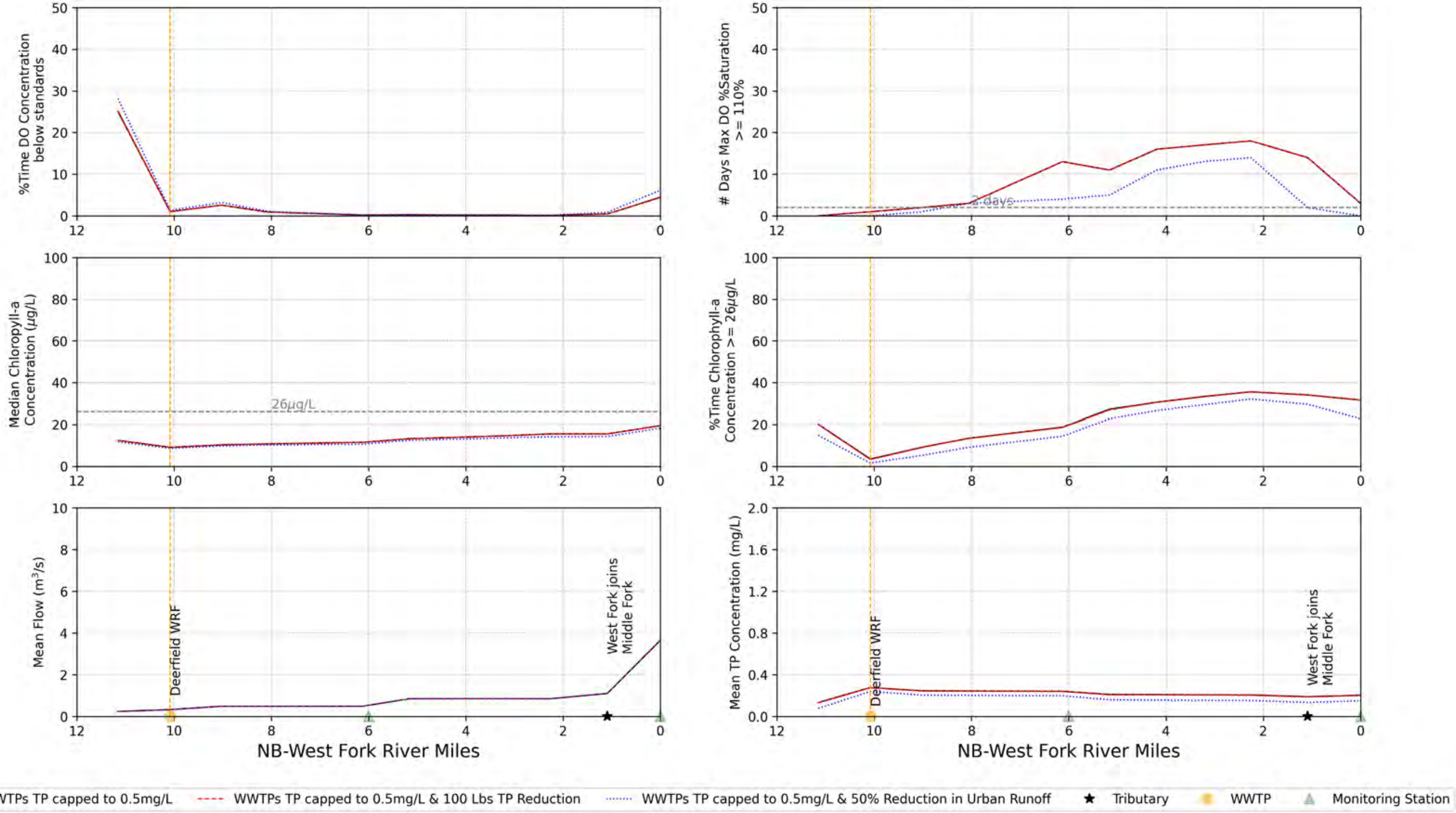
Watershed TP Reduction Comparison



TP=0.5 mg/L vs. TP=0.5 mg/L & 100 Lbs TP Reduction vs. TP=0.5 mg/L & 50% Reduction in Urban Runoff



WF - TP=0.5 mg/L vs. TP=0.5 mg/L & 100 Lbs TP Reduction vs. TP=0.5 mg/L & 50% Reduction in Urban Runoff



Key Takeaways

- The water quality impact of removing 100 lbs of P from the entire MS4s is negligible
- Targeted P removal from a specific reach might be more effective
- Balance between P removal costs and environmental benefits
- Future review can include effectiveness and ROI of selected watershed plan projects

NBWW NARP: Membership Survey

Membership Survey Needed

NORTH BRANCH CHICAGO RIVER WATERSHED WORKGROUP

Survey Results will be used to help inform implementation

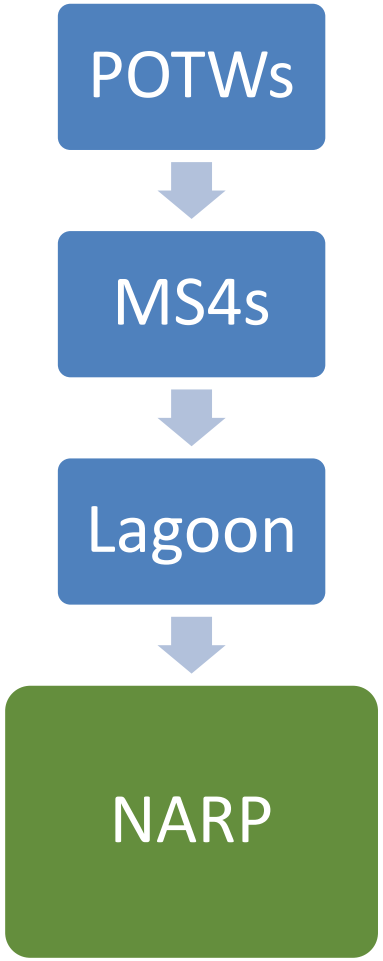
1. 14 total Questions
2. Feedback is Anonymous
3. Appropriate to inform Implementation Plan
4. Important compliment to Stakeholder Engagement

QR SURVEY CODE

Membership Survey Needed

Survey Results will be used to help inform implementation

1. Questions are intended to help parties integrate
2. NARP is intended to provide benefits to all members
3. Additional benefits can be realized from the effort and NBWW continued activity after NARP
4. Based on alternatives analysis performed to date, understand the value MS4 communities play in addressing watershed issues.



Membership Survey Needed

How do urbanized waterways potentially impact risk of eutrophication or phosphorus-based impairment?

1. Highly modified flow regime
2. Temperature modification – reduced DO capacity, faster chemistry
3. System seeding – large storm vs small storm impacts
4. Pond incubation – highlights the importance of maintenance
5. Literature for TP contribution from urban runoff may not be informed by current research

Image courtesy of ILM

Next Steps

NARP is due December 2025

1. One remaining general membership meeting
2. Remaining scenarios to complete (4)
3. Implementation Plan outline to Monitoring and Executive Committees in March
    a) Separate section of NARP Report
    b) Details out investments, approach, and timelines
4. NARP outline in July/August to Monitoring and Executive Committees
    a) Technical content
    b) Content is largely fixed, NBWW provides input on extent and presentation
5. Entire NARP would look to wrap October/November

In Closing

NARP is due December 2025

1. Much to discuss and consider between now and end of calendar year
2. MS4 participation/input will be critical
3. POTWs have plan to reach regulatory compliance by 2030.
4. Regulate yourselves or you will be regulated (by others)
   - ❑ Establish a program
   - ❑ Prepare to execute the program
   - ❑ Data and metrics
   - ❑ Demonstrate progress
   - ❑ Numbers matter – as in results matter

Additional Thoughts

NARP is due December 2025, but this is not the end

1. In many waterways 0.5mg/l will make drastic improvements, but it typically does not address all impairments (303d) or risk of eutrophication
2. 0.5mg/L → 0.3mg/L → 0.1mg/L for POTWs
   a) Time to get to each tier
   b) Could be watershed specific
   c) Without agriculture it is easy for IEPA or others to chase the highest load contributor
3. Due to makeup of watershed, anticipate MS4 interaction

Questions

Brian Valleskey, CFM, CLP

Bvalleskey@Geosyntec.com

Phone: 630-362-3362

Yifan He, PhD, EIT

Yifan.He@Geosyntec.com

Phone: 630-481-5465

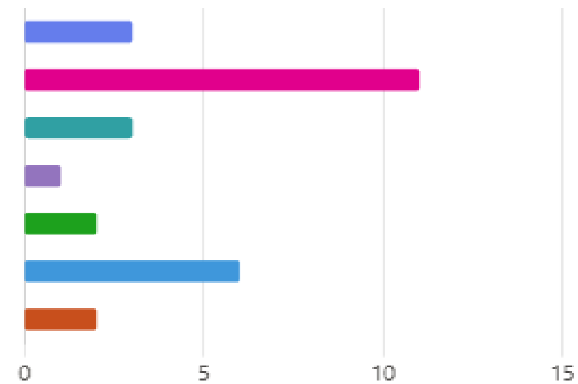
Appendix D: NARP Survey Responses

NBWW Stakeholder Survey for Implementation Plan Development

Responses Overview as of 3.17.2025

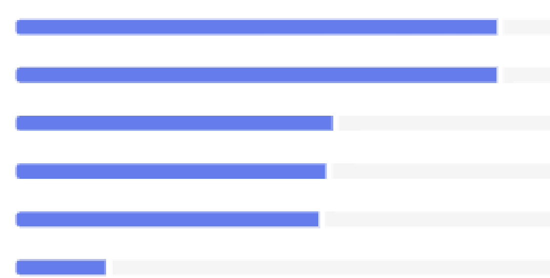
1. Do you identify as one of the following:

WWTF (permittee)	3
MS4 (permittee)	11
Non-for profit (NFP)	3
Non-governmental organization (NGO)	1
Regulatory agency	2
Interested stakeholder not identified above	6
Other	2



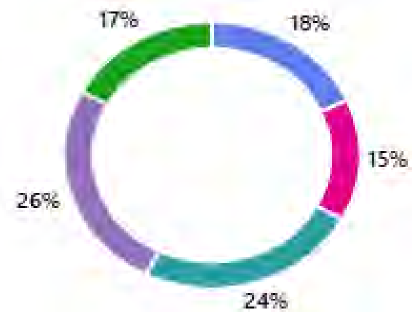
2. Rank the following objectives of your organization in the participation of the NBWW other than permit compliance.

1	Water quality improvement
2	Meeting regulatory requirements
3	Education & outreach
4	Removing impaired water bodies off the Illinois EPA 303(d) list
5	Networking and watershed collaboration
6	Other



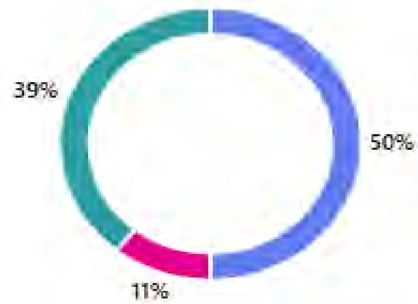
3. What should be the role of NBWW upon completion of the NARP? Select all that apply.

Education and advocacy organization	15
NARP implementation only – keep stakeholders informed regarding future developments stemming...	12
Continue monitoring and data collection/sharing	20
Watershed plan implementation	21
Funding source coordination to facilitate all the above	14



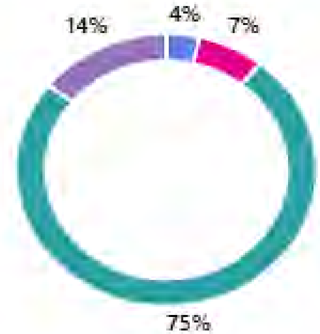
4. Has the NBWW adequately engaged stakeholders throughout the NARP process?

Yes	14
No	3
Not sure	11



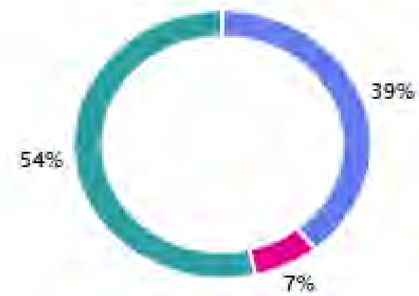
5. What could the NBWW do to improve stakeholder engagement?

Hold more general membership meetings in a year	1
Send more emails or targeted mailings	2
Provide more member specific information which can be better distributed and internally shared amongst...	21
Other	4



6. What other measures can the NBWW consider to obtain water quality standards (beyond WWTP regulatory standards)?

NBWW would work with stakeholders to identify a process for MS4 project implementation and load...	11
NBWW would facilitate a process with SMC and watershed community to explore more stringent...	2
NBWW will develop a prioritized list of projects to reestablish natural stream function (to the maximu...	15



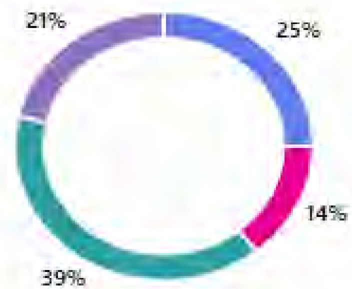
7. Define how improved streams benefit your community?

Improves property values	1
Provides recreational opportunities/community asset	6
Flood control	13

Aesthetic appeal	3
Not sure	0
Other	5

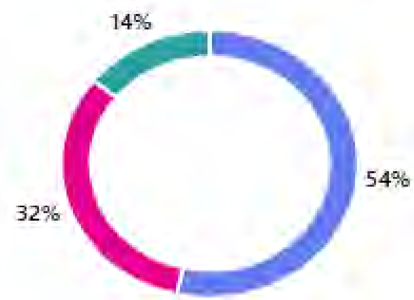
8. How is NARP meeting information and associated materials shared amongst your organization?

Meeting materials are forwarded to and/or summarized for decision makers in my organization	7
Meeting participation is objectively summarized and provided to decision makers in my organization	4
When something important comes up I let them know	11
Not sure	6



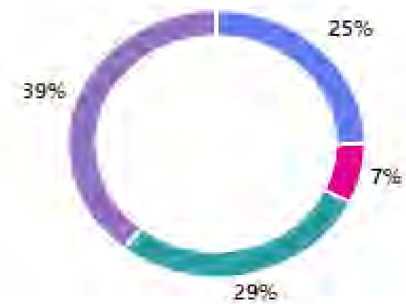
9. If the Skokie Lagoon is deemed to be a significant source of potential impairment to the NBCR, how should it be addressed?

Lagoon maintenance (regular maintenance)	15
Evaluate the feasibility of lagoon bypass	9
Evaluate feasibility of dredging program to maintain pool volume	4



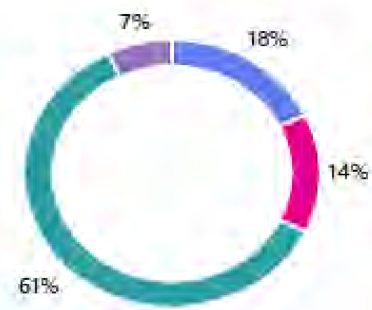
10. Upon reaching regulatory compliance of 0.5 mg/L at both NSWRD and Deerfield WWTFs, MS4s will be the leading contributor to TP load in the watershed. How should that be addressed?

It should be addressed in future MS4 permit cycle language	7
MS4s submit voluntary compliance schedule for reducing by X%	2
MS4s voluntarily continue to implement projects independently	8
Explore programmatic implementation pathways such as a public-private partnership (P3).	11



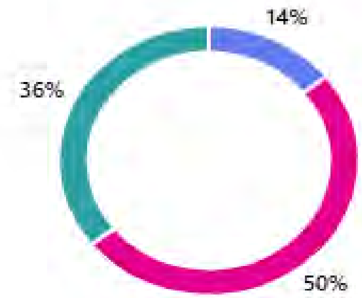
11. Hydromodification due to excessive urbanization and high watershed imperviousness is a key issue for the NBCR watershed. What might be preferred means of addressing this issue?

Reduce Imperviousness through incentives	5
Work to naturalize streamflow (infiltration, baseflow stabilization)	4
Stream restoration and corridor protection	17
Not sure	2



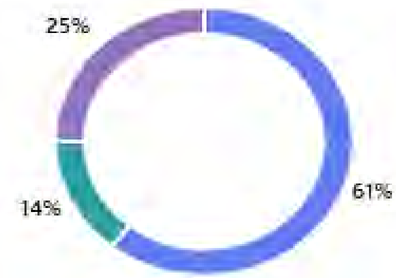
12. Has your agency ever investigated the value of proactive compliance versus forced compliance from a cost perspective? This would entail reaching a water quality target lower than required in a future permit condition prior to enforced regulation.

Yes	4
No	14
Not sure	10



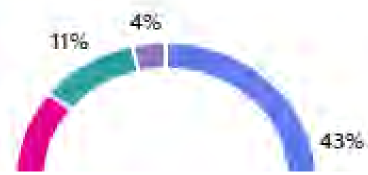
13. If an Implementation Plan can be developed to help stakeholders eliminate identified phosphorus-based impairments, what role would your agency be willing to provide?

Insight and oversight	17
Informed financial contribution	0
Land for project implementation	4
Voluntary compliance to any identified target reductions as applicable	7



14. What is a responsible horizon for achieving NARP compliance? *NARP compliance entails addressing phosphorus related impairments which violate the dissolved oxygen (DO) standard due to excessive algal or aquatic plant growth.*

10 years	12
20 years	12




50 years 3
100 years 1
43%