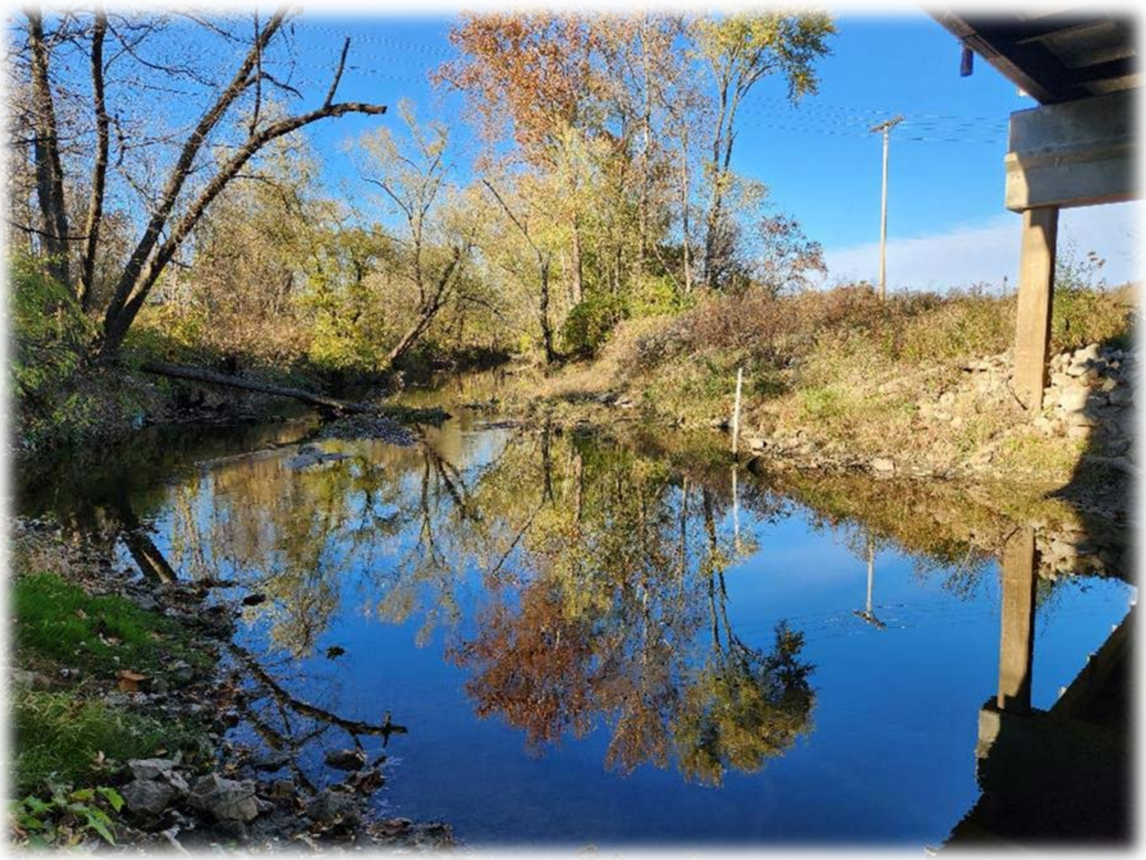
NUTRIENT ASSESSMENT REDUCTION PLAN

December 2023

CITY OF MATTOON, ILLINOIS



PREPARED BY: NORTHWATER CONSULTING

PREPARED FOR: CITY OF MATTOON, ILLINOIS

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LIST OF ACRONYMS

BNR	Biological Nutrient Removal
CFS	Cubic Feet Per Second
CWA	Clean Water Act
DAF	Design Average Flow
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
FOIA	Freedom of Information Act
HUC	Hydrologic Unit Code
INLRS	Illinois Nutrient Loss Reduction Strategy
MGD	Million Gallons per Day
NARP	Nutrient Assessment Reduction Plan
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NPS	Nonpoint Source
NH_3	Ammonia
NO_3^-	Nitrate
NPDES	National Pollution Discharge Elimination System
P	Phosphorus
POTW	Publicly Owned Treatment Works
SWCD	Soil and Water Conservation District
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
USGS	United States Geological Survey
WMP	Watershed Management Plan
WWTP	Wastewater Treatment Plant

City of Mattoon Treatment Plant

1. INTRODUCTION & BACKGROUND

In 2018, the Illinois EPA instituted nutrient reduction permit requirements applicable to Publicly Owned Treatment Works (POTW) with effluent discharges greater than 1-million gallons per day (MGD). The nutrient reduction approach for POTWs supports a pathway to establish site-specific permit limits for phosphorus at each facility in lieu of instituting a statewide limit. The Nutrient Assessment Reduction Plan (NARP) requirement resulted from negotiations with environmental organizations, Illinois EPA, and the Illinois Association of Wastewater Agencies.

A NARP Special Permit Condition is now included in a National Pollution Discharge Elimination System (NPDES) permit if a receiving stream segment or downstream segment is on the Illinois Clean Water Act (CWA) 303(d) list as impaired with phosphorus-related causes. A NARP is also required if there is a “risk of eutrophication” as defined by meeting any of the three conditions outlined in Table 1.

Table 1 - Illinois EPA Risk of Eutrophication Criteria

Risk of Eutrophication if any of these Conditions Met:		
pH	**Median Sestonic Chlorophyll α**	**On any Two Days During Illinois EPA Monitoring Week, Daily Max**
> 9	> 26 µg/L	pH > 8.35 and DO saturation > 110%

Whether the NARP special permit condition is triggered by a CWA 303(d) impairment listing, or eutrophication risk criteria, the designation is often based on limited data. For example, the risk of eutrophication justification for some sites is based on only two non-consecutive weeks of continuous Dissolved Oxygen (DO) and pH data collection performed by the Illinois EPA. In some cases, the data is over 10 years old.

The Illinois EPA allows the NPDES permittee to undertake additional data collection and assessment, which can confirm NARP triggering conditions, or determine that the watershed does not have a phosphorus-related impairment or risk of eutrophication. If sufficient evidence indicates no impairment or risk of eutrophication, it is possible that phosphorus regulation and mitigation measures may not be necessary. The following actions have been proposed to comply with the NARP permit condition:

- Examine if sufficient data exists to fully characterize impairment or risk of eutrophication in the receiving watershed.
    - If data is insufficient, create a water quality monitoring plan and collect data.
- If existing or new data indicates a full NARP is required:
    - Undertake watershed characterization.
    - Model watershed and instream processes.
    - Establish defensible site-specific water quality criteria.
    - Define scenarios and strategies to achieve water quality targets.
    - Implement NARP recommended actions and engage stakeholders.

This report details the monitoring program implemented to support a NARP Strategy and Work Plan. Section 2 provides an overview of water quality triggers. Section 3 describes the monitoring program, methods, and results with interpretation at the end of the section. Section 4 presents a Strategy and Work Plan following a watershed characterization.

1.1 TREATMENT PLANT BACKGROUND

The City of Mattoon, located in Coles County, Illinois, operates one POTW with a design average flow (DAF) of 5.3 MGD. The facility is subject to a NARP special permit condition with a deadline of December 31, 2023. The plant serves a population of 16,900 with 6,500 residential, commercial, and industrial connections.

Treatment consists of screening, grit removal, primary settling, activated sludge, secondary settling, sand filtration, and excess flow treatment. The Wastewater Treatment Plant (WWTP) discharges to Kickapoo Creek, a small drainage ditch at the point of discharge that is characterized with seven-day one in ten-year low flow (7Q10) of 0 cubic feet per second (CFS). Approximately 11.4 miles downstream from the outfall, Riley Creek joins Kickapoo, and a further 5.75 miles downstream Kickapoo joins the Embarras River. The City of Charleston's WWTP (DAF 3.3 MGD) discharges into Cassell Creek, a tributary of Riley Creek (Figure 1). Charleston also has a NARP requirement in its NPDES permit.

2. NARP TRIGGERS & ACTIONS

The Mattoon NARP special condition was triggered by historical data indicating a risk of eutrophication in an unnamed segment downstream of the plant's outfall. An Illinois Freedom of Information Act (FOIA) request identified the triggering segment as BEN-01, a segment of Kickapoo Creek downstream from the confluence with Riley Creek. Supporting data was limited and not considered adequate to fully understand the risk of eutrophication, or conclusive that nutrient concentrations in Mattoon effluent contributed to the threshold exceedances (Table 2). The upstream watershed area of the plant outfall is 5.9 mi^2 and the risk of eutrophication segment is 13.4 miles downstream with a watershed area that is nearly 17 times the size (100 mi^2).

Table 2 - Illinois EPA Risk of Eutrophication Designation Data - Mattoon WWTP

Site	Description	Continuous Monitoring Duration	Days Exceeding DO & pH Threshold	Sestonic Chlorophyll α Samples	Sestonic Chlorophyll α Exceedances
BEN-01	Kickapoo Creek after Confluence with Riley Creek	2 weeks in 2011 2 weeks in 2016	6 days, all in 2011	3 in 2011 3 in 2016	0

Additional data mining was undertaken using publicly available sources to locate any other informative and relevant nutrient, DO, pH or chlorophyll data. Several sites were identified in the study area (Figure 1), however, there were no more than 5 measurements per parameter since 2002. Because the risk of eutrophication segment (BEN-01) receives effluent from both Charleston and Mattoon, a water quality monitoring plan (Appendix A) was created in cooperation with the City of Charleston to further evaluate the risk of eutrophication and guide additional components of the NARP process. The plan was presented to Illinois EPA staff via email with a request for feedback on 7 September 2022. While monitoring was carried out in cooperation with Charleston, this report focuses on Mattoon and the combined segment that receives effluent from both plants.

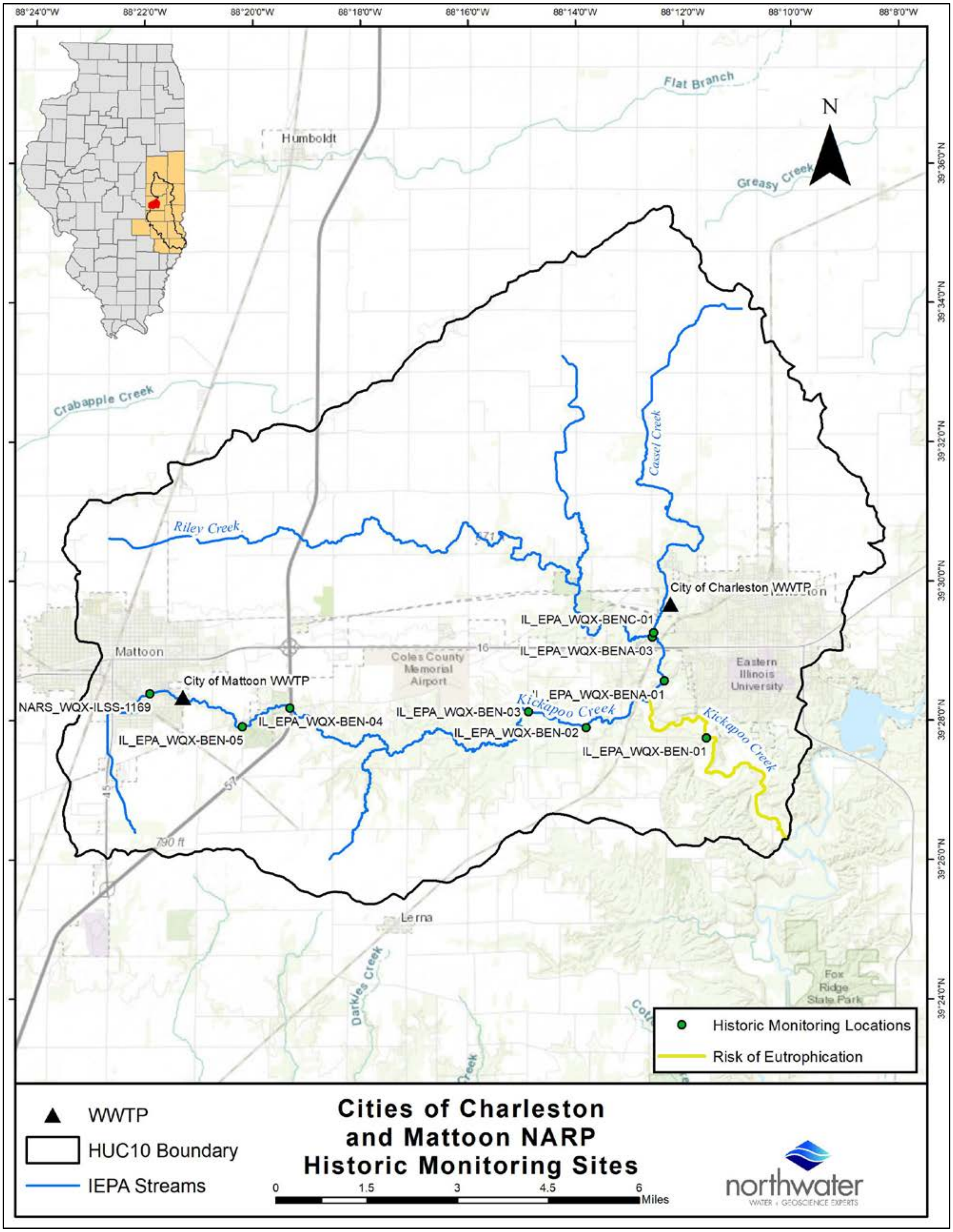


Figure 1 - Watershed Map and Historic Monitoring Sites

3. WATER QUALITY MONITORING PROGRAM & RESULTS

Based on the Illinois EPA recommendations, a combined monitoring effort between Charleston and Mattoon was carried out with three main objectives:

1. Confirm or contest the appropriateness of the NARP requirement for each plant's NPDES permit.
2. Improve understanding of nutrient dynamics to inform next steps if a NARP needs to be advanced to establish site-specific phosphorus limits.
3. Provide data to guide equitable implementation of nutrient reduction measures among contributors if such reductions are necessary.

Mattoon retained Northwater Consulting to develop the monitoring plan and support the city in implementing the monitoring program. The Work Plan and Strategy presented in Sections 4.2 and 4.3 are guided by the monitoring results and the foundation of next steps in the NARP process.

3.1 MONITORING STATIONS & INFRASTRUCTURE

Figure 2 and Table 3 illustrate the 5 stations and pertinent details about the monitoring commissioned by the City of Mattoon in 2022 and 2023. Section 3.2 details methods and parameters.

The City of Mattoon's WWTP discharges to Kickapoo Creek above the confluence with Riley Creek. The monitoring program was designed as a modified upstream/downstream configuration (Figure 2, Figure 3) to capture stream conditions (1) before and after the WWTP outfall, and (2) before and after Riley Creek flows into Kickapoo. As previously noted, the Charleston WWTP contributes effluent to Kickapoo via Riley Creek upstream of the stream segment identified as having a risk of eutrophication.

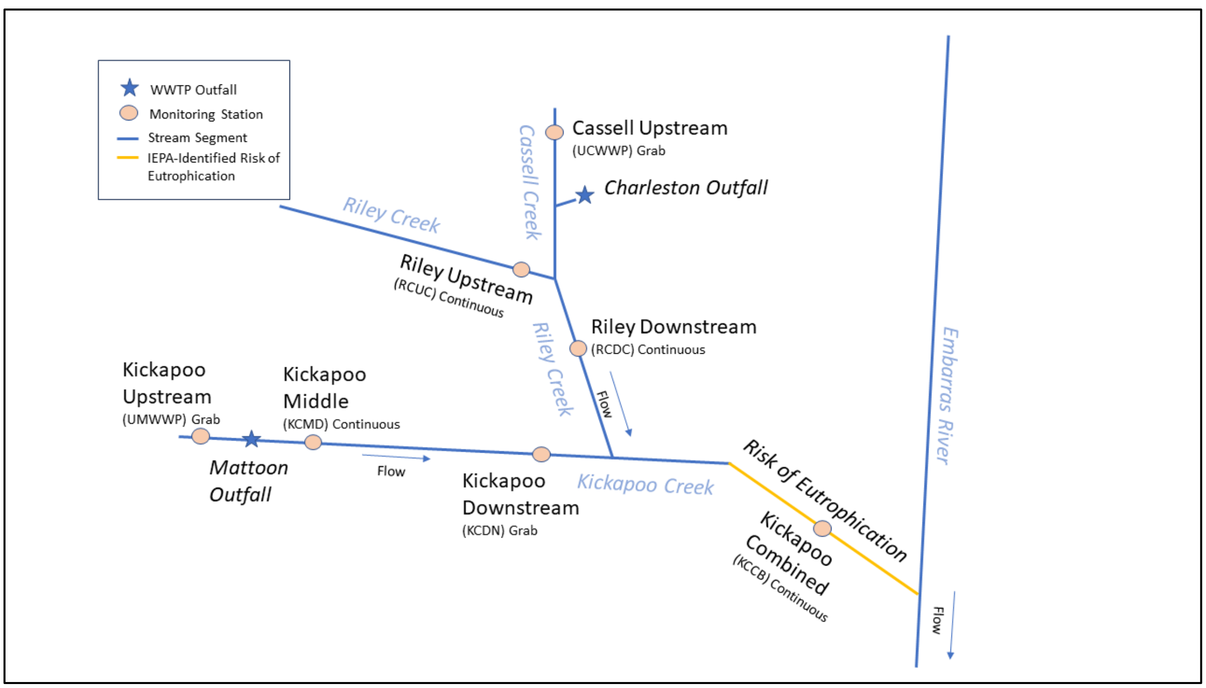


Figure 2 – Monitoring Program Schematic (not to scale)

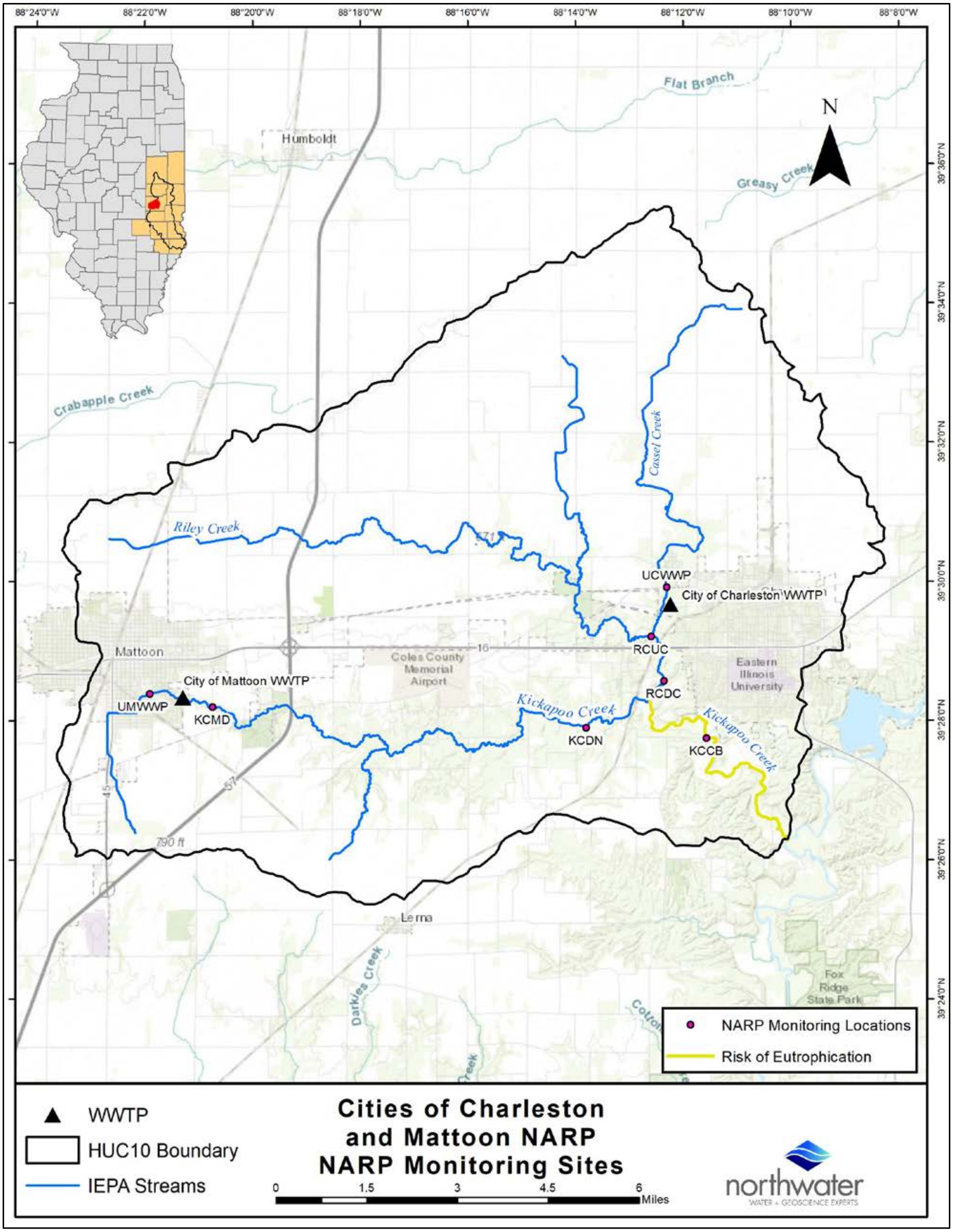


Figure 3 - NARP Monitoring Locations

Grab sample collection began on Mattoon's Kickapoo Creek sites in August 2022 (Table 3). Due to manufacturer delays, the continuous monitoring instrumentation was deployed in October 2022. On Riley Creek above the confluence with Kickapoo, grab sampling began in June 2022 and continuous monitoring began in July 2022 as part of Charleston's NARP activities. For all stations, the program concluded at the end of October 2022 and resumed in May 2023. Monitoring then concluded on Kickapoo Creek sites at the end of October 2023, and for Charleston's Riley Creek site, at the end of July 2023. Although the program spanned two years, grab sample and continuous monitoring from the May-October period is fully represented at all sites.

Table 3 - Monitoring Stations - 2022-2023 Period

Station ID	Alternate Station IDs	Name	Lat/Long (decimal degrees)	Approximate Distance from Outfall (mi)	Watershed Area (mi²)	Type of Sampling	Monitoring Periods (2022-2023)
UMWWP	*NA*	Kickapoo Creek Upstream	39.4731612, -88.3651197	0.25 (upstream)	5.2	Grab Only Weekly	October 2022 & May – October 2023
KCMD	*NA*	Kickapoo Creek Middle	39.486860, -88.210115	1.1 (downstream)	7.0	Continuous/ Biweekly Grab	October 2022 & May – October 2023
RCDC	BENA-01 (Illinois EPA)	Riley Creek Downstream	39.476217, -88.206194	1.5 (downstream of Charleston outfall)	66.3	Continuous/ Biweekly Grab	June - October 2022 & May – July 2023
KCDN	BEN-02 (Illinois EPA)	Kickapoo Creek Downstream	39.465059, -88.230240	10.7 (downstream)	30.6	Grab Only Weekly	October 2022 & May – October 2023
KCCB	BEN-01 (Illinois EPA)	Kickapoo Creek Combined	39.46252, -88.19315	13.4 (downstream)	100.2	Continuous/ Biweekly Grab	October 2022 & May – October 2023

3.2 METHODS

Sampling parameters were selected to be directly responsive to the NARP triggering criteria, with a combination of continuous monitoring, spot checks with handheld meters and grab samples submitted for lab analysis. Table 4 summarizes all parameters and other details including methods and sampling frequency. Continuous data collection stations included temporarily deployed infrastructure to facilitate use of water quality sondes. Sondes were placed in 3" perforated PVC pipes that extended from the bank as close as practical to the channel thalweg. The sondes were positioned so that they were in flowing water and not influenced by stagnant or non-flowing backwater conditions.

Continuous Monitoring (3 Stations: KCMD, KCCB and RCDC)

- In-Situ Inc. AquaTroll 500 multiparameter continuous monitoring sondes with internal logging and battery deployed at three of the four stations (KCMD, KCCB and RCDC).
    - Bi-weekly site visits to download data, calibrate and maintain the sensors and infrastructure. All instrument calibrations and maintenance followed manufacturer's recommended practices and calibration logs were saved.
- The sondes were equipped with pH, DO, temperature, conductivity, and chlorophyll α optical fluorescence sensors. The sondes also included pressure transducers to record water height/stage.
- Data collection frequency was 15-minutes to enable the capture of daily maxima and minima of parameters such as pH and DO, which is relevant to Illinois EPA eutrophication risk criteria.
- Chlorophyll α optical fluorescence data was collected to better understand its occurrence and variability through the monitoring period as it is a eutrophication risk criterion (26 µg/L is the NARP threshold). The sensor data is considered a qualitative measurement and not reliable to make conclusive determinations of NARP triggers.

Spot Checks and Field Water Quality Data

- Kickapoo Creek upstream of the WWTP outfall (UMWWP) is a small, highly channelized stream. During the sampling period there was streamflow observed during every site visit but one. With limited resources available, spot and grab sampling were considered adequate for securing baseline data.
- The Kickapoo Creek Downstream station (KCDN) is just upstream of the confluence with Riley Creek. With limited resources available, spot and grab sampling were considered adequate for securing baseline data of changes in water chemistry downstream of the outfall and above the confluence.
- The Kickapoo Creek Upstream station and Kickapoo Creek Downstream stations were monitored weekly for DO, pH, conductivity, temperature, and turbidity. Monitoring was performed by Northwater Consulting and Mattoon WWTP staff using handheld water quality meters.
- At all other sites on Kickapoo and Riley Creeks, (KCMD, KCCB and RCDC) spot checks were performed bi-weekly for DO, pH, temperature, conductivity, and turbidity using calibrated handheld water meters (YSI ProQuatro and YSI ProDSS).
- Flow was measured bi-weekly at all sites using a measuring tape, top set wading rod and electromagnetic flowmeter. The United States Geological Survey (USGS) midsection method was applied to measure flows using a Hach FH-950 electromagnetic velocity meter, tape measure, and a top-set wading rod.

Laboratory Analysis

- Nutrient grab samples were collected on the bi-weekly schedule at all stations.
- Parameters included Total Phosphorus (TP), Orthophosphate, Total Nitrogen (TN), Ammonia (NH_3) and Nitrate (NO_3^-), as well as chlorophyll α (Table 4).
- Nitrogen analysis was added for the 2023 monitoring season to support an improved understanding of in-steam chemistry processes.

- Laboratory analysis for nutrients was performed by Mattoon and Charleston WWTP staffs in-house. Chlorophyll α was sent to an accredited contract laboratory (Pace Analytics, Peoria, IL) for analysis.

WWTP Effluent

Effluent data is collected as part of the Illinois EPA-required Discharge Monitoring Report (DMR). Parameters relevant to the NARP study include daily discharge, TP and TN which are monitored and reported monthly.

- The average effluent flow for Mattoon during the monitoring period was 3.2 MGD, or 4.95 ft^3/s.
- The average effluent TP concentration during the monitoring period was 4.3 mg/L.

Example of Temporary Infrastructure at KCMD

Table 4 - Water Quality Monitoring Parameters and Methods

Parameter	Collection Type	Frequency	Method	Method Identifier	Sonde Calibration Method
Dissolved Oxygen	Continuous Probe	Continuous	Optical	InSitu: EPA Approved Method YSI: ASTM D888-09	100% Air Saturation
	Handheld Meter	Bi-weekly	Optical	ASTM D888-09	-
pH	Continuous Probe	Continuous	Potentiometric	EPA 150.2	2 Point 7 & 10 pH
	Handheld Meter	Bi-weekly	Potentiometric	EPA 150.2	-
Water Temperature	Continuous Probe	Continuous	Thermistor	EPA 170.1	Factory Calibration
	Handheld Meter	Bi-weekly	Thermistor	EPA 170.1	-
Chlorophyll-α	Continuous Probe	Continuous	In-situ Optical Fluorescence	Instrument Manufacturer Optical Method	2 Point Rhodamine 0 & 2.9 RFU
	Grab	Bi-weekly	Lab Spectrophotometric	EPA 445.0	-
Total Phosphorus	Grab	Bi-weekly	Colorimetry	EPA 365.1 / EPA 365.3	-
Orthophosphate	Grab	Bi-weekly	Colorimetry	EPA 365.1 / EPA 365.3	-
Ammonia	Grab	Bi-weekly	Colorimetry	Hach 10205	-
Nitrate	Grab	Bi-weekly	Colorimetry	Hach 10206	-
Total Kjeldahl Nitrogen	Calculated	-	Calculated	-	-
Total Nitrogen	Grab	Bi-weekly	Colorimetry	Hach 10208	-
Conductivity	Continuous Probe	Continuous	Resistor Network	EPA 120.1	1 Point 1,413 µS/cm
	Handheld Probe	Bi-weekly	Resistor Network	EPA 120.1	-

3.4 MONITORING RESULTS

This section presents results of the monitoring program and is organized into relevant sections based on the measured parameters relevant to the NARP. All grab sampling data and contract laboratory reports can be found in Appendix B.

STREAMFLOW

Table 5 and Figure 5 present a summary of the flow data collected during the monitoring period. Some data were influenced by precipitation and runoff events however, flows were generally low at all the sites through the monitoring period. Drought conditions were experienced as illustrated by nearby USGS station 03343400 on the Embarras River near Camargo, which in 2022 and 2023 respectively recorded its second and third lowest mean flows from May-October (Figure 4). The monitoring period is not considered representative of average conditions, and the hydrology and flows of the river systems were more significantly driven by WWTPs during this period than is typical.

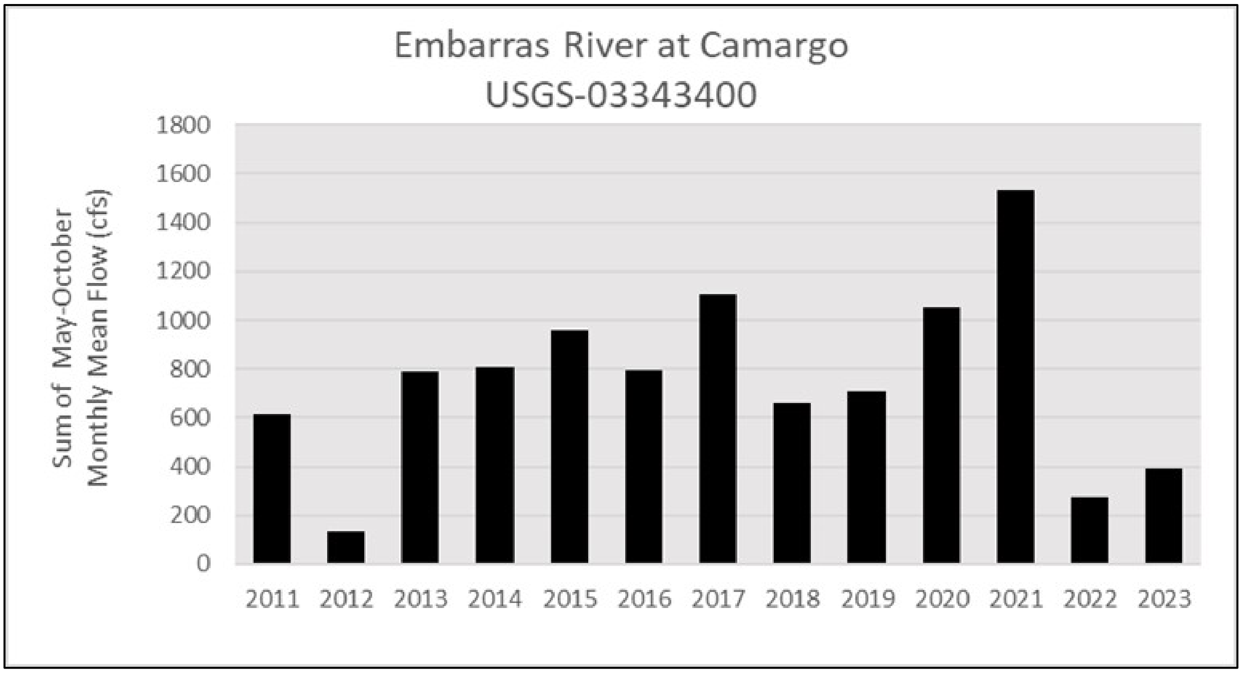


Figure 4 - Sum of Monthly Mean Flows (May-October) at USGS-03343400, Embarras River at Camargo

Kickapoo Creek Upstream (UMWWP)

- Kickapoo Creek upstream of the WWTP typically had very low flows, with a median of 0.13 cfs. There was one instance of zero discharge on 15 September 2022. The highest flow measured was 1.84 cfs on 15 May 2023 following a precipitation event.

Kickapoo Creek Before Confluence with Riley (KCMD & KCDN)

- Kickapoo Creek Middle (KCMD) is 1.1 miles downstream from the Mattoon WWTP outfall. Based on flows measured at this station and the upstream station, the WWTP effluent made up most of the flow on this section of Kickapoo Creek except during high flow events. There are several dates where effluent is estimated to be over 90% of the flow.

- Kickapoo Creek Downstream (KCDN) is approximately 10.7 miles downstream of the WWTP and captures all the Kickapoo Creek watershed before the confluence with Riley Creek. During dry periods, the flows at KCDN are similar to KCMD, but during wet periods, the flows at KCDN are higher, indicating there is significant nonpoint source (NPS) runoff from the watershed.
- Measured flows range from 0.9 cfs to 16.5 cfs at KCDN and from 1.1 cfs to 8.8 cfs at KCMD during the monitoring period.

Riley Creek Downstream (RCDC)

- Riley Creek joins Kickapoo approximately 8 miles downstream from the WWTP, and the station captures nearly the entire 66 mi^2 Riley Creek watershed, including the Charleston WWTP. Flows in Riley are typically higher than the flows in Kickapoo Creek with its ~30 mi^2 watershed. Measured flows ranged from 1.3 cfs to 53.2 cfs.

Kickapoo Creek Combined (KCCB)

- The Kickapoo “combined” station is over 13 stream miles from the Mattoon WWTP outfall and captures the entire Kickapoo Creek - Riley Creek watershed of 100 mi^2. The station also captures the WWTP discharge from Charleston, which is located on Cassell Creek, a tributary of Riley.
- Measured flows ranged from 2.5 to 73.8 cfs during the monitoring period, however, on two occurrences high flows could not be measured using wading methods due to safety concerns.
- At the lowest measured stage, Kickapoo Creek flows at this site are estimated to be roughly 35-45% from the WWTP. During higher flows this proportion is significantly less.

Table 5 - Summary of Flow Data

Station	# Measurements	Range (cfs)	Median	Approximate WWTP % of Flow at Median	Notes
Kickapoo Creek Upstream (UMWWP)	13	0.0-1.8	0.1	Upstream	-
Kickapoo Creek Middle (KCMD)	13	1.1-8.8	3.0	95%	-
Kickapoo Creek Downstream (KCDN)	13	0.9-16.5	3.6	90%	-
Riley Creek Downstream (RCDC)	8	1.3-53.2	13.6	Tributary (~25% Charleston Effluent)	** The monitoring period differed for Riley Creek and captured more wet weather, raising the median and proportion of effluent.
Kickapoo Creek Combined (KCCB)	13	2.5-73.8	7.4	~35-45% Mattoon ~20-30% Charleston	**2022 and 2023 experienced drought, increasing the proportion of base flow from WWTP effluent well above normal levels.

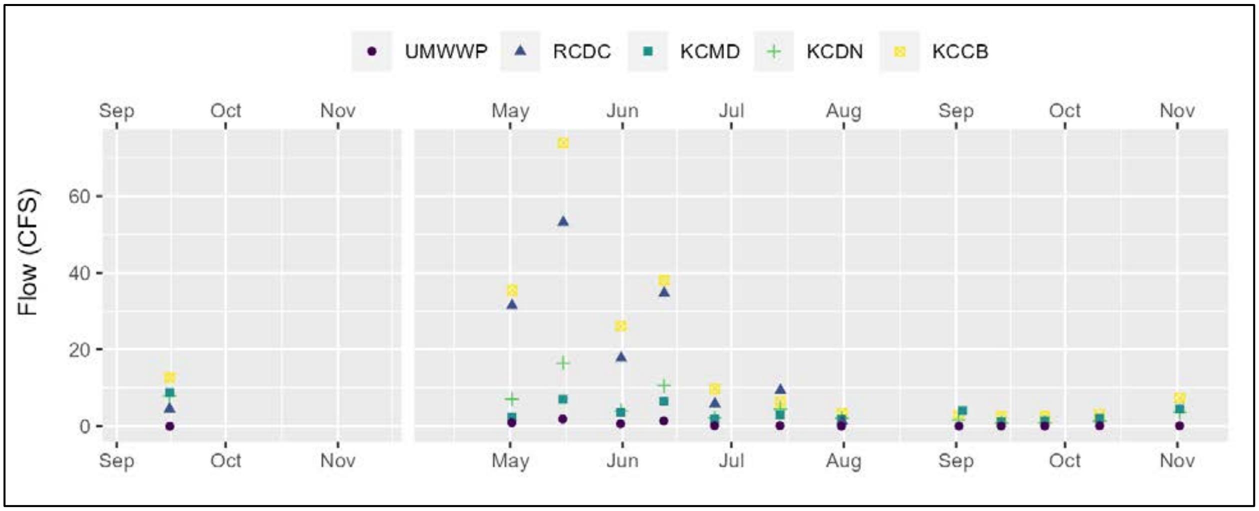


Figure 5 - Flow Measurements During Monitoring Period (note flow was not collected at KCCB on 21 July 2022 and 4 August 2022)

SESTONIC CHLOROPHYLL A

Chlorophyll α results are shown in Figure 6 and were low throughout the monitoring period at all sites (n=13: KCCB; n=15: all others), typically far below the 26 µg/L risk of eutrophication threshold.

- Kickapoo Creek upstream (UMWWP) had two samples with results at or above the 26 µg/L risk threshold, on 23 May 2023 and 12 September 2023. Both were collected during dry periods when flow was low.
- At KCCB there was one outlier result in October 2022 with a concentration of 21 µg/L on Kickapoo Creek. The elevated chlorophyll α result coincides with the Charleston WWTP discharging treated water from their excess flow lagoon. The concentration detected is reflective of that lagoon environment and not a bloom of sestonic algae growth in lower Kickapoo Creek. Treated water from the lagoon had been discharging periodically during 6 of the 10 days before the sample was collected, and elevated results were also observed in Riley Creek.
    - Continuous chlorophyll fluorescence results are not considered quantitative concentration measurements; however, sensor data did corroborate that there were elevated levels in the stream at that time. Sensor data also indicated elevated levels coincident with other lagoon releases.
    - Outside of these elevated periods, the sensor-recorded levels remained near zero, indicating that chlorophyll risk of eutrophication exceedances are unlikely.
- Overall, laboratory results are low and below risk of eutrophication thresholds. This is expected in a stream with perennial baseflow conditions.

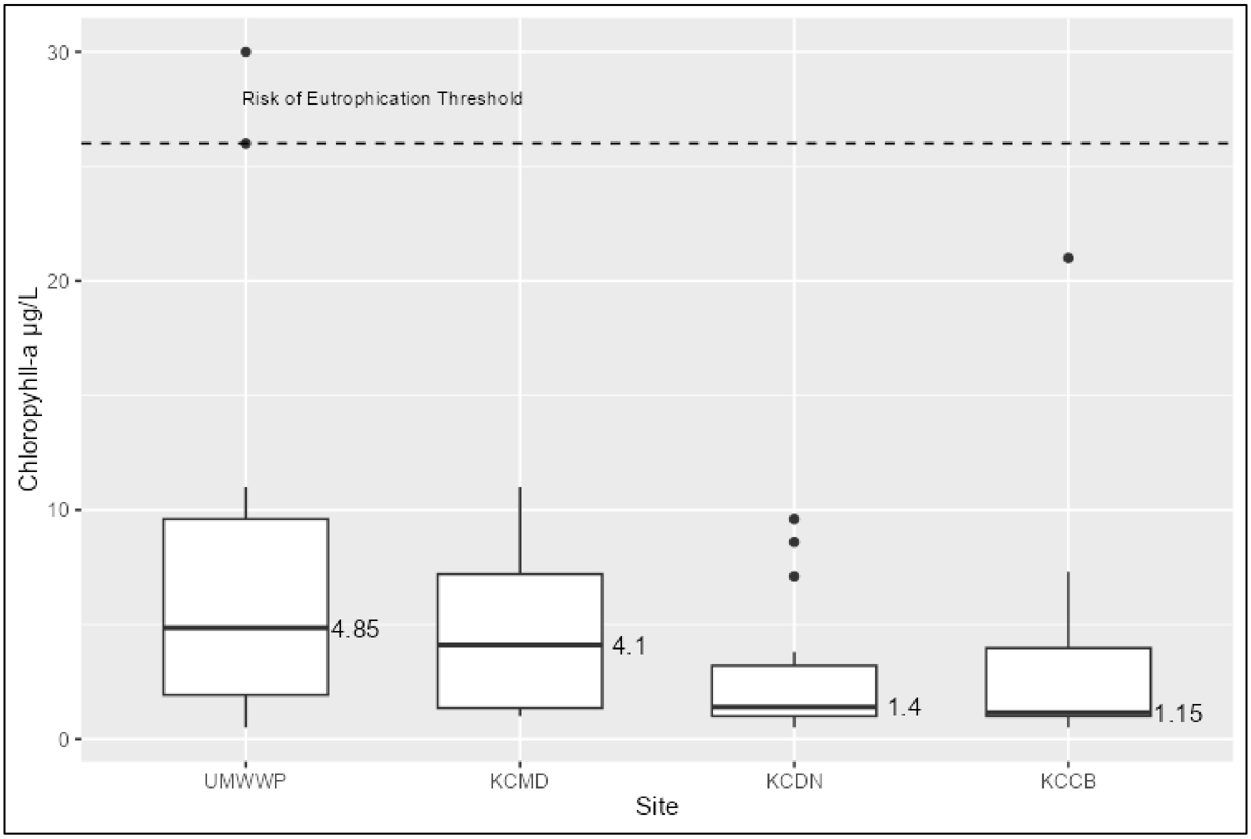


Figure 6 - Chlorophyll α Results (presented as box plots with sample medians annotated)

KICKAPOO CREEK UPSTREAM (UMWWP) – DO, pH, PHOSPHORUS

UMWWP Key Takeaways:

- This station is upstream and outside the influence from the Mattoon WWTP outfall and is not continuously monitored.
- Eutrophication risks were not met based on the DO + pH criteria.
- Eutrophication risk conditions were not met based on the median sestonic chlorophyll α criteria, however two samples were above the 26 µg/L threshold.
- High chlorophyll results occurred when TP was also high.
- Data indicates that NPS are a contributor of Kickapoo Creek upstream nutrient loads during normally flowing conditions.

Kickapoo Creek upstream of the Mattoon WWTP was monitored at a minimum frequency of weekly (n=51). DO saturation and pH results are illustrated in Figure 7. Many of the measurements were made in the late morning or afternoon when DO and pH are expected to be near their daily peaks. There were no exceedances of the DO + pH risk of eutrophication criteria observed in the monitoring period. However, this site was not monitored continuously, thus it is impossible to quantify the true number and magnitude of exceedances, if any.

There is phosphorus available in the stream from NPS. The mean TP concentration was 0.64 mg/L (n=34), and the maximum was 2.79 mg/L. The phosphorus results were most elevated during the September-

November months, when flows were at their lowest. Interestingly, the two highest chlorophyll results occurred when TP samples were above 2.0 mg/L. There was a TP outlier of over 7 mg/L on 26 September 2023, and it is believed to be an analysis error as the orthophosphate measure remained low and there were no other samples nearing this concentration. Thus, this measurement was removed from the dataset. Abnormally low flows during much of the monitoring period indicate that data at this site is not representative of typical conditions.

Kickapoo Creek at S. 6th Street. Upstream of Mattoon WWTP (UMWWP)

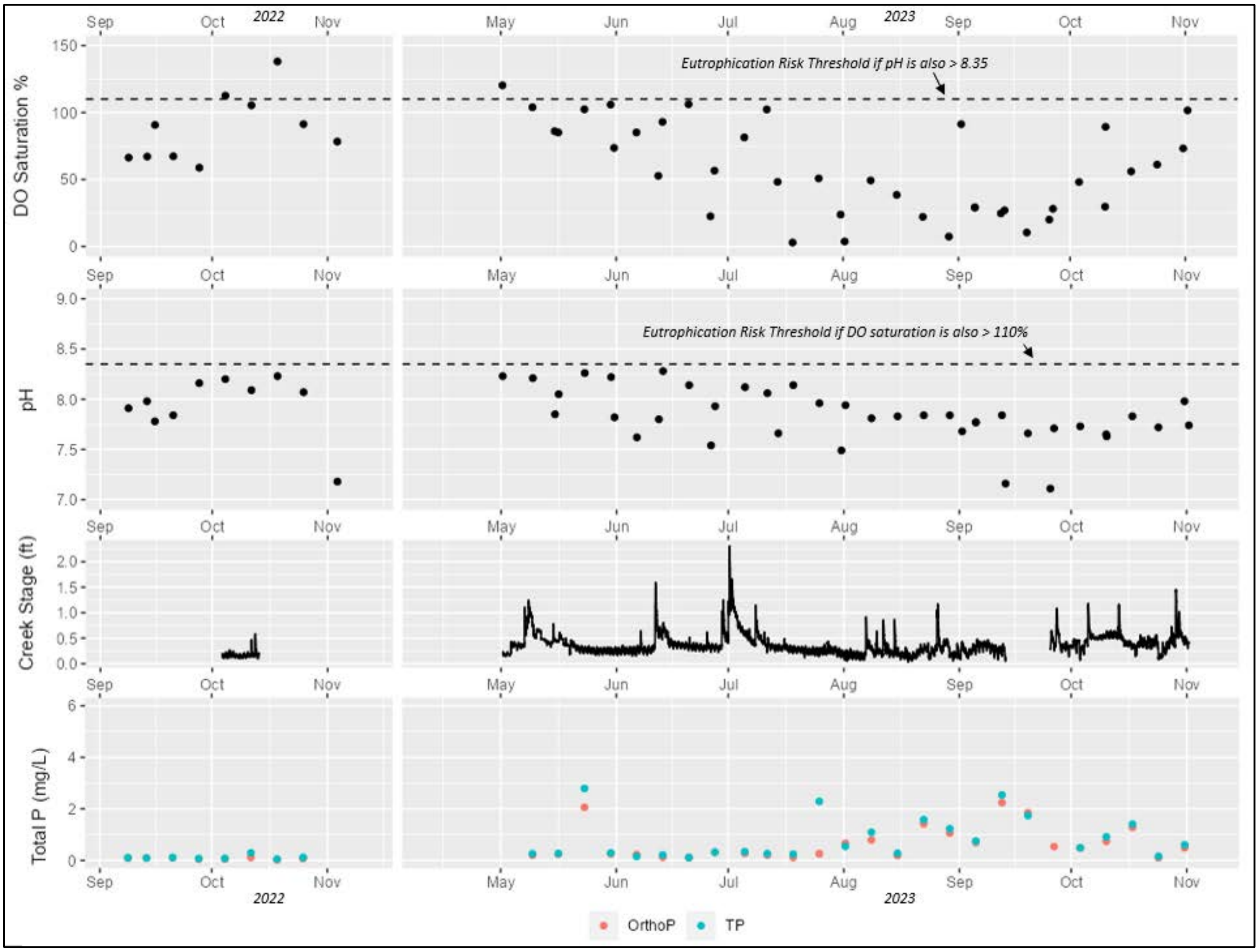


Figure 7 - Kickapoo Creek Upstream (UMWWP) - DO saturation, pH, TP, and Stage from KCMD – 2022-2023

KICKAPOO CREEK MIDDLE (KCMD) – DO, pH, PHOSPHORUS

KCMD Key Takeaways:

- This station captures the watershed that includes the WWTP. The site is approximately 1.1 miles downstream of the outfall.
- Eutrophication risk conditions were not met based on the DO + pH criteria, nor the pH >9 criteria.
    - There were 196 days of continuous monitoring.
- Eutrophication risk conditions were not met based on the median sestonic chlorophyll α criteria.
- Phosphorus concentrations are elevated compared to the upstream and downstream sites.

Kickapoo Creek Middle is 1.1 miles downstream of the WWTP and was monitored with in-situ sensors. This allowed for characterization of the diel range of DO and pH (Figure 8). Additionally, grab samples were collected, and spot checks were performed during instrument calibration visits, approximately every two weeks. There were 196 monitoring days with both DO and pH measurements. None of these measurements exceeded the risk of eutrophication criteria of daily maximum 110% DO saturation and

8.35 pH (Table 6). Chlorophyll was generally low, well below the 26 µg/L criteria. The median chlorophyll α concentration was 4.1 µg/L with a maximum of 11 µg/L.

Table 6 – Kickapoo Creek Downstream Near the Outfall (KCMD) - Summary of Continuous Monitoring Results

Days with Continuous Monitoring	Median Daily Maximum	# of Days Exceeding the Risk of Eutrophication Criteria (8.35 pH + 110% DO)	% of Days Exceeding the Risk of Eutrophication Criteria (8.35 pH + 110% DO)
196	80.3% (DO Saturation) 7.4 (pH)	0 days	0%

A pattern in DO and pH related to precipitation and runoff events was observed. During high flow events, DO saturation and pH dip, and then recover to normal levels over a period of days. These dips in DO during runoff events caused several brief instances below 5.0 mg/L. Data do not appear to be related to nutrient issues in the stream. The mean TP concentration at KCMD was 3.0 mg/L (n=34) with maximum values of 7.2 mg/L and 6.1 mg/L occurring in September 2023, during a period of low flow. Mean orthophosphate was 2.7 mg/L (n=35) with a maximum of 7.01 mg/L. The results indicate there are notable phosphorus concentrations in the stream from NPS. Dense canopy cover may restrict algal growth and eutrophication conditions at this station.

Kickapoo Creek Middle, at Odd Fellow Rd. Downstream of Mattoon WWTP (KCMD)

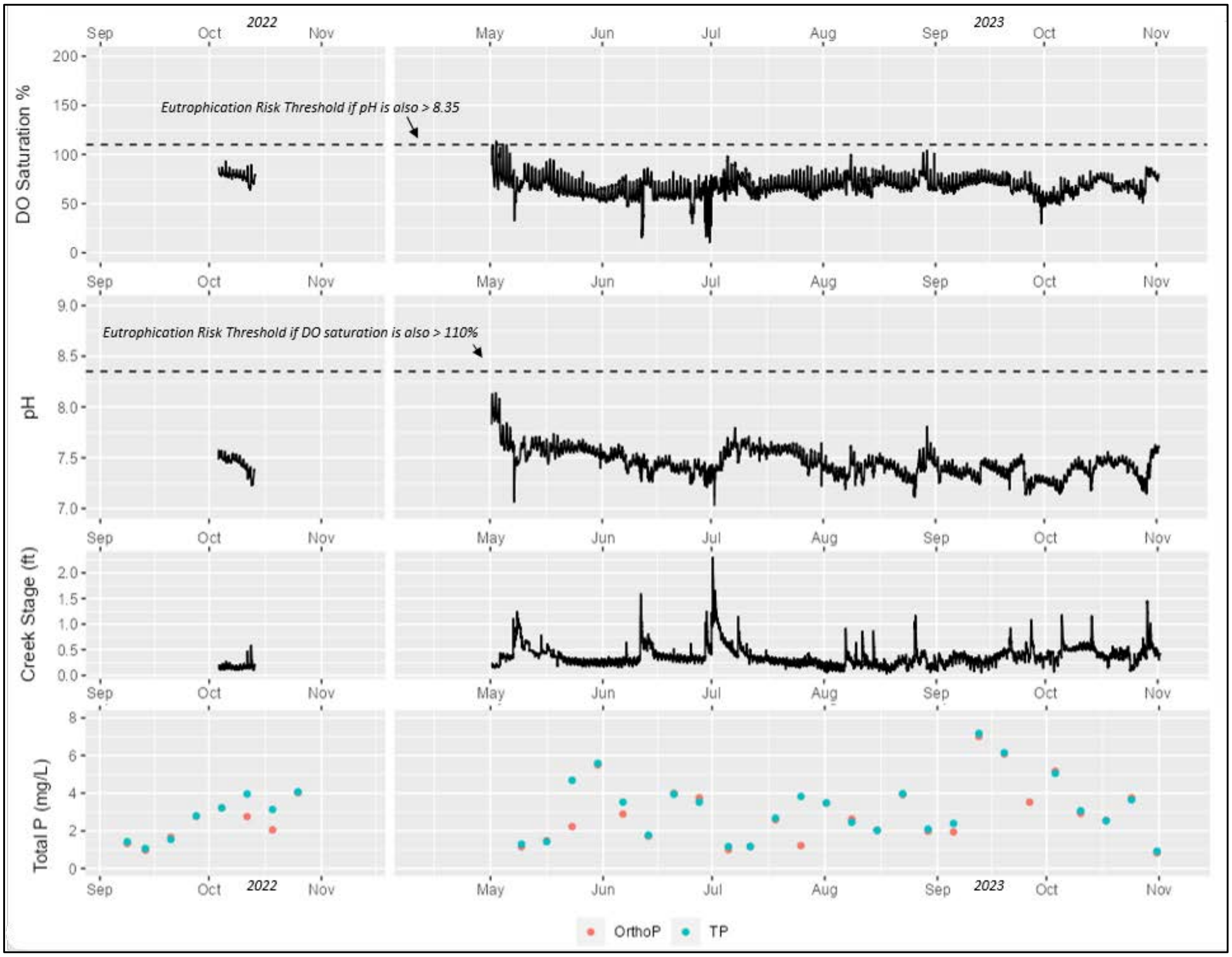


Figure 8 – Kickapoo Creek Middle 1.1 Miles Downstream from the Mattoon Outfall (KCMD) - DO saturation, pH, TP, and Stage - 2022-2023

KICKAPOO CREEK DOWNSTREAM (KCDN) – DO, pH, PHOSPHORUS

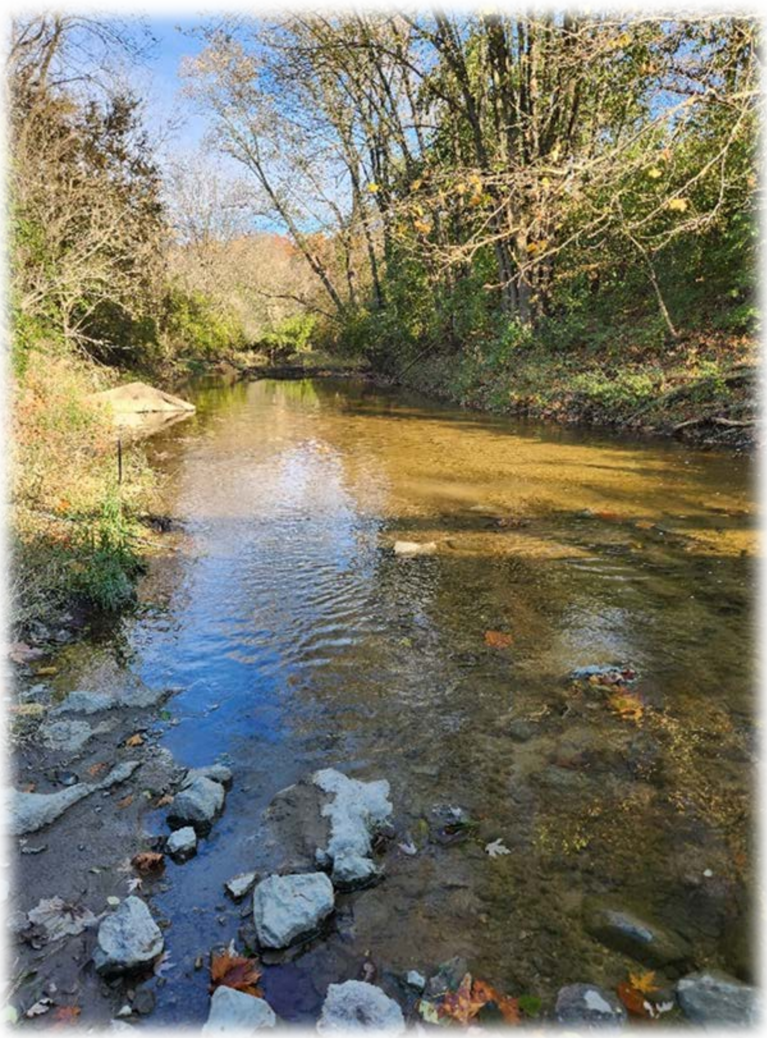
KCDN Key Takeaways:

- This station is 10.7 miles downstream from the WWTP, and 0.7 miles upstream from where Riley Creek enters Kickapoo Creek.
- Eutrophication risk was met based on the DO + pH criteria.
    - 10 days during the monitoring period.
- Eutrophication risk conditions were not met based on the pH > 9 criteria.
- Eutrophication risk conditions were not met based on the median sestonic chlorophyll α criteria.
- Data indicates that NPS is a contributor of Kickapoo Creek nutrient loads.

Kickapoo Creek Downstream is 10.7 miles from the WWTP, but upstream from where Riley Creek enters Kickapoo. This site was monitored approximately weekly. Dissolved Oxygen saturation + pH (n= 49) and TP (n=34) results are illustrated in Figure 9. Most measurements were made in late morning or early afternoon when DO and pH are expected to be approaching their daily peaks. Based on the DO + pH risk of eutrophication criteria, there were 10 exceedances, most in early summer 2023, and typically occurred during base flow conditions. Total Phosphorus results from samples collected coincident with DO + pH samples above 100% and 8.35 were typically near or below median TP.

As expected in a small stream with good canopy cover and consistent baseflow, sestonic chlorophyll α levels are low relative to the 26 µg/L threshold, with a mean of 2.8 µg/L and a maximum of 9.6 µg/L from 15 samples.

This station experienced a risk of eutrophication exceedance in about 20% of DO + pH samples during the monitoring period. The site was not monitored continuously and data regarding the duration and magnitude of the eutrophication risks are not quantifiable. Results indicate there is phosphorus available in the stream from both point and NPS in the 30 mi^2 watershed. The mean phosphorus concentration was 2.0 mg/L and the maximum was 5.4 mg/L. Concentrations generally increased as pH, DO, and flows decreased over the summer monitoring period into early fall.



Kickapoo Creek Downstream, at N. County Road 1680E. Downstream of Mattoon WWTP (KCMD)

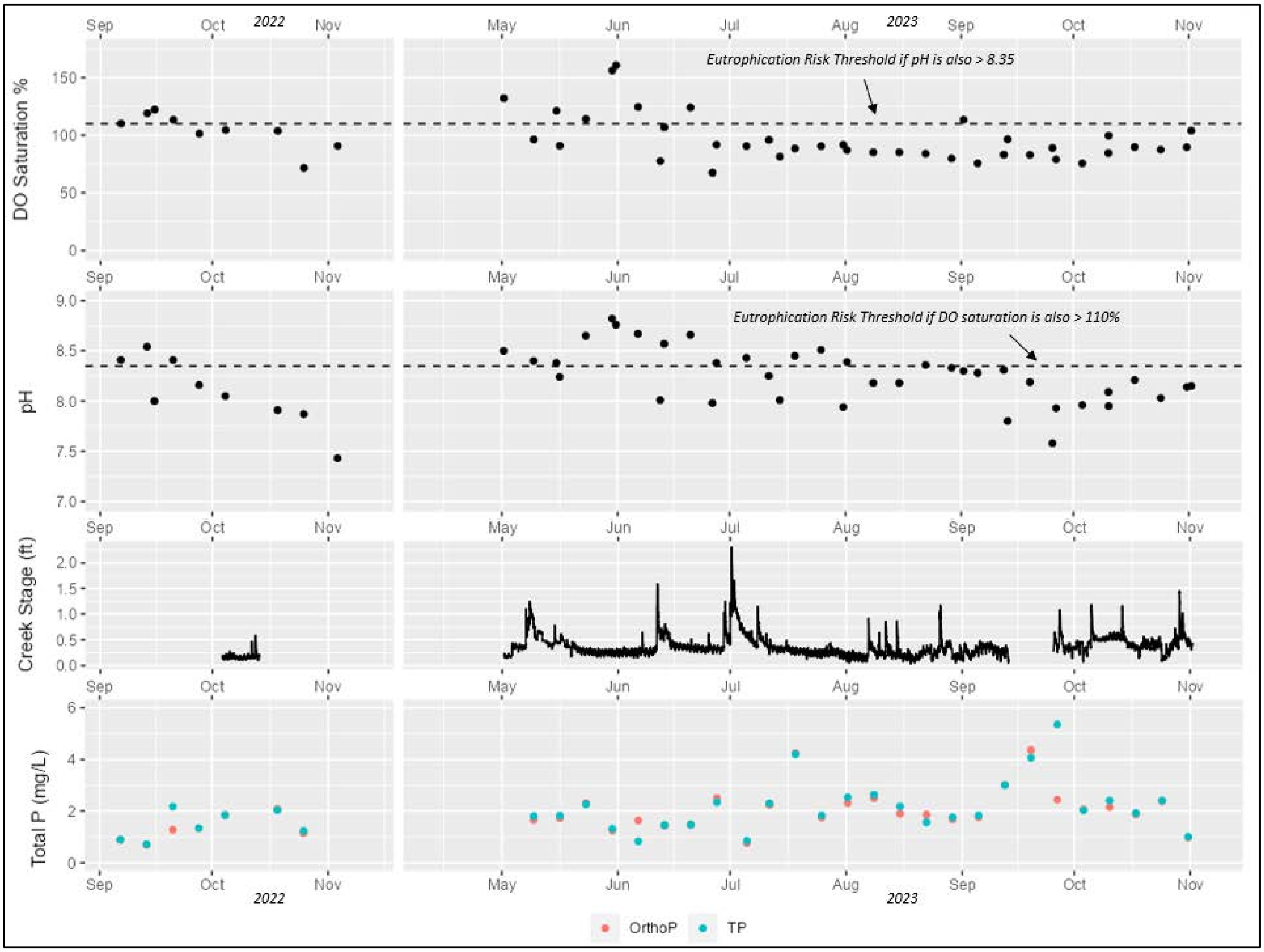


Figure 9 – Kickapoo Creek Downstream (KCDN) - DO Saturation, pH, TP, and Stage from KCMD - 2022 – 2023

RILEY CREEK DOWNSTREAM (RCDC)

Riley Creek downstream was monitored with continuous monitoring equipment and grab sampling as part of the City of Charleston's NARP from July – October 2022 and May – August 2023. It is noted as it may serve as an important reference point for development of NARP strategies and planning between Charleston and Mattoon. For a full description of this site and results, see the City of Charleston NARP Strategy and Work Plan.

KICKAPOO CREEK COMBINED (KCCB) – DO, pH, PHOSPHORUS

KCCB Summary:

- This station is downstream of the confluence with Riley Creek and influenced by both the Charleston and Mattoon WWTP outfalls. It is approximately 13.5 stream miles downstream of the Mattoon WWTP and 4.3 stream miles downstream from Charleston.

- Eutrophication risk conditions were met based on the DO + pH criteria.
    - The DO + pH eutrophication risk criteria was exceeded on 40% of the days monitored with sensors.
    - Most of the exceedances occurred in the spring to early summer (mid-July).
- Eutrophication risk conditions were not met based on the pH > 9 criteria.
- Eutrophication risk conditions were not met based on the median sestonic chlorophyll *a* criteria.
- Phosphorus levels are low compared to upstream of the confluence with Riley Creek at KCDN.
- Water quality at this site is influenced by both the effluent of Charleston and Mattoon's WWTP, as well as NPS phosphorus in the 100 mi^2 watershed.
- Dense canopy cover and soft stream substrates are likely limiting periphyton growth.

Kickapoo Creek "Combined" (KCCB) is downstream of the confluence with Riley Creek. It is the stream segment identified by the Illinois EPA that triggered the NARP special permit condition for Mattoon and Charleston. The station was monitored with sondes and grab sampling. For the monitoring period October 2022 and May – October 2023 there were 198 days of DO and pH sensor data collected (Figure 10), of which 40% exceeded the risk of eutrophication criteria (Table 7).

An equipment failure resulted in a data gap from late June to mid-July 2023. During this period, 1 of 4 grab samples exceeded the DO + pH risk of eutrophication criteria. The mean chlorophyll α concentration was 4.8 µg/L and the maximum was 21 µg/L (n=13). It is important to note that this maximum concentration was an outlier, influenced by discharge of treated wastewater from Charleston's excess flow lagoon, described previously. The next highest concentration was 7.3 µg/L, indicating sestonic chlorophyll α is not a eutrophication risk criteria of concern at this site. Sensor data corroborates this assertion, as the peaks in chlorophyll fluorescence coincide with treated lagoon wastewater releases.

Table 7 - Summary of KCCB Continuous Monitoring Results

Days with Continuous Monitoring	Median Daily Maximum	# of Days Exceeding the Risk of Eutrophication Criteria (8.35 pH + 110% DO)	% of Days Exceeding the Risk of Eutrophication Criteria (8.35 pH + 110% DO)
198	122% (DO Saturation) 8.3 (pH)	79	40%

Most of the risk of eutrophication exceedances occurred early in the monitoring season. In August 2023, several rainstorms over a few days increased creek stage slightly. This influx of rainwater appeared to keep the diel range of pH from rising above the 8.35 threshold, even while DO was consistently above the 110% daily maximum level.

Mean TP concentration at KCCB was 1.27 mg/L (n=24) with several samples exceeding 2 mg/L. These high concentrations occurred during some of the lowest measured flows at this site. Mean orthophosphate concentration was 1.25 mg/L as phosphorus (n=23), with results mirroring those of TP. There is not a consistent pattern or correlation between phosphorus concentrations and eutrophication risk occurrences, as many of the longest durations of eutrophication risks occur when concentrations are statistically lower.

The results indicate patterns in phosphorus are similar to Kickapoo Creek Downstream (KCDN) before its confluence with Riley. However, river flows and phosphorus loads are greater at Kickapoo Creek Combined (KCCB) compared to the next station upstream, indicating that the Riley Creek watershed is also contributing nutrients likely from both point and NPS. Charleston monitoring data was important for further assessing the eutrophication dynamics and guiding strategies.

Kickapoo Creek Combined, Lincoln Hwy Road. Downstream of Mattoon and Charleston WWTPs (KCCB)

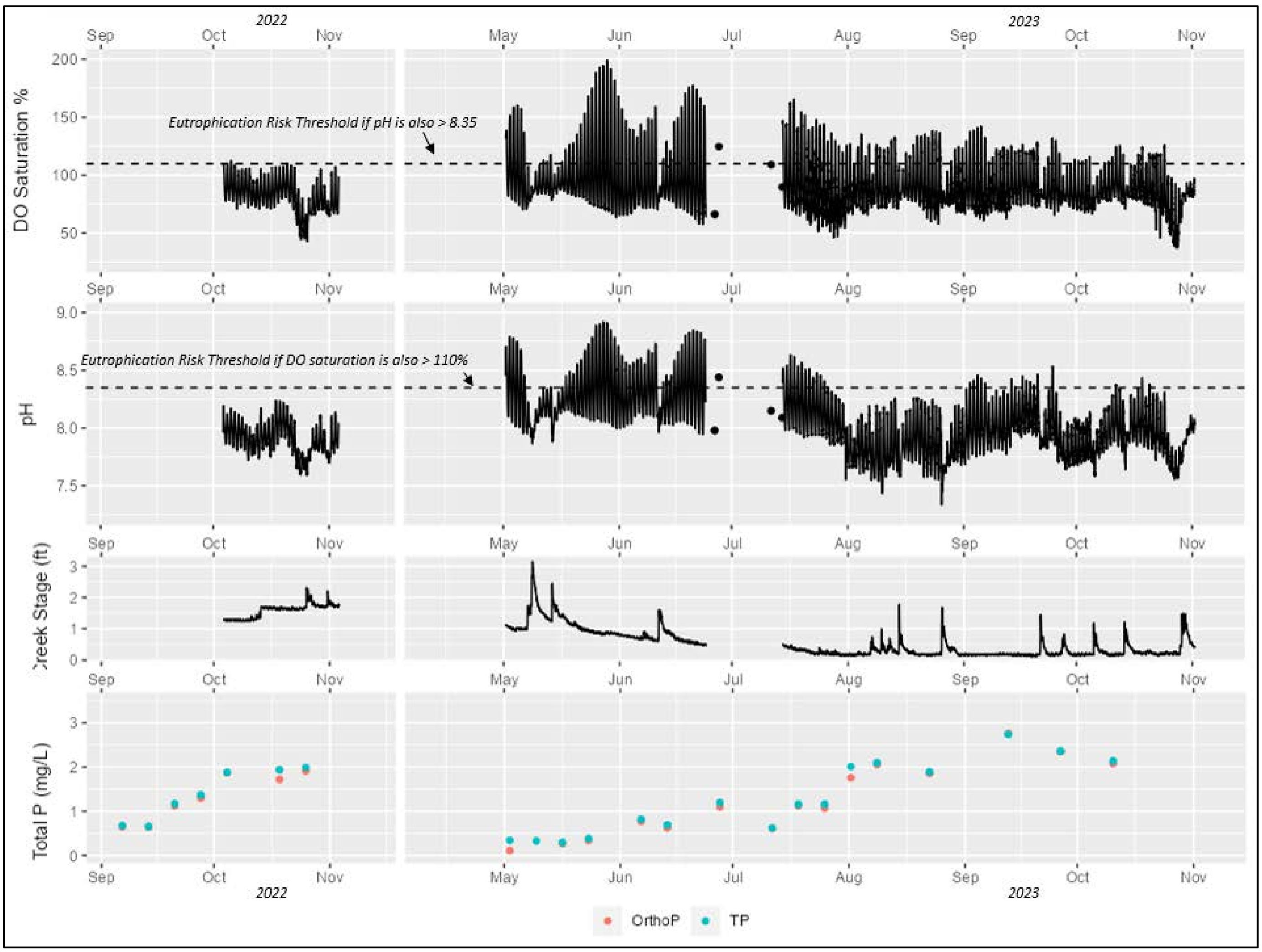


Figure 10 - Kickapoo Creek "Combined" (KCCB) DO Saturation, pH, and TP - 2022 - 2023

3.5 INTREPRETATION & ANALYSIS

The monitoring results identified eutrophication risk based on one of the three criteria defined by the Illinois EPA (pH > 8.35 and DO saturation > 110%) at the two furthest downstream stations, which had documented risk associated with pH and DO saturation criteria. There were no exceedances of the median chlorophyll α or pH > 9 criteria. The upstream station and downstream station closest to the WWTP outfall did not exceed risk of eutrophication criteria. The occurrences that were documented do not appear to correlate with patterns in phosphorus concentrations.

The results illustrate the complex watershed and stream system processes affecting water quality and contributing to eutrophication risk. Therefore, the treated effluent from Mattoon may be only one of several drivers. The data demonstrates that NPS and treated wastewater effluent are both contributors of phosphorus. Nonpoint sources are likely responsible for the highest concentrations detected and comprise a larger fraction of the annual yields entering the stream systems.

The dry conditions and lower baseflows during the 2023 monitoring period likely elevated the frequency and duration of risk of eutrophication exceedances and may not be the most representative snapshot of data to inform the NARP. The segment of Kickapoo Creek (KCCB / IEPA_BEN-01) was the original stream segment that triggered the NARP permit condition for both Charleston and Mattoon.

Approximately 40% of monitored days in 2022 and 2023 were above the threshold of 8.35 pH and 110% DO daily maximum which corroborates 2011 Illinois EPA monitoring results, and it was this stream segment that had the most significant number of eutrophication risk conditions. However, the 2016 Illinois EPA data did not show any eutrophication risk occurrences. Mattoon intends to focus further efforts and next steps on the NARP on this segment, and in coordination with the City of Charleston. A Strategy and Work Plan is presented in subsequent sections.

4. NARP STRATEGY & WORK PLAN

Based on an understanding of the watershed dynamics and the results of the monitoring program, the NARP Strategy and Work Plan is presented focusing on the Kickapoo Creek stream segment BEN-01 and the associated 65,489-acre watershed. This watershed area is included within the 2022 Embarras River Watershed Management Plan (WMP), which is an Illinois EPA approved nine-element plan and was supported by the City Mattoon. Kickapoo Creek represents 4.2% of the entire Embarras River basin.

This Kickapoo Creek watershed comprises of 67% agriculture and 13% urban/developed lands and includes the City of Charleston WWTP in addition to the Mattoon WWTP. Mattoon and Charleston intend to coordinate and synthesize NARP efforts.

4.1 WATERSHED CHARACTERIZATION

A concise watershed characterization is presented and includes relevant information related to hydrology, land cover, climate and demographics. Current and historical water quality impairments are summarized and estimates of phosphorus loading from NPS and point sources are presented. Most of the data presented are derived and/or recalculated from the 2022 Embarrass River WMP for only the Kickapoo Creek basin. This section also details applicable linkages with the 2022 WMP, other relevant plans, efforts, and initiatives.

HYDROLOGIC UNIT CODES

Kickapoo Creek is in east-central Illinois, entirely within Coles County and within the larger Embarras River watershed. The 10-digit Hydrologic Unit Code (HUC - 0512011206) watershed is 65,489 acres and contains 3 smaller HUC12 subwatersheds (Table 8).

Table 8 - Kickapoo Creek HUC 12 subwatersheds

HUC Name	HUC 12 ID	Area (acres)
Sweetwater Creek – Kickapoo Creek	05120112603	24,602
Riley Creek	05120112601	25,944
Cassell Creek	05120112601	14,944
	Total:	**65,489**

STREAMS & LAKES

According to the National Hydrography Dataset (NHD) there are 184 miles of streams and rivers, including artificial drainageways (Table 9). Kickapoo is the longest named stream at 20.6 miles followed by Riley (15.4 miles) and Cassell (8.6 miles). Unnamed tributaries and artificial drainage ways cover 132 miles. Water quality impairments are included in a proceeding section of this watershed characterization.

Table 9 - Watershed Stream Segments and Illinois EPA Assessment ID

Stream Name	Illinois EPA Assessment ID	Length (Miles)
Unnamed Tributary/Drainage Way	N/A	132
Kickapoo Creek	BEN-01/BEN-02	20.6
Riley Creek	BENA-01/BENA-02/ BENA-03	15.4
Cassell Creek	BENC-01	8.6
Union Drainage District Number 3	N/A	4.5
Sweetwater Creek	BENB	2.7
	Total:	**184**

The NHD also identifies 243 acres of lakes, ponds and reservoirs, the largest lake is unnamed and 21 acres in size. The largest named lake is Lake Windermere at 8 acres.

CLIMATE NORMALS

Based on climate normals published by the Illinois State Climatologist for Charleston for the period of 1991 – 2020 (UofI, 2023), Mattoon receives an average of 42.29 inches of precipitation per year (3.44 inches/ month). April is typically the wettest month, averaging 4.78 inches. Average temperature is 54 degrees Fahrenheit and July is the warmest month.

The watershed experienced 19% less precipitation than average in 2022 and 2023. The monitoring data supporting this NARP is from a climatic and hydrological period that is not representative of average conditions.

LAND COVER

Table 10 presents the land cover of the watershed. The two predominant land cover categories are (i) 67% agriculture comprising 43,824 acres of cultivated crops, and (ii) 13% developed/urban areas comprising of 8,262 acres according to the National Land Cover Database (NLCD) (Dewitz, J., 2021).

Of the fifteen HUC10 watersheds in the Embarras Basin, Kickapoo Creek contains the highest proportion of developed land area.

Table 10 – Kickapoo Creek Watershed Land Cover

Land Cover	Area (acres)	% of Watershed Area
Cultivated Crops	43,824	67%
Developed	8,262	13%
Forest	6,550	10%
Developed Open Space	3,814	5.8%
Grasslands/Hay/Pasture	2,763	4.2%
Open Water	162	0.25%
Wetlands	91	0.14%
Barren Land	23	0.04%
Total:	**65,489**	**100%**

Riley Creek (HUC12 05120112601) has the greatest proportion of agriculture/cultivated crops (78%), followed by Cassell Creek (HUC12 05120112601) at 74% and Sweetwater Creek (HUC12 05120112603) at 64%. The City of Mattoon has 4,965 acres of its 6,598-acre municipal area within the watershed. The City of Charleston covers a land area of 6,087 acres, of which 4,783 acres are in the watershed.

DEMOGRAPHICS & ECONOMY

Mattoon is the second largest population center in the watershed after Charleston, however, Mattoon has a larger land area within the watershed. According to the US Census Bureau, Matton's 2022 population was 16,666, a decline of 10.2% since 2010 and 1.3% since 2020. The City of Charleston is also in the watershed with a 2022 population of 17,119, which has declined 21.6% since 2010 according to the US Census Bureau.

Mattoon falls within an Environmental Justice area designated by a low-income population and has a poverty rate of 22.46%. Median household income (2018 – 2022) is $45,953 compared to $72,563 for Illinois and the national average of $69,021.

WATER QUALITY IMPAIRMENTS

There are no current impairments on the 2020/2022 303(d) list for streams in the Kickapoo Creek watershed. Historic impairments from 2009, 2014, 2016, and 2018 include Aquatic Life Use listings with DO, pH and TP causes (Table 11).

Table 11 - Kickapoo Creek Watershed Historical Impairments

Receiving Stream	HUC12 Watershed	Illinois Assessment Unit	303(d) Impairments	Causes Related to P & Years on List
Cassell Creek	051201120603	IL_BENC-01	Fully Supports Designated Uses	N/A
Riley Creek	051201120802	IL_BENA-01	Aquatic Life	DO: 2018, ’16, ‘14 pH:2008
Kickapoo Creek	051201120802	IL_BEN-01, IL BEN-02	Aquatic Life	Phosphorus (total): 2008

RELATIONSHIP TO OTHER PLANS & WATERSHED EFFORTS

Two recent plans and studies are relevant to the Mattoon NARP, (i) the 2022 Embarras River WMP, and (ii) the Kickapoo Creek/Riley Creek Total Maximum Daily Load (TMDL), currently in development. The Embarras WMP was developed with financial assistance from the Illinois EPA Section 319 program in partnership with the Coles County Soil and Water Conservation District (SWCD), Illinois Extension and the Illinois Farm Bureau. Primary concerns addressed by the plan include erosion, sedimentation, water quality, and a lack of education.

The TMDL was triggered by the 2018 DO impairment on Riley Creek. Stage 1 (watershed characterization, data analysis, and methodology section) has been completed and Stage 3 (Model calibration, TMDL scenarios, and implementation plan) is underway with a draft expected by the Illinois EPA in January of 2024.

EMBARRAS RIVER WATERSHED MANAGEMENT PLAN

The 2022 Embarras River WMP represents an update to the 2011 plan and encompasses an area of approximately 2,435 mi^2. The Embarras River is considered a priority for phosphorus reduction as noted in the Illinois Nutrient Loss Reduction Strategy (INLRS). This was the primary driver of the plan and the focus of recommendations. Mattoon contributed by providing input to the Planning Committee. Implementation of the plan is already underway to reduce nutrient and sediment loading. In Coles County, the SWCD intends to partner with the Illinois Farm Bureau and others to secure grant funding to implement practices in Polecat Creek, a priority HUC12 subwatershed east of Charleston.

KICKAPOO CREEK TMDL

A TMDL, is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards and are a requirement of Section 303(d) of the CWA. Illinois EPA is leading efforts now to assess and address water quality impairments with one underway to tackle DO on the Riley Creek segment BENA-01. The TMDL covers the entire Kickapoo Creek HUC10. As previously described, a TMDL consists of 2 primary stages. Stage 1 is complete and provides a detailed watershed characterization and an analysis of water quality data relevant to the impairment being addressed. Refer to this report for more information on the HUC10.

Of relevance is Section 5 discussing potential pollution sources. Both septic systems and NPS pollution from agricultural sources are listed. Next steps in the TMDL process are to complete modeling and estimate the needed reductions to achieve the DO standard. An implementation plan will include broad recommendations to reduce NPS source pollution similar to those that found in the Embarras River WMP.

POINT & NONPOINT SOURCE LOADING

Point source pollution is defined by the United States EPA as “any single identifiable source of pollution from which pollutants are discharged, such as a pipe, ditch, ship or factory smokestack” (Hill, 1997). The NPDES, a provision of the Clean Water Act, prohibits point source discharge of pollutants into waters of the U.S. unless a permit is issued by the USEPA or a state or tribal government. Individual permits are specific to individual facilities (e.g., water or wastewater treatment facilities), and general permits are for a group of facilities in a geographical area. Permits describe the allowed discharge of pollutant concentrations (mg/L) and loads (lbs/day). The Mattoon WWTP currently does not have an effluent phosphorus permit limit.

Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. The term "nonpoint source" is defined to mean any source of water pollution that does not meet the legal definition of "point source." Unlike pollution from point sources like industrial and sewage treatment plants, NPS pollution comes from many diffuse sources and is caused by rainfall or snowmelt moving over and through the ground. The runoff picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters (USEPA, 2018).

Point source loading of phosphorus from the Mattoon and Charleston WWTPs is provided in Table 12. Average annual loading from 2017 through 2022 is 36,208 lbs for Mattoon and 16,083 lbs for Charleston.

Table 12 - Annual Phosphorus Load from WWTPs in lbs - (Data Source: Illinois EPA and USEPA ECHO)

WWTP	2017	2018	2019	2020	2021	2022	Average Annual
Mattoon	45,046	35,650	42,640	33,809	32,979	27,124	**36,208 lbs**
Charleston	14,798	14,895	14,989	16,617	19,505	15,699	**16,083 lbs**

Based on the 2022 Embarras River WMP, the average annual NPS phosphorus load for the watershed is 65,390 lbs/yr. The total average annual phosphorus loading is therefore estimated at 117,638 lbs, with the Mattoon WWTP accounting for 30.8%. Nonpoint sources are responsible for ~56% of average annual phosphorus loads in the watershed and are a larger contributor than both Charleston and Mattoon WWTPs combined (Figure 11).

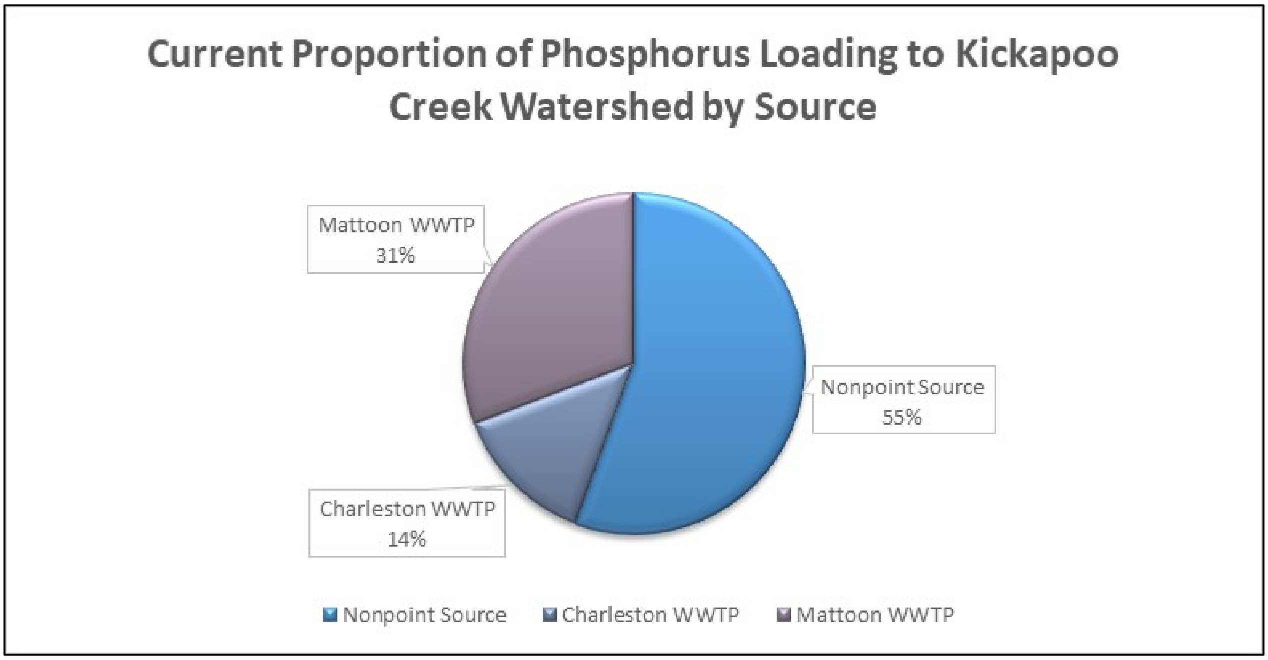


Figure 11 – Proportion of Annual Total Phosphorus Load to Kickapoo Creek Watershed by Source

4.2 NARP STRATEGY

Mattoon's plan is to focus on the BEN-01 segment of Kickapoo Creek and its watershed described in Section 4.1. The segment is downstream from the confluence with Riley Creek and exhibited DO + pH eutrophication risk based on Illinois EPA criteria in 2011, 2016 and more recently in 2022/2023. The monitoring program in 2022/2023 demonstrated that DO + pH eutrophication risk criteria are met at locations throughout the watershed, even at locations upstream and outside the influence of WWTP effluent.

The Mattoon WWTP contributes approximately 30.8% of the average annual phosphorus loading to the Kickapoo Creek watershed. Nonpoint sources are estimated to contribute almost 2X the load of the Mattoon WWTP and are a larger contributor to the water quality issues and eutrophication risk conditions

(Figure 11). The availability of phosphorus in the stream systems is systemic due to the agricultural and urban (wastewater) land uses that dominate the watershed. Based on the monitoring program, DO + pH eutrophication risk conditions are greater where riparian and canopy cover conditions are poor, which are typically areas under agricultural production. The DO + pH eutrophication risk occurrences that were documented consistently do not correlate with phosphorus concentrations measured in the waters, and as previously mentioned, the eutrophication risks occur both upstream and downstream of wastewater influences.

The City of Mattoon recognizes their contribution of phosphorus to the watershed and how this input is a part of complex and dynamic processes that may affect the frequency and/or duration of eutrophication risks under certain conditions. The city does not have jurisdiction over land management practices outside of municipal boundaries where a majority of the nutrients originate.

In this context, the City of Mattoon's NARP is focused on improving water quality in the watershed in three ways:

1. **WWTP Plant Upgrades** – Mattoon is pursuing treatment plant upgrades aimed to reduce phosphorus effluent to 0.5 mg/L (avg. annual geometric mean).
    a. Mattoon's contribution of phosphorus will be reduced by at least 75% with these upgrades. The annual loading will be reduced to the range of 8,500 – 8,700 lbs/year from over 36,000 lbs/year.
    b. This will result in Mattoon's portion of annual watershed phosphorus loading being reduced from **31% to 11%** (accounting for plant upgrades at Charleston). Figure 12 illustrates the proportion of phosphorus loading after planned treatment upgrades.
    c. The plant upgrades and phosphorus load reductions will have a positive effect on water quality and eutrophication risk conditions.
2. **Collaborate** - on and continue to support current and future watershed planning and TMDL efforts that address NPS pollution loading. Mattoon has supported current and past watershed planning.
    a. Evaluate developing an internal means to track involvement and investments in a measurable way to report on progress and improvements.
3. **Local Watershed Group** – no group currently exists for Kickapoo Creek. Mattoon would consider participating in a watershed group if one were to be established, recognizing that this would need to involve the agricultural community, the Coles County SWCD and the City of Charleston.
4. **Source Water Protection** – Mattoon will continue to invest in water quality improvements, planning and compliance related to our two water supply lakes and their watersheds (Lake Paradise and Lake Mattoon). Improving the source water will help mitigate treatment costs and may also translate into effluent improvements.

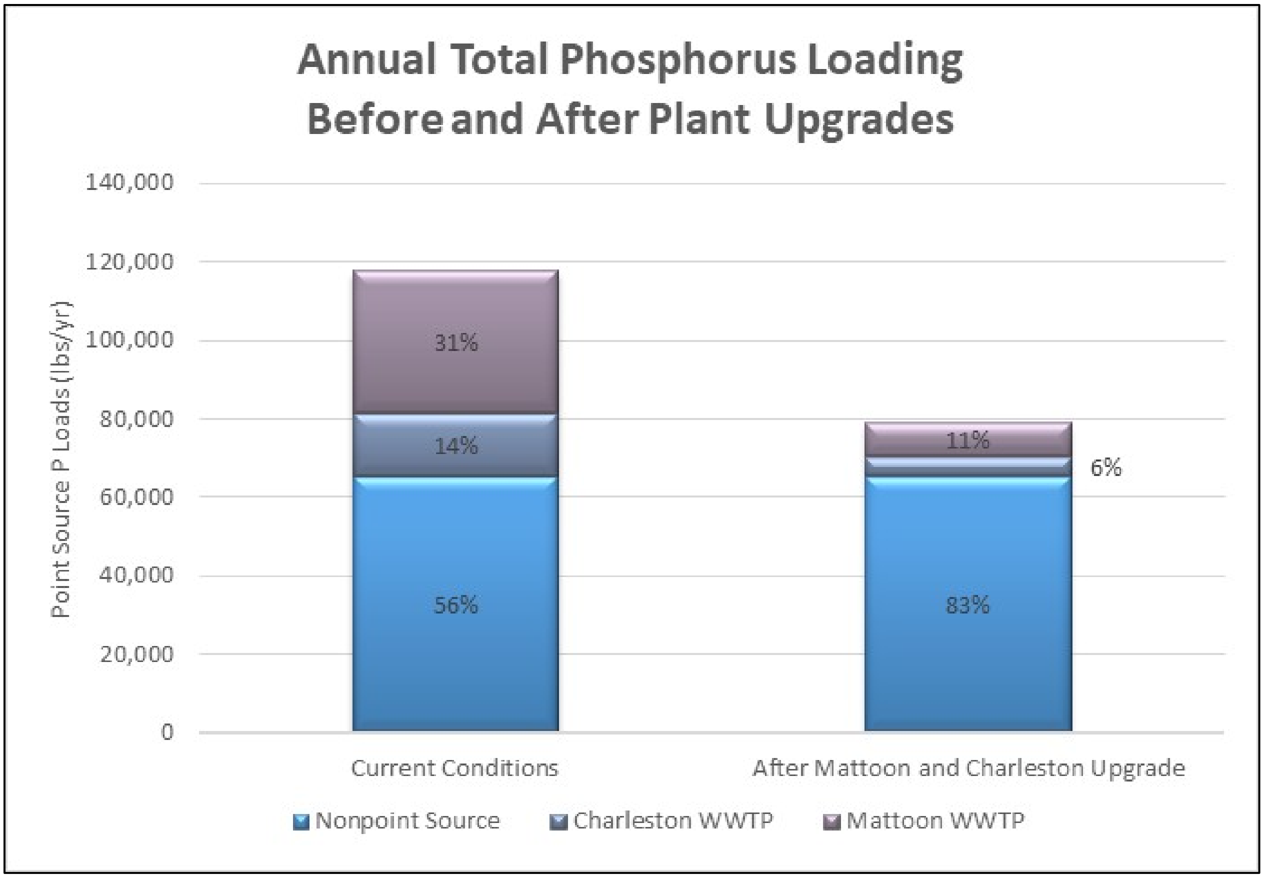


Figure 12 – Phosphorus Loads from Point and NPS Before and After Treatment Plant Upgrades

Appendix C provides the treatment plant upgrade plans. The plans include upgrades to achieve Biological Nutrient Removal (BNR) and meet a new phosphorus limit of 0.5 mg/L. It is estimated that the new system will achieve a 76% reduction in phosphorus loading. The City of Mattoon is committed to removing nutrients from the discharge to the watershed. Plant upgrades will also include improvements to solids handling, the aeration system, the grit system and CSO treatment. These plant upgrades and corresponding point source reductions will have a positive effect on water quality and reduce risk of eutrophication conditions.

Significant efforts and investments to reduce NPS and point source phosphorus loading in the watershed are underway or in planning including: (i) the 2022 Embarras River WMP, (ii) Kickapoo Creek TMDL, and (iii) wastewater treatment plant upgrades. These combined efforts constitute an effective and impactful nutrient assessment and reduction plan that will see immediate water quality improvements.

4.3 NARP WORK PLAN

The Work Plan includes a schedule and cost estimate for NARP activities moving forward. Mattoon, alongside the City of Charleston, is committed to a series of key activities that will significantly reduce phosphorus loading to Kickapoo Creek, the subject of a risk of eutrophication designation that triggered the NARP. Furthermore, Mattoon will work with area stakeholders to further limit NPS loading through collaborative efforts outside of their jurisdiction. Actions include plant upgrades, potential involvement in a watershed group and partnerships to help secure outside funding for NPS reductions.

ACTIONS & SCHEDULE

A schedule of activities is presented in Table 13. Planning for plant upgrades are already underway, with a facility plan completed in 2021. If sufficient need warrants the establishment of a watershed group for Kickapoo Creek, Mattoon will consider supporting the Coles County SWCD in its establishment and participate. A fragmented but established watershed group currently exists for the Embarras River and supported the development of the 2022 WMP. Mattoon will also consider seeking partnerships with others to secure outside grant funding for NPS reduction projects recommended in the WMP and Kickapoo Creek TMDL. One example is through the Illinois EPA Section 319 program.

Table 13 - NARP Actions and Schedule

NARP Action	Anticipated Start Date	Anticipated End Date	Notes
Plant upgrades	Planning underway	2034	Upgrades will achieve compliance with 0.5 mg/L effluent concentration limit and will achieve a ~76% reduction in TP loading before the 2035 permit deadline.
Watershed Group	TBD	TBD	Mattoon will consider participation in a Kickapoo Creek stakeholder group if outside interest and a need dictates its formation. Mattoon will support the Coles County SWCD as a coordinating entity.
NPS Reduction Grants	TBD	TBD	Mattoon will look for opportunities to partner with other entities to implement NPS recommendations in the Embarras River WMP and Kickapoo Creek TMDL.

BUDGET & COST ESTIMATES

The full suite of Mattoon WWTP capital improvements and plant upgrades is estimated at over **$39,000,000**. Participation in a watershed group is estimated at **$5,000** per year including some limited financial support to the Coles County SWCD. The cost of NPS measures is currently unknown.

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APPENDIX A: MONITORING PLAN

City of Charleston
&
City of Mattoon
Wastewater Treatment Plants

Nutrient Assessment Reduction Plan
Data Mining & Monitoring Plan

July 2022

Prepared for: City of Charleston, Illinois
City of Mattoon, Illinois
Prepared by: Northwater Consulting

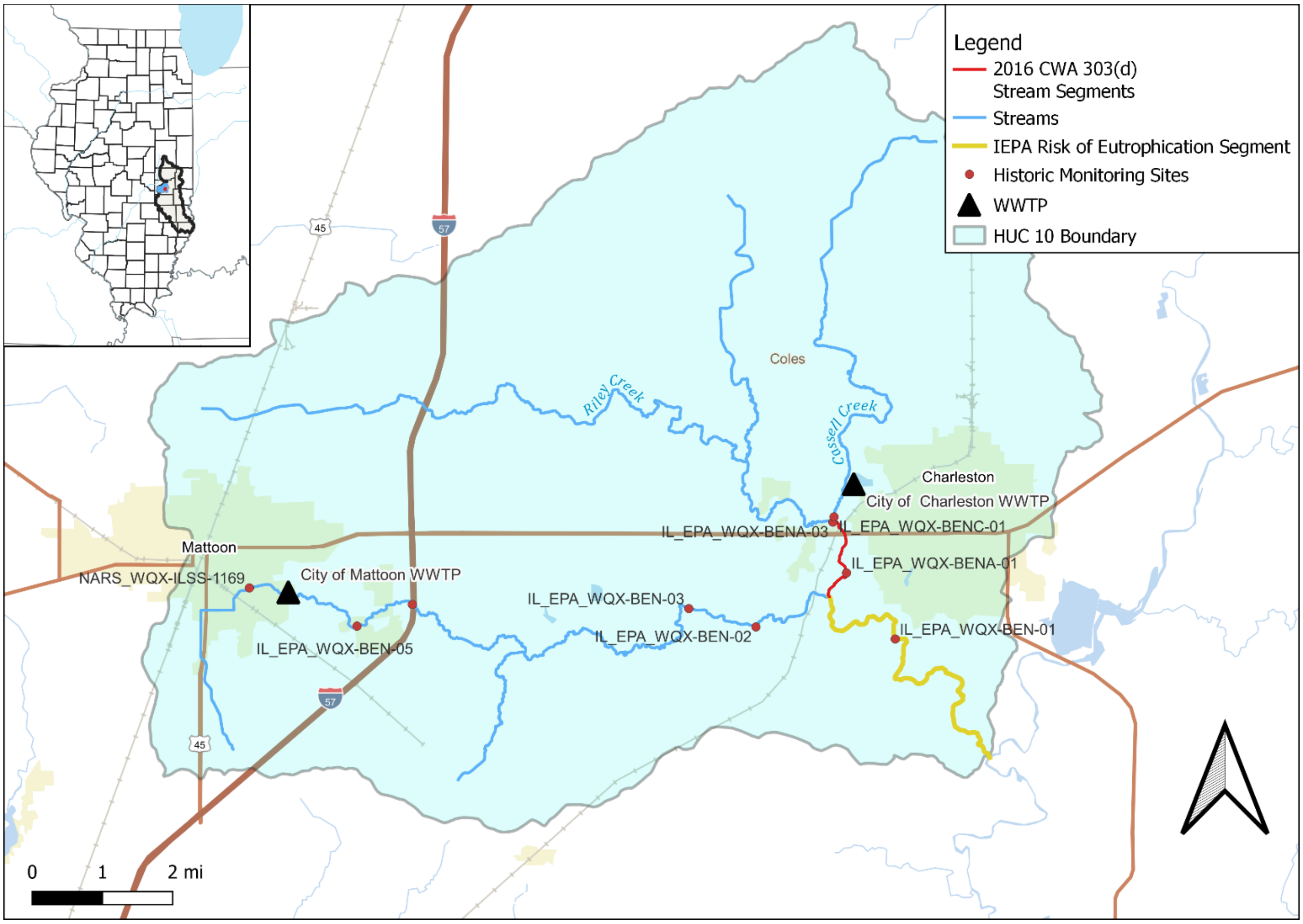

Figure 1. Project Area

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1 Introduction

1.1 NARP Process & Requirements

In 2018, the Illinois EPA (IEPA) instituted a new process for permitting of Publicly Owned Treatment Works (POTW) discharges that would allow for consideration of site-specific conditions for phosphorus limits. The Nutrient Assessment Reduction Plan (NARP) process resulted from negotiations with environmental organizations, IEPA, and the Illinois Association of Wastewater Agencies. A NARP Special Permit Condition is required if a receiving stream segment or downstream segment is on the Illinois Clean Water Act 303(d) list as impaired with phosphorus-related causes. A NARP is also required if there is a "risk of eutrophication" as defined by meeting any of the conditions outlined in Table 1.

Table 1. IEPA Risk of Eutrophication Criteria

Risk of eutrophication if any of these conditions met		
pH	Median sestonic chlorophyll *a*	On any two days during IEPA monitoring week, daily max
>9	>26 u/l	pH>8.35 and DO sat >110%

The City of Charleston and the City of Mattoon each operate one treatment plant that is required to undertake the NARP process as part of their National Pollution Discharge Elimination System (NPDES) permit. However, in this process, it may be determined through collection and assessment of relevant data that the watershed does not have a phosphorus-related impairment or risk of eutrophication. In this case, phosphorus input reductions and other measures may not be necessary. Northwater Consulting was retained by Charleston and Mattoon to assess if a NARP is required for their facilities, and if so, develop a strategy for development of a full NARP. This process has several components which include:

- Examining if there is sufficient water quality data to determine if NARP requirements apply.
  - If data insufficient, create a water quality monitoring plan and collect data.
- Undertake watershed characterization and determine if additional NARP components are required.
- If a full NARP is required:
  - Engage stakeholders throughout the process.
  - Model watershed and instream processes.
  - Establish defensible site-specific water quality criteria.
  - Define scenarios and strategies to achieve water quality targets.
  - Implement the recommendations of the NARP.

1.2 Data for NARP Determination

To make a determination, sufficient dissolved oxygen (DO), pH and sestonic chlorophyll *a* data must be available between May 1 and October 31 to assess if any of the eutrophication risk criteria are met. Based on mining and analysis of existing datasets for the outfall and associated stream segments, it was determined that additional water quality data collection is necessary to evaluate impairments and eutrophication risks according to NARP criteria.

This plan outlines the recommended monitoring and data collection actions necessary to assess requirements for the treatment plants. The data will also support focused recommendations and a strategy to develop additional NARP components for each, if required. The plan is intended to guide cities of Charleston and Mattoon through the data collection and assessment phase. More detailed results of the process and plan are presented herein.

2 Data Mining Results

The receiving streams were cross referenced with the 2016, 2018 and 2020/2022 IEPA Clean Water Act Section 303(d) list[1] of impaired waters. Details of phosphorus-related impairments are summarized for the treatment plants. The only stream segment recently impaired is Riley Creek, which is downstream of Cassell Creek, the receiving waterbody for the Charleston treatment plant effluent. Riley has been on the 303(d) list in 2008, and 2014-2018. However, IEPA determined the DO impairment on Riley Creek Segment IL_BENA-01 is not due to excess algal growth[2]. Cassell flows to Riley and Riley is tributary to Kickapoo Creek (Figure 1 and Figure 3). Kickapoo Creek, the receiving stream for Mattoon's effluent has not been listed since 2006 (fish kill) and 2008 (unknown cause). However, Kickapoo segment BEN-01, downstream of the confluence of Riley and Kickapoo qualified Charleston and Mattoon for a NARP special permit condition, as 2011 IEPA data showed 6 days monitored with pH > 8.35 and DO saturation >110%.

Table 2. Receiving Stream and Tributary Segment Summary

Mattoon and Charleston Receiving Stream Segments				
Receiving Stream	HUC12 Watershed	Illinois Assessment Unit	303(d) Impairments	Causes Related to P & Years on List
Cassell Creek	051201120603	IL_BENC-01	Fully Supports Designated Uses	N/A
Riley Creek	051201120802	IL_BENA-01	Aquatic Life	DO: 2018, '16, '14 pH:2008
Kickapoo Creek	051201120802	IL_BEN-01, IL BEN-02	Aquatic Life	Phosphorus (total): 2008

Receiving Major Watershed	POTW Design Average Flow	POTW Design Maximum Flow
Embarras River	Charleston - 3.3 MGD / Mattoon 5.3 MGD	Charleston - 6.0 MGD / Mattoon 14.0 MGD

[1] https://www2.illinois.gov/epa/topics/water-quality/watershed-management/tmdls/Pages/303d-list.aspx
[2] external.epa.illinois.gov/WebSiteApi/api/PublicNotices/GetDocument/10175

A search was completed for existing water quality data collected since January 1, 2002 from the USEPA Water Quality Portal[3] and Mattoon and Charleston provided effluent monitoring data. These data were examined to understand if eutrophication risk determinations could be made using DO, pH, chlorophyll *a* and water temperature. A summary of the data mining and analysis results for the receiving stream and stations on relevant nearby segments is presented in Table 3. Figure 1 shows site locations.

Table 3. Receiving Stream and Tributary Water Quality Summary

Site	Analyte	Mean	units	Number of Measurements	Begin Date	End Date
IL_EPA_WQX-BEN-01	Chlorophyll a, corrected for pheophytin	2.24	ug/l	5	5/31/2016	8/2/2021
IL_EPA_WQX-BEN-01	Dissolved oxygen (DO)	7.40	mg/l	3	5/31/2016	8/29/2016
IL_EPA_WQX-BEN-01	pH	7.93	None	3	5/31/2016	8/29/2016
IL_EPA_WQX-BEN-01	Temperature, water	23.50	deg C	3	5/31/2016	8/29/2016
IL_EPA_WQX-BEN-02	Chlorophyll a, corrected for pheophytin	4.14	ug/l	2	6/8/2021	8/2/2021
IL_EPA_WQX-BENA-01	Chlorophyll a, corrected for pheophytin	2.80	ug/l	5	5/31/2016	8/4/2021
IL_EPA_WQX-BENA-01	Dissolved oxygen (DO)	7.40	mg/l	3	5/31/2016	8/29/2016
IL_EPA_WQX-BENA-01	pH	7.97	None	3	5/31/2016	8/29/2016
IL_EPA_WQX-BENA-01	Temperature, water	23.07	deg C	3	5/31/2016	8/29/2016
IL_EPA_WQX-BENA-03	Chlorophyll a, corrected for pheophytin	4.38	ug/l	5	5/31/2016	8/2/2021
IL_EPA_WQX-BENA-03	Dissolved oxygen (DO)	7.73	mg/l	3	5/31/2016	8/29/2016
IL_EPA_WQX-BENA-03	pH	8.00	None	3	5/31/2016	8/29/2016
IL_EPA_WQX-BENA-03	Temperature, water	23.53	deg C	3	5/31/2016	8/29/2016
IL_EPA_WQX-BENC-01	Chlorophyll a, corrected for pheophytin	3.70	ug/l	2	6/8/2021	8/2/2021
NARS_WQX-ILSS-1169	Dissolved oxygen (DO)	1.80	mg/l	1	9/30/2014	9/30/2014
NARS_WQX-ILSS-1169	pH	7.62	None	2	9/30/2014	9/30/2014
NARS_WQX-ILSS-1169	Temperature, water	15.10	deg C	1	9/30/2014	9/30/2014

Few usable monitoring sites sourced from publicly available data were found for the receiving streams, Cassell Creek, upstream Kickapoo, and relevant downstream segments. An Illinois Freedom of Information Act request to IEPA revealed additional continuous monitoring data from 2011 and 2016 indicating the Kickapoo Creek segment BEN-01 met the risk of eutrophication threshold based on %DO + pH from 6 of 7 days monitored in July 2011. No risk was identified from 15 days of continuous monitoring in 2016 nor from 3 grab samples taken in 2011 and 3 in 2016. While this was sufficient to trigger the NARP special condition, at no site was there enough to fully understand the risk of eutrophication, nor make a defensible determination of the source of nutrients. Both receiving segments, Cassell Creek (IL_BENC) and Kickapoo Creek Upstream (IL_BEN-02) had only a single site downstream

[3] www.waterqualitydata.us

of the outfall, and only chlorophyll *a* was collected. The limited data on the impaired segment of Riley Creek (IL_BENA) exhibits appropriate DO, pH and generally low sestonic chlorophyll *a*. Other relevant sites on the receiving segments, upstream tributaries and downstream show little variation in DO and pH among sites.

Additional data collection and analysis will help to better assess the contributions of treatment plants to the receiving streams and the downstream impaired segment and allow for an informed decision on the necessity of undertaking a comprehensive NARP that includes watershed characterization, development of site-specific water quality targets, and implementation. It should be noted that a Total Maximum Daily Load (TMDL) is underway for the Kickapoo Creek watershed to address the low DO impairment for Riley Creek. Stage 1 is complete, including a watershed characterization. Additional monitoring and modeling comprise next steps in the process. In addition, a Watershed Management Plan is near completion for the entire Embarras River watershed.

3 Monitoring Plan Overview

Considering the effort and investment necessary for NARP development, and the lack of data available to make "at risk" determinations, stream monitoring is recommended. Water quality data will facilitate the assessment of the risk of eutrophication and guide additional components if required.

The proposed in-stream water quality monitoring expands upon past data collection efforts. The program will be organized by Northwater Consulting, in partnership with Charleston Public Works and the City of Mattoon. To augment existing records, data collection is prioritized to locations with previous monitoring, where possible. To maintain cost effectiveness, a combination of grab sampling and continuous monitoring is proposed. The goal is to collect adequate data during the critical period between May and October when NARP triggering conditions are most likely to occur and to provide information on the contribution of each plant's effluent to the risk of eutrophication on Kickapoo Creek. Monitoring will determine initial impacts to water quality in the receiving streams, water quality in the NARP-triggering segment of Kickapoo as well as contributions from major tributaries (Riley Creek before it combines with Cassell Creek). This will guide future stages of the NARP such as additional watershed characterization, assessing impairment causes/sources, and water quality model development. Further, the risk of eutrophication can be evaluated.

Recommended monitoring elements include:

1. Three grab sample-only sites:
    a. Cassell Creek: upstream of Charleston POTW outfall.
    b. Kickapoo Creek: upstream of Mattoon POTW outfall.
    c. Kickapoo Creek: downstream of Mattoon POTW outfall just before confluence with Riley Creek.

2. Four continuous sensor sites:
    a. Riley Creek: upstream of confluence with Cassell Creek.
    b. Riley Creek: on segment upstream of Kickapoo Creek.
    c. Kickapoo Creek: downstream of Mattoon POTW outfall (middle Kickapoo site).
    d. Kickapoo Creek combined: on downstream segment with risk of eutrophication.

3. Continuous sensor site parameters:
    a. Hydrological: stream stage.
    b. Water quality: pH, sestonic chlorophyll *a*, water temp, DO, conductivity.
4. At all sites:
    a. Grab samples and storm monitoring.
    b. Weekly at Cassell and Kickapoo upstream and downstream; biweekly at Riley upstream and downstream and Kickapoo middle and combined.
        i. Stream discharge/flow.
        ii. In-situ analysis of pH, conductivity, oxidation reduction potential, temperature, dissolved oxygen and turbidity.
        iii. Grab samples for laboratory analysis of orthophosphate, total phosphorus, chlorophyll *a.*

Recommended parameters capture data critical for making the NARP determination. While there are myriad sampling methods that could be employed and characteristics available to measure, such as periphyton (attached algae chlorophyll) and nitrogen, this sampling scheme is designed to adhere closely to Illinois EPA guidance.

4 Stream Monitoring

4.1 General Schedule

Data collection will commence as soon as possible, on or around July 1, 2022 for Charleston and on or around August 1, 2022 for Mattoon and will continue through October 31. The critical period of monitoring is May 1-October 31, when water quality issues are most likely to occur. Because of the truncated 2022 season, we propose to continue data collection starting May 1, 2023 through approximately July 31, 2023 until a sufficient dataset is gathered.

4.2 Stations

Seven monitoring stations are proposed to capture receiving stream water quality before and after the addition of treated effluent at each plant, and to determine potential tributary impacts and characterize the segment that met IEPA's risk of eutrophication criteria (Figure 3). Monitoring will provide sufficient data for NARP determination and additional stages of the process, if necessary. The stations are located at bridge crossings or preestablished access points. The upstream sites are close enough to the outfall to capture as much of the watershed upstream as possible without the influence of effluent. The downstream sites are located at a distance to allow for sufficient mixing of effluent and streamflow and to evaluate the immediate impacts of nutrients from the treatment plants before they combine. The Kickapoo "combined" site will allow for characterization of the segment that triggered the NARP. Data collected using this approach can then be used to develop a predictive model estimating nutrient sources (if required) and the potential impacts to downstream water quality.

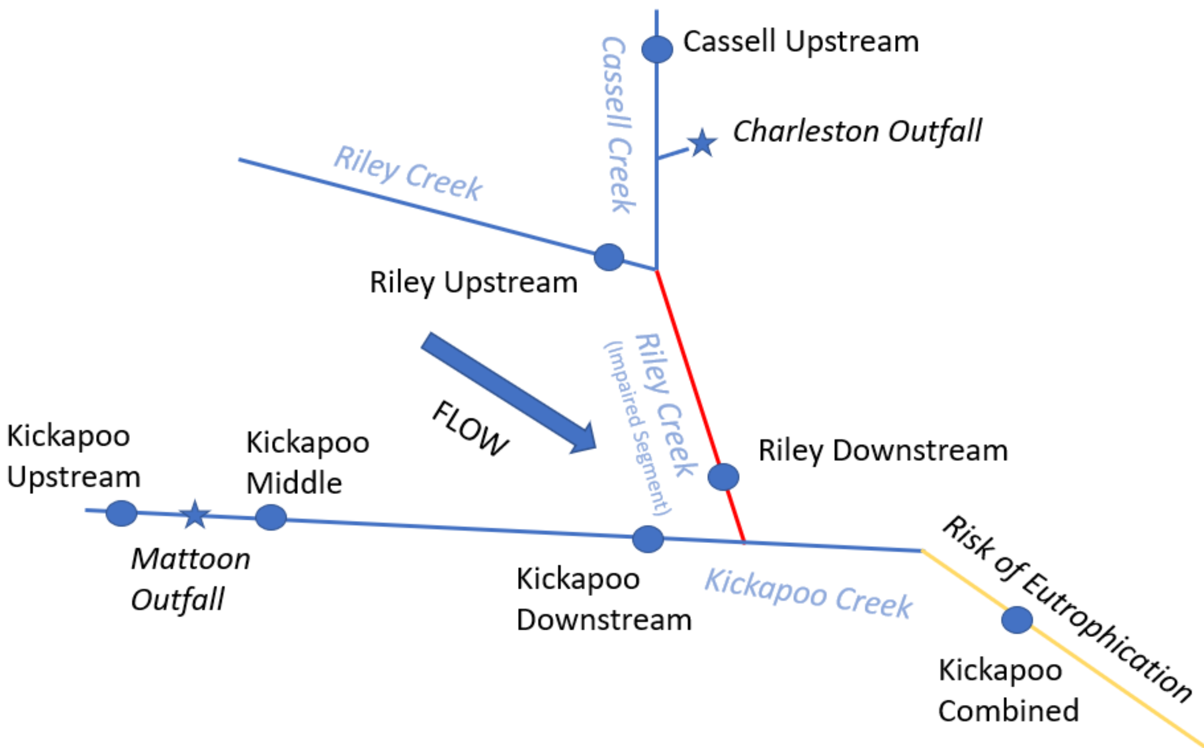

Figure 2. Line Diagram of Monitoring Creeks and Monitoring Locations

Table 4 – Proposed Water Quality Monitoring Stations

Station ID	Name	Lat/Long	Station ID and organization which previously collected data at this site	Approximate distance from outfall	Type of Sampling
U-CWWP	Cassell Creek Upstream	39.498636, -88.205340	NA	0.625 mi	Grab Only, Weekly and Storm
RC-UC	Riley Creek Upstream	39.486860, -88.210115	IEPA BENA-03	0.7 mi	Continuous, Biweekly Grab and Storm
RC-DC	Riley Creek Downstream	39.476217, -88.206194	IEPA BENA-01	1.5 mi	Continuous, Biweekly Grab and Storm

Station ID	Name	Lat/Long	Station ID and organization which previously collected data at this site	Approximate distance from outfall	Type of Sampling
U-MWWP	Kickapoo Creek Upstream	39.4731612, -88.3651197	NARS IL_SS-1169	0.25 mi	Grab Only, Weekly and Storm
KC-MD	Kickapoo Creek Middle	39.470013, -88.345709	NA	1.1 mi	Continuous, Biweekly Grab and Storm
KC-DN	Kickapoo Creek Downstream	39.465059, -88.230240	IEPA BEN-02	7.5 mi	Grab Only, Weekly and Storm
KC-CB	Kickapoo Creek Combined	39.46252, -88.19315	IEPA-BEN-01	10 mi	Continuous, Biweekly Grab and Storm

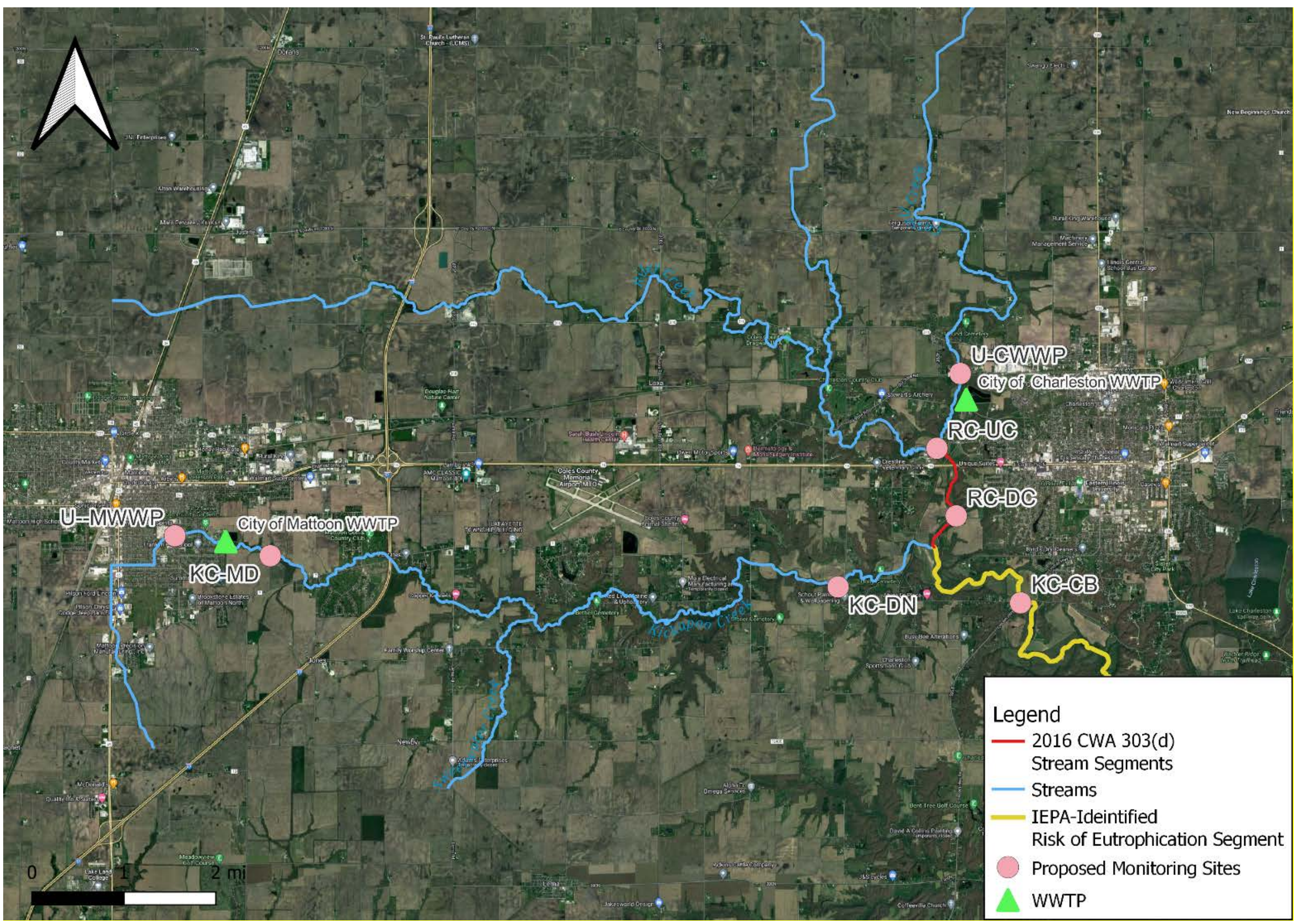

Figure 3. Proposed Monitoring Sites

4.2.1 City of Charleston Monitoring Location Information

Monitoring will begin in summer 2022. The Cassel Creek upstream site captures a 17.8 mi^2 watershed and is approximately 0.1 miles from the outfall with no significant point or nonpoint sources between. The Riley Creek upstream site is located just above its confluence with Cassell Creek, which is approximately 0.6 miles from the outfall. This site captures the influence of a major upstream tributary with 39 mi^2 watershed that contributes to the combined load downstream. Figure 3 illustrates the orientation of sites. The downstream monitoring site on Riley Creek is approximately 1.5 miles from the outfall, and 0.9 miles from where Cassell and Riley Creek combine. The Riley Creek downstream site is located on segment IL_BENA. This combination of sites site represents the best chance of capturing the initial impact of the effluent on Riley Creek, while also identifying the influence of upstream tributaries.

Riley Creek Looking Downstream - RC-UC

4.2.2 City of Mattoon Monitoring Location Information

Monitoring will begin in summer 2022. The Kickapoo Creek upstream site is approximately 0.1 miles from the outfall with no significant point or nonpoint sources between and captures a 5.8 mi^2 watershed with both urban and agricultural land cover. The Kickapoo middle site is approximately 1.1 miles downstream from the Mattoon outfall and represents the best chance to capture the initial impacts of treated effluent on Kickapoo Creek. The downstream monitoring site on Kickapoo Creek is approximately 7.5 miles from the outfall, and 1.3 miles above the confluence with Riley Creek. This location captures a 30.5 mi^2 watershed and the effects of nonpoint sources to Kickapoo Creek before it combines with Riley.

Kickapoo Creek Looking Downstream – KC-MD

4.2.3 Kickapoo Creek "Combined" Monitoring Location Information

Monitoring of the Kickapoo Creek combined site will begin in summer 2022. This site is located downstream of the confluence of Kickapoo and Riley Creek on stream segment BEN-01 which was identified by IEPA as meeting the risk of eutrophication thresholds. Monitoring at this location, combined with the others in this plan will allow for full evaluation of eutrophication risk. Further, the combination of monitoring sites will characterize stream dynamics, and, if required will inform modeling in future NARP phases including allocation of nutrient sources.

4.3 Sampling and Analyses

Sampling will use industry standards and manufacturer protocols for calibration, maintenance, and data collection, and will be documented.

4.3.1 Hydrology Data

Stream stage and discharge data will be collected at each site (Table 5). If a sufficient range of flows is captured, a rating curve can support estimates of stream loading which will inform watershed characterization and further NARP development, if necessary.

Table 5. Hydrology Parameters

Parameter	Collection Type	Frequency	Instrument/Method
Stream Stage	Continuous Probe, Staff Gauge	Continuous, Discreet	Vented Pressure Transducer, Graduated Staff Gauge
Discharge	Manual	Bi-weekly, with additional storm samples	Digital Electromagnetic Flow Meter + wading staff or ADCP

4.3.2 Water Quality Data

Multiparameter sondes with integrated sensor wipers to reduce biofouling will be installed at each continuous monitoring site and will collect data on a 15-minute interval (Table 6). Sondes will be left in place for multi-week deployments and serviced and/or calibrated bi-weekly using manufacturer protocols unless conditions allow for a longer period between service, though no less frequently than every 30 days. Multiparameter sondes manufactured by In-Situ Instruments will be deployed. Grab samples and in-situ water quality measurements will be collected to augment sonde data, support quality assurance and provide additional parameters useful for the NARP assessment.

Grab samples will be collected on a bi-weekly frequency at continuous monitoring sites, and weekly at grab sample only sites. 40 CFR Part 136 procedures will be followed and will include using laboratory-provided bottles, adherence to recommended sample preservation, holding times, and conditions for samples. Grab samples will be analyzed in-house at the City of Charleston and City of Mattoon plant laboratories respectively, with chlorophyll *a* being outsourced to an accredited environmental laboratory.

Table 6. Water Quality Parameters

Parameter	Collection Type	Frequency	Method	Method Identifier
Dissolved Oxygen	Continuous Probe	Continuous	Optical	InSitu: EPA approved method YSI: ASTM D888-09
	Handheld Meter	Bi-weekly, Storm	Optical	ASTM D888-09
pH	Continuous Probe	Continuous	Potentiometric	EPA 150.2
	Handheld Meter	Bi-weekly, Storm	Potentiometric	EPA 150.2
Water Temperature	Continuous Probe	Continuous	Thermistor	EPA 170.1
	Handheld Meter	Bi-weekly, Storm	Thermistor	EPA 170.1
Chlorophyll-a	Continuous Probe	Continuous	In-situ Optical Fluorescence	Instrument Manufacturer Optical Method
	Grab	Bi-weekly, Storm	Lab Spectrophotometric	EPA 445.0
Total Phosphorus	Grab	Bi-weekly, Storm	Colorimetry	EPA 365.1 / EPA 365.3
Orthophosphate	Grab	Bi-weekly, Storm	Colorimetry	EPA 365.1 / EPA 365.3
Conductivity	Continuous Probe	Continuous	Resistor Network	EPA 120.1
	Handheld Probe	Bi-weekly, Storm	Resistor Network	EPA 120.1

5 Data Management & Quality Control

Data will be downloaded from each logger at each site visit and will be maintained in a relational Microsoft Access database or Microsoft Excel spreadsheet. Continuous data will be corrected for drift using the statistical software R, package driftR[4] using a standard procedure based on instrument calibration. A full quality assurance and quality control procedure document will be included in a final monitoring report and implemented.

[4] https://rdocumentation.org/packages/driftR/versions/1.1.0

APPENDIX B: WATER QUALITY DATA

Appendix B Data Table 1 - UMWWP Grab Sample Data

Date Time	Site	DO Sat	Temp	Flow	Turbidity	Stage	DO Conc.	NH3-N	NO3-N	TN	OrthoP as P	TP	Redox	ChlA	Sp. Cond.	pH
UTC		%	C	CFS	RFU	ft	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mV	µg/L	µS/cm	SU
8/4/22 20:00	UMWWP	97.1	24.3	8.16	18		8.09				5	5.00	143		463	7.12
8/10/22 17:45	UMWWP	114.3	23.7				9.73				0.05	0.05				8.11
8/17/22 17:25	UMWWP	93	22.6				8.01				0.029	0.05				8.19
8/17/22 22:09	UMWWP	98.4	28	0.1	9.03		7.71						161		781	7.45
8/24/22 17:27	UMWWP	80	23.4			0.7	6.92				0.094	2.57				8.07
8/31/22 17:30	UMWWP	75.5	22.8				6.5				0.089	0.10				8.05
8/31/22 22:00	UMWWP	88	26.4		12.4	1.65	7.27						183		502	7.57
9/8/22 17:45	UMWWP	66.3	23.6				5.78				0.087	0.11				7.91
9/13/22 17:23	UMWWP	67.1	20.6				6.06				0.099	0.09				7.98
9/15/22 19:46	UMWWP	90.7	24	-0.01	10.1	0.5	7.66						170		751	7.78
9/20/22 17:36	UMWWP	67.3	25.2			1.4	5.18				0.103	0.12		0.5		7.84
9/27/22 17:39	UMWWP	58.8	15.5			0.5	5.88				0.052	0.07				8.16
10/4/22 17:40	UMWWP	112.6	16.8				10.97				0.059	0.08				8.20
10/11/22 17:40	UMWWP	105.4	14.5			0.86	10.95				0.117	0.30		4.1		8.09
10/18/22 17:45	UMWWP	138.1	8.5			0.48	16.37				0.025	0.05				8.23
10/25/22 17:30	UMWWP	91.3	16.9			0.57	8.96				0.074	0.12		3.5		8.07
11/3/22 19:32	UMWWP	78.3	15.38		10.32	0.62	7.73						118		428	7.18
5/1/23 15:25	UMWWP	120.3	9.9	0.92	4.67	0.86	13.56						285			8.23
5/9/23 17:27	UMWWP	103.9	18.7				9.67	0.172	7.51	8.04	0.206	0.26		6.8		8.21
5/15/23 16:29	UMWWP	86	16.3	1.84	25.5	0.82	8.45						280		474	7.85
5/16/23 15:45	UMWWP	85.1	15.4				8.53	0.234	3.72	4.69	0.246	0.27				8.05
5/23/23 16:00	UMWWP	102.4	19.9				9.37	0.207	3.97	4.72	2.06	2.79		26		8.26
5/30/23 17:35	UMWWP	105.9	24.7				8.94	0.186	3.85	4.11	0.255	0.29				8.22
5/31/23 15:30	UMWWP	73.6	22.8	0.63	8.96	0.62	6.32						254		569	7.82
6/6/23 15:50	UMWWP	85.1	21.4				7.58	0.153	3.21	3.27	0.228	0.16				7.62
6/12/23 13:15	UMWWP	52.7	15.9	1.36	8.16	0.68	5.23						158		440	7.80
6/13/23 16:00	UMWWP	93	19.9				8.86	0.174	3.76	3.97	0.125	0.22		9.8		8.28
6/20/23 16:10	UMWWP	106.2	24.7				8.78	0.199	1.16	2.03	0.098	0.12				8.14
6/26/23 13:15	UMWWP	22.5	20.4	0.15	10.41	0.48	2.04						228		402	7.54
6/27/23 15:35	UMWWP	56.6	23.7				5.39	0.549	0.6	1.83	0.313	0.32		3.8		7.93
7/5/23 15:55	UMWWP	81.4	24.7				6.74	0.139	3.49	4.34	0.275	0.34				8.12
7/11/23 16:38	UMWWP	102.3	24.7				8.51	0.125	2.62	3.41	0.211	0.27		1.4		8.06
7/14/23 14:28	UMWWP	48.2	22.5	0.16	11.4	0.54	4.17						6		696	7.66
7/18/23 15:10	UMWWP	2.9	23.3				0.26	0.334	1.13	1.87	0.116	0.24				8.14
7/25/23 15:35	UMWWP	50.8	25.2				4.46	0.67	2.02	1.2	0.261	2.29		1		7.96
7/31/23 13:18	UMWWP	23.8	21.9	0.03	33.8	0.44	1.56						-24		608	7.49
8/1/23 15:10	UMWWP	3.7	22.4				0.34	0.797	0.376	2.07	0.663	0.55				7.94
8/8/23 15:00	UMWWP	49.3	21.9				4.33	0.607	0.608	1.94	0.791	1.09		1		7.81
8/15/23 14:50	UMWWP	38.5	20.2				3.62	0.506	1.07	3.66	0.186	0.28				7.83
8/22/23 15:30	UMWWP	22.1	26.5				1.85	1.34	0.166	2.68	1.42	1.58		5.6		7.84
8/29/23 15:14	UMWWP	7.4	20.7				4.25	1.45	0.872	2.41	1.06	1.23				7.84
9/1/23 23:06	UMWWP	91.3	23.4	0.05	14.64		7.54						-13		485	7.68
9/5/23 15:00	UMWWP	29.1	23.6				2.53	2.1	2.04	5.04	0.695	0.75				7.77
9/12/23 14:55	UMWWP	24.7	19.7				2.32	2.82	0.433	4.15	2.24	2.54		30		7.84

Date Time	Site	DO Sat	Temp	Flow	Turbidity	Stage	DO Conc.	NH3-N	NO3-N	TN	OrthoP as P	TP	Redox	ChlA	Sp. Cond.	pH
UTC		%	C	CFS	RFU	ft	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mV	µg/L	µS/cm	SU
9/13/23 14:30	UMWWP	27	15.7	0.05	25	0.46	2.5						-60		600	7.16
9/19/23 14:15	UMWWP	10.4	15.1				1.12	2.84	0.57	5.5	1.85	1.74				7.66
9/25/23 14:52	UMWWP	20	17.1	0.05	22	0.45	1.85						23		528	7.11
9/26/23 14:40	UMWWP	28.1	18.7				2.67	0.536	0.59	1.18	0.537			1.8		7.71
10/3/23 15:20	UMWWP	48.1	19				4.33	2.64	0.688	3.67	0.482	0.49				7.73
10/10/23 15:00	UMWWP	29.7	10.6				4.28	2.36	0.74	3.89	0.743	0.92		9		7.65
10/10/23 18:09	UMWWP	89.3	15.5	0.13	7.02	0.48	8.63						158		783	7.63
10/17/23 15:20	UMWWP	56	14				6.5	2.21	1.43	3.48	1.28	1.41				7.83
10/24/23 15:00	UMWWP	61.1	13.3				6.68	0.829	1.06	2.69	0.102	0.16		11		7.72
10/31/23 15:00	UMWWP	73.2	7.2				8.58	0.147	1.42	2.54	0.487	0.61				7.98
11/1/23 19:17	UMWWP	101.6	8.9	0.12	17.47	0.62	11.63						90		557	7.74

Appendix B Data Table 2 - KCMD Grab Sample Data

Date Time	Site	DO Sat	Temp	Flow	Turbidity	Stage	DO Conc.	NH3-N	NO3-N	TN	OrthoP as P	TP	Redox	ChlA	Sp. Cond.	pH
UTC		%	C	CFS	RFU	ft	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mV	µg/L	µS/cm	SU
8/4/22 19:38	KCMD	83.5	23	16.58	13.4		7.16				1.63	1.69	148.3		452	7.08
8/10/22 17:56	KCMD	84.4	22.7				7.31				0.70	0.92				7.67
8/17/22 17:38	KCMD	63.4	23				5.47				1.64	1.75				7.74
8/17/22 21:40	KCMD	50.1	23.7	4.05	4.07		4.22						186.5		808	7.74
8/24/22 17:38	KCMD	69.5	22.5			0.87	6.2				0.05	2.61				7.76
8/31/22 17:45	KCMD	82.3	22.1				7.17				0.64	0.72				7.93
8/31/22 21:45	KCMD	72.1	22.4		8.24	1.16	6.27						180		486	7.62
9/8/22 17:53	KCMD	81.7	23.4				6.94				1.33	1.42				7.75
9/13/22 17:35	KCMD	77.9	21.4				6.88				0.97	1.06				7.88
9/15/22 19:29	KCMD	93.6	23	8.78	8.8	1.1	8.05						175.5		543	7.97
9/20/22 17:50	KCMD	70.1	23.9			1.1	5.95				1.65	1.54		1.7		7.68
9/27/22 17:50	KCMD	64.7	18.5			0.8	6.05				2.77	2.79				7.93
10/4/22 17:55	KCMD	98.1	17.8				9.33				3.21	3.22				7.87
10/11/22 17:53	KCMD	99.8	18.2			1.1	9.49				2.75	3.95		4.5		7.69
10/18/22 17:52	KCMD	110.9	13.8				11.42				2.05	3.13				7.79
10/25/22 17:40	KCMD	71.2	17.8			0.84	6.87				4.02	4.07		1		7.68
11/3/22 19:14	KCMD	47.4	17.9		2.29	0.89	4.46						122.6		452	7.2
5/1/23 15:52	KCMD	79.9	10.4	2.42	1.48	0.86	8.92						266.2		524	7.89
5/9/23 17:41	KCMD	70.3	16.8			1.3	6.85	3.22	5.2	10.2	1.15	1.29		9.6		7.87
5/15/23 17:46	KCMD	76.7	16.6	7.01	4.11	0.98	7.53						215.4		452	7.63
5/16/23 16:00	KCMD	72.8	16.2			1	7.16	0.14	8.55	9.02	1.47	1.42				7.75
5/23/23 16:10	KCMD	64.9	17.7			0.8	6.15	0.28	10.8	16.4	2.22	4.68		4.7		7.84
5/30/23 17:46	KCMD	55.1	19.8			0.4	5.03	0.297	12.9	15.7	5.49	5.58				7.7
5/31/23 16:25	KCMD	53.3	20.3	3.63	2.06	0.8	4.72						228.5		569	7.44
6/6/23 16:00	KCMD	58.3	18.7			0.8	5.51	0.257	17.3	19.4	2.89	3.52				7.69
6/12/23 13:48	KCMD	56.8	17.1	6.47	3.99	1.11	5.44						141.5		403	7.57
6/13/23 16:10	KCMD	75	18.9			1.35	7.2	0.145	10.3	10.5	1.71	1.77		4.1		7.73
6/20/23 16:20	KCMD	55.1	20.4			0.8	4.99	0.219	21.4	22.7	3.99	3.94				7.67
6/26/23 13:45	KCMD	37	20.9	1.87	4.97	0.9	3.29						215.5		549	7.4
6/27/23 15:45	KCMD	51.2	21.1				4.68	0.153	15.2	22.4	3.75	3.52		2		7.62
7/5/23 16:05	KCMD	71.5	23.7				6.56	0.088	5.68	7.28	1.00	1.16				7.91
7/11/23 16:51	KCMD	62	22.3				5.45	0.233	8.09	9.35	1.16	1.17		1.9		7.85
7/14/23 15:00	KCMD	54.4	22.7	2.98	3.38	0.9	4.72						88.9		707	7.51
7/18/23 15:18	KCMD	58.7	22.2				5.14	0.181	14.7	15.5	2.59	2.67				7.87
7/25/23 15:45	KCMD	60.9	23				5.4	0.177	17.6	18	1.21	3.82		1		7.87
7/31/23 14:02	KCMD	64.5	22.5	1.69	4.63	0.75	5.7						25.7		602	7.42
8/1/23 15:20	KCMD	57.6	22.1				5.11	0.139	17.8	20.4	3.47	3.48				7.82
8/8/23 15:21	KCMD	68.8	22.4				5.96	0.115	9.59	11.4	2.62	2.45		9		7.77
8/15/23 15:00	KCMD	61.3	21.8				5.4	0.145	9.79	11.8	2.04	2.02				7.84
8/22/23 15:40	KCMD	57.4	24.6				4.8	0.182	6.74	22.4	3.92	3.97		5.4		7.72
8/29/23 15:22	KCMD							0.039	10.3	10.5	1.98	2.09				
8/29/23 15:40	KCMD	57.4	24.6				4.8									7.72
9/2/23 22:30	KCMD	76.6	23.3	3.99	2.88	0.98	6.42						124.6		492	7.47

Date Time	Site	DO Sat	Temp	Flow	Turbidity	Stage	DO Conc.	NH3-N	NO3-N	TN	OrthoP as P	TP	Redox	ChlA	Sp. Cond.	pH
UTC		%	C	CFS	RFU	ft	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mV	µg/L	µS/cm	SU
9/5/23 15:10	KCMD	57.6	23.2				4.92	0.131	18.8	12.6	1.94	2.39				7.75
9/12/23 15:05	KCMD	62.6	20.8				5.63	0.099	21.4	25.5	7.01	7.17		1		7.65
9/13/23 14:52	KCMD	77.7	18.8	1.05	0.42	0.69	7.1						107.2		554	7.04
9/19/23 14:25	KCMD	59.1	18.3				5.77	0.137	31.2	30.5	6.08	6.14				7.55
9/25/23 15:09	KCMD	68.7	19.9	1.35	0.65	0.97	6.12						84.6		504	7.03
9/26/23 14:50	KCMD	63	21.1				6.8	0.789	22.8	3.77	3.52			9.9		7.57
10/3/23 15:30	KCMD	53.8	20.4				4.86	0.128	14.4	22.7	5.16	5.05				7.49
10/10/23 15:11	KCMD	64.8	15				7.18	0.11	20.1	20.9	2.92	3.06		11		7.65
10/10/23 17:30	KCMD	79.6	15.9	2.02	0.45	1.15	7.64						172.9		801	7.44
10/17/23 15:30	KCMD	66.5	15.2				6.7	0.107	14.3	21.7	2.55	2.53				7.75
10/24/23 15:10	KCMD	60.7	16.1				5.88	0.145	19.6	20	3.75	3.64		1		7.81
10/31/23 15:10	KCMD	71.2	12.6				7.46	0.06	7.66	8.23	0.83	0.92				7.84
11/1/23 19:58	KCMD	83.7	12.7	4.49	0.41	1	8.77						129.8		512	7.52

Appendix B Data Table 3 - KCMD Grab Sample Data

Date Time	Site	DO Sat	Temp	Flow	Turbidity	Stage	DO Conc.	NH3-N	NO3-N	TN	OrthoP as P	TP	Redox	ChlA	Sp. Cond.	pH
UTC		%	C	CFS	RFU	ft	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mV	µg/L	µS/cm	SU
8/4/22 19:38	KCMD	83.5	23	16.58	13.4		7.16				1.63	1.69	148.3		452	7.08
8/10/22 17:56	KCMD	84.4	22.7				7.31				0.70	0.92				7.67
8/17/22 17:38	KCMD	63.4	23				5.47				1.64	1.75				7.74
8/17/22 21:40	KCMD	50.1	23.7	4.05	4.07		4.22						186.5		808	7.74
8/24/22 17:38	KCMD	69.5	22.5			0.87	6.2				0.05	2.61				7.76
8/31/22 17:45	KCMD	82.3	22.1				7.17				0.64	0.72				7.93
8/31/22 21:45	KCMD	72.1	22.4		8.24	1.16	6.27						180		486	7.62
9/8/22 17:53	KCMD	81.7	23.4				6.94				1.33	1.42				7.75
9/13/22 17:35	KCMD	77.9	21.4				6.88				0.97	1.06				7.88
9/15/22 19:29	KCMD	93.6	23	8.78	8.8	1.1	8.05						175.5		543	7.97
9/20/22 17:50	KCMD	70.1	23.9			1.1	5.95				1.65	1.54		1.7		7.68
9/27/22 17:50	KCMD	64.7	18.5			0.8	6.05				2.77	2.79				7.93
10/4/22 17:55	KCMD	98.1	17.8				9.33				3.21	3.22				7.87
10/11/22 17:53	KCMD	99.8	18.2			1.1	9.49				2.75	3.95		4.5		7.69
10/18/22 17:52	KCMD	110.9	13.8				11.42				2.05	3.13				7.79
10/25/22 17:40	KCMD	71.2	17.8			0.84	6.87				4.02	4.07		1		7.68
11/3/22 19:14	KCMD	47.4	17.9		2.29	0.89	4.46						122.6		452	7.2
5/1/23 15:52	KCMD	79.9	10.4	2.42	1.48	0.86	8.92						266.2		524	7.89
5/9/23 17:41	KCMD	70.3	16.8			1.3	6.85	3.22	5.2	10.2	1.15	1.29		9.6		7.87
5/15/23 17:46	KCMD	76.7	16.6	7.01	4.11	0.98	7.53						215.4		452	7.63
5/16/23 16:00	KCMD	72.8	16.2			1	7.16	0.14	8.55	9.02	1.47	1.42				7.75
5/23/23 16:10	KCMD	64.9	17.7			0.8	6.15	0.28	10.8	16.4	2.22	4.68		4.7		7.84
5/30/23 17:46	KCMD	55.1	19.8			0.4	5.03	0.297	12.9	15.7	5.49	5.58				7.7
5/31/23 16:25	KCMD	53.3	20.3	3.63	2.06	0.8	4.72						228.5		569	7.44
6/6/23 16:00	KCMD	58.3	18.7			0.8	5.51	0.257	17.3	19.4	2.89	3.52				7.69
6/12/23 13:48	KCMD	56.8	17.1	6.47	3.99	1.11	5.44						141.5		403	7.57
6/13/23 16:10	KCMD	75	18.9			1.35	7.2	0.145	10.3	10.5	1.71	1.77		4.1		7.73
6/20/23 16:20	KCMD	55.1	20.4			0.8	4.99	0.219	21.4	22.7	3.99	3.94				7.67
6/26/23 13:45	KCMD	37	20.9	1.87	4.97	0.9	3.29						215.5		549	7.4
6/27/23 15:45	KCMD	51.2	21.1				4.68	0.153	15.2	22.4	3.75	3.52		2		7.62
7/5/23 16:05	KCMD	71.5	23.7				6.56	0.088	5.68	7.28	1.00	1.16				7.91
7/11/23 16:51	KCMD	62	22.3				5.45	0.233	8.09	9.35	1.16	1.17		1.9		7.85
7/14/23 15:00	KCMD	54.4	22.7	2.98	3.38	0.9	4.72						88.9		707	7.51
7/18/23 15:18	KCMD	58.7	22.2				5.14	0.181	14.7	15.5	2.59	2.67				7.87
7/25/23 15:45	KCMD	60.9	23				5.4	0.177	17.6	18	1.21	3.82		1		7.87
7/31/23 14:02	KCMD	64.5	22.5	1.69	4.63	0.75	5.7						25.7		602	7.42
8/1/23 15:20	KCMD	57.6	22.1				5.11	0.139	17.8	20.4	3.47	3.48				7.82
8/8/23 15:21	KCMD	68.8	22.4				5.96	0.115	9.59	11.4	2.62	2.45		9		7.77
8/15/23 15:00	KCMD	61.3	21.8				5.4	0.145	9.79	11.8	2.04	2.02				7.84
8/22/23 15:40	KCMD	57.4	24.6				4.8	0.182	6.74	22.4	3.92	3.97		5.4		7.72
8/29/23 15:22	KCMD							0.039	10.3	10.5	1.98	2.09				
8/29/23 15:40	KCMD	57.4	24.6				4.8									7.72
9/2/23 22:30	KCMD	76.6	23.3	3.99	2.88	0.98	6.42						124.6		492	7.47
9/5/23 15:10	KCMD	57.6	23.2				4.92	0.131	18.8	12.6	1.94	2.39				7.75

Date Time	Site	DO Sat	Temp	Flow	Turbidity	Stage	DO Conc.	NH3-N	NO3-N	TN	OrthoP as P	TP	Redox	ChlA	Sp. Cond.	pH
UTC		%	C	CFS	RFU	ft	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mV	µg/L	µS/cm	SU
9/12/23 15:05	KCMD	62.6	20.8				5.63	0.099	21.4	25.5	7.01	7.17		1		7.65
9/13/23 14:52	KCMD	77.7	18.8	1.05	0.42	0.69	7.1						107.2		554	7.04
9/19/23 14:25	KCMD	59.1	18.3				5.77	0.137	31.2	30.5	6.08	6.14				7.55
9/25/23 15:09	KCMD	68.7	19.9	1.35	0.65	0.97	6.12						84.6		504	7.03
9/26/23 14:50	KCMD	63	21.1				6.8	0.789	22.8	3.77	3.52			9.9		7.57
10/3/23 15:30	KCMD	53.8	20.4				4.86	0.128	14.4	22.7	5.16	5.05				7.49
10/10/23 15:11	KCMD	64.8	15				7.18	0.11	20.1	20.9	2.92	3.06		11		7.65
10/10/23 17:30	KCMD	79.6	15.9	2.02	0.45	1.15	7.64						172.9		801	7.44
10/17/23 15:30	KCMD	66.5	15.2				6.7	0.107	14.3	21.7	2.55	2.53				7.75
10/24/23 15:10	KCMD	60.7	16.1				5.88	0.145	19.6	20	3.75	3.64		1		7.81
10/31/23 15:10	KCMD	71.2	12.6				7.46	0.06	7.66	8.23	0.83	0.92				7.84
11/1/23 19:58	KCMD	83.7	12.7	4.49	0.41	1	8.77						129.8		512	7.52

Appendix B Data Table 4 - KCDN Grab Sample Data

Date Time	Site	DO Sat	Temp	Flow	Turbidity	Stage	DO Conc.	NH3-N	NO3-N	TN	OrthoP as P	TP	Redox	ChlA	Sp. Cond.	pH
UTC		%	C	CFS	RFU	ft	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mV	µg/L	µS/cm	SU
8/4/22 19:08	KCDN	85	24.2	53.86	68.4		7.21				1.33	1.46	149		345	7.41
8/9/22 18:08	KCDN	91.6	23.4				7.8				0.73	1.18				8.11
8/16/22 17:57	KCDN	126.6	25.1				10.48				0.48	1.10				8.52
8/17/22 21:06	KCDN	124.7	25.1	4.35	3.96		10.28						182		644	8.10
8/23/22 17:53	KCDN	115.6	24.3			1.2	9.68				1.39	1.89				8.36
8/30/22 14:04	KCDN	85	22.2			2.39	7.4				0.52	0.65				7.78
8/31/22 20:56	KCDN	90.4	23.4		13	1.56	7.72						184		465	7.60
9/6/22 17:57	KCDN	110.2	22.9				9.47				0.89	0.90				8.41
9/13/22 18:36	KCDN	119.1	21.5				10.52				0.70	0.71				8.54
9/15/22 17:55	KCDN	122.3	20.9	7.92	4.35	1.3	10.93						179		562	8.00
9/20/22 17:37	KCDN	113.3	24.9				9.39				1.28	2.17		0.5		8.41
9/27/22 17:05	KCDN	101.5	15.4				10.15				1.34	1.34				8.16
10/4/22 17:53	KCDN	104.6	14.6				10.67				1.85	1.84				8.05
10/11/22 17:29	KCDN													0.5		
10/18/22 17:36	KCDN	103.8	7.6				12.4				2.08	2.04				7.91
10/25/22 17:22	KCDN	71.6	16.3				7				1.15	1.24		3.8		7.87
11/3/22 18:54	KCDN	90.9	14.7		0.67	1.28	9.19						121		377	7.43
5/1/23 16:44	KCDN	132.3	11.4	7.02	0.42	1.32	14.36						218		506	8.50
5/9/23 18:02	KCDN	96.4	19.3			1.9	8.9	1.69	4.83	7.96	1.66	1.80		9.6		8.40
5/15/23 19:29	KCDN	121.2	18.9	16.46	4.16	1.54	11.22						210		610	8.38
5/16/23 16:20	KCDN	91	17.3			1.4	8.76	0.016	4.11	3.96	1.73	1.82				8.24
5/23/23 16:25	KCDN	114.1	19.9			1.3	10.37	0.024	4.65	4.31	2.31	2.26		1		8.65
5/30/23 18:02	KCDN	156.2	24.1			1	13.21	0.011	4.75	5.73	1.25	1.32				8.82
5/31/23 18:44	KCDN	160.8	26.7	4.04	2.71	1.32	12.83						124		591	8.76
6/6/23 16:15	KCDN	124.7	20.2			0.4	11.19	0.003	6.17	4.42	1.64	0.83				8.67
6/12/23 14:53	KCDN	77.6	17.1	10.56	9.46	1.53	7.46						139		318	8.01
6/13/23 16:20	KCDN	107	18.9			1.4	9.92	0.021	6.76	6.74	1.44	1.46		1.7		8.57
6/20/23 16:35	KCDN	124.2	23.1			1.5	10.64	0.022	7.19	7.9	1.47	1.48				8.66
6/26/23 14:40	KCDN	67.5	23.5	2.2	1.55	1.24	5.74						191		631	7.98
6/27/23 16:00	KCDN	91.9	22.7				7.91	0.023	10.9	12.4	2.50	2.34		1		8.38
7/5/23 16:25	KCDN	90.7	25.5				7.45	0.022	4.16	6.07	0.77	0.86				8.43
7/11/23 17:21	KCDN	96	25.1				7.9	0.042	4.29	4.96	2.24	2.30		1		8.25
7/14/23 15:50	KCDN	81.4	24.3	4.49	8.9	1.21	6.8						105		650	8.01
7/18/23 15:50	KCDN	88.5	23.7				7.51									8.45
7/18/23 15:41	KCDN							0.044	8.79	7.35	4.24	4.20				
7/25/23 16:05	KCDN	90.6	25.3				7.64	0.044	8.93	8.76	1.75	1.83		1.5		8.51
7/31/23 15:00	KCDN	91.8	23.6	2.03	7.04	0.9	7.79						98		624	7.94
8/1/23 15:40	KCDN	87.1	23				7.55	0.007	11.4	13.4	2.31	2.53				8.39
8/8/23 15:37	KCDN	85.2	22				7.48	0.058	11.9	10.7	2.50	2.64		1		8.18
8/15/23 15:15	KCDN	85.2	22				7.48	0.062	7.52	10.2	1.90	2.18				8.18
8/22/23 16:00	KCDN	84.1	26.6				6.72	0.064	4.21	9.44	1.86	1.57		2.6		8.36
8/29/23 15:38	KCDN	79.8	21.4				7.08	0.039	8.6	8.25	1.68	1.76				8.33
9/1/23 20:05	KCDN	113.4	24.3	1.64	4.35	1.1	9.36						110		419	8.30
9/5/23 15:25	KCDN	75.6	24.1				6.4	0.041	10.2	8.36	1.76	1.83				8.28

Date Time	Site	DO Sat	Temp	Flow	Turbidity	Stage	DO Conc.	NH3-N	NO3-N	TN	OrthoP as P	TP	Redox	ChlA	Sp. Cond.	pH
UTC		%	C	CFS	RFU	ft	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mV	µg/L	µS/cm	SU
9/12/23 15:20	KCDN	83.2	19.7				7.62	0.035	7.46	14.8	3.01	3.01		8.6		8.31
9/13/23 15:35	KCDN	96.6	17.7	0.86	2.51	1.08	9.05						118		565	7.80
9/19/23 14:40	KCDN	83	15.9				8.27	0.034	17.7	18.3	4.36	4.06				8.19
9/25/23 15:40	KCDN	89	18.5	0.92	2.25	1.06	8.19						96		490	7.58
9/26/23 15:05	KCDN	79	19.5				7.3	0.047	11.4	2.77	2.44	5.35		7.1		7.93
10/3/23 15:45	KCDN	75.6	19.2				6.97	0.027	4.72	8.77	2.06	2.03				7.96
10/10/23 15:27	KCDN	84.6	10.7				9.28	0.009	10.2	8.55	2.15	2.41		1.4		8.09
10/10/23 17:04	KCDN	99.7	11.3	1.26	0.37	1.8	10.66						140		635	7.95
10/17/23 15:45	KCDN	89.8	11.3				9.8	0.003	8.04	7.13	1.88	1.92				8.21
10/24/23 15:25	KCDN	87.5	12.3				9.38	0.012	12.6	13.7	2.38	2.41		1		8.03
10/31/23 15:25	KCDN	89.7	6.7				11.1	0.014	5.85	6.25	0.98	1.01				8.14
11/1/23 20:18	KCDN	104	7.7	3.59	1.77	1.28	12.33						88		370	8.15

Appendix B Data Table 5 - KCCB Grab Samples

Date Time	Site	DO Sat	Temp	Flow	Turbidity	Stage	DO Conc.	NH3-N	NO3-N	TN	OrthoP as P	TP	Redox	ChlA	Sp. Cond.	pH
UTC		%	C	CFS	RFU	ft	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mV	µg/L	µS/cm	SU
8/4/22 18:38	KCCB	80.2	24.5		42.3		6.66				0.98	1.13	143		363	7.40
8/9/22 18:20	KCCB	88.3	23				7.57				0.45	0.54				7.93
8/16/22 18:08	KCCB	115.8	24.4				9.69				0.78	0.83				8.40
8/17/22 20:30	KCCB	109	24.6	6.43	4.73		9.07						183		661	7.93
8/23/22 18:07	KCCB	116.2	23.8			1.5	9.81				1.28	1.27				8.31
8/30/22 14:18	KCCB	78.7	21.4				6.97				0.53	0.66				7.43
8/31/22 21:15	KCCB	88.5	22.3		63.3	3.15	7.7						182		355	7.73
9/6/22 18:10	KCCB	100.8	22.7			1.76	8.7				0.65	0.68				8.15
9/13/22 18:49	KCCB	123.1	21.2			1.68	10.97				0.65	0.66				8.53
9/15/22 18:48	KCCB	112.1	21.2	12.67	3.5	1.58	10.02						167		582	8.01
9/20/22 17:50	KCCB	108.9	25.4				8.96				1.13	1.17		1.8		8.38
9/27/22 17:18	KCCB	97.3	15.2			1.38	9.79				1.30	1.37				8.27
10/4/22 18:04	KCCB	97.9	15.2				9.84				1.87	1.88				8.04
10/11/22 18:39	KCCB													0.5		
10/18/22 17:46	KCCB	96.3	7.8			1.32	11.45				1.72	1.94				8.00
10/25/22 17:32	KCCB	65.5	16.7			1.34	6.36				1.91	1.99		21		7.85
11/3/22 18:15	KCCB	73.2	14.2		1.77	1.45	7.53						125		406	7.33
5/1/23 18:17	KCCB	116.4	12.1	35.46	1.38	1.37	12.59						65		548	8.49
5/2/23 16:50	KCCB	114.1	12.9				12.09	0.002	5.51	6.44	0.11	0.34				8.38
5/9/23 17:49	KCCB	95.2	18.6			2.38	8.92	0.478	8.25	10.9		0.33		7.3		7.96
5/15/23 18:42	KCCB	95.1	17.5	73.83	14.2	1.76	9.09						220		545	8.22
5/16/23 17:47	KCCB	95.2	16.8			1.7	9.24	0.058	6.99	8.29	0.27	0.30				8.03
5/23/23 17:41	KCCB	138.4	22.2			1.32	12.1	0.01	4.56	7.24	0.34	0.38		1		8.51
5/31/23 18:15	KCCB	138	24.7	26.08	3.29	1.08	11.42						144		573	8.42
6/6/23 17:47	KCCB	122.7	23.3			0.88	10.5	0.029	4.99	11.8	0.77	0.82				8.40
6/12/23 15:21	KCCB	78.9	17.2	38.06	14.2	1.4	7.62						133		424	8.20
6/13/23 17:50	KCCB	115.7	21.7			1.16	10.2	0.034	5.12	7.88	0.63	0.70		4.7		8.41
6/26/23 15:22	KCCB	66.2	22.9	9.72	3.09	0.78	5.62						158		566	7.98
6/27/23 18:05	KCCB	124.6	25.6			0.86	10.19	0.035	7.23	8.24	1.10	1.20				8.44
7/11/23 18:22	KCCB	109	26.4			1.5	8.78	0.042	4.33	4.4	0.61	0.62		1		8.15
7/14/23 16:15	KCCB	89.7	24.1	6.4	12	0.6	7.52						100		654	8.09
7/18/23 17:35	KCCB	131.7	25.5			0.54	10.79	0.032	7	9.6	1.13	1.16				8.16
7/25/23 17:45	KCCB	122.1	28.7				9.94	0.056	6.87	10.7	1.07	1.16		1.3		8.29
7/31/23 16:58	KCCB	91	23.7	3.4	8.72	0.31	7.7						102		613	7.92
8/1/23 17:36	KCCB	105.5	25				8.71	0.064	10.1	16.3	1.76	2.01				8.24
8/8/23 17:32	KCCB	110.8	24.3				9.28	0.061	12.9	13.9	2.05	2.10		1		8.25
8/22/23 17:45	KCCB	112.6	27.9				8.83	0.066	13.2	13.8	1.86	1.89		1		8.18
9/1/23 21:30	KCCB	129.6	24.3	2.87	7.49	0.3	10.69						87		458	8.36
9/12/23 17:15	KCCB	98.6	21.5			0.22	8.7	0.057	11.5	13.3	2.76	2.74		14		7.96
9/13/23 16:00	KCCB	93.9	17.8	2.5	1.97	0.29	879						111		466	7.75
9/25/23 16:10	KCCB	95.2	18.9	2.54	7.14	0.27	8.7						86		483	7.74
9/26/23 15:30	KCCB													4.9		
9/26/23 17:30	KCCB	103	20.4				8.97	0.05	9.77	11.3	2.35	2.36				8.02
10/10/23 16:30	KCCB	95.1	11.7	2.97	0.61	0.29	10.08						139		709	7.92
10/10/23 17:23	KCCB	97	14.3				9.97	0.021	8.08	9.74	2.08	2.14		2.4		7.87
11/1/23 20:50	KCCB	101.6	8.4	7.36	3.78	0.58	11.3						110		412	8.06

APPENDIX C: FACITLITY IMPROVEMENT PLAN

REPORT

Facility Plan

Discharge Optimization and Feasibility Studies Included

Prepared for: City of Mattoon

Project Number: M0220170

DRAFT

Prepared by: Clark Dietz, Inc. Date: August 2021

Professional Consulting and Design Services

Clark Dietz

Engineering Quality of Life®

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Abbreviations and Acronyms

A	Area
AA	Annual Average
AGS	Aerobic Granualr Sludge
AOR	Actual Oxygen Requirement
A^2O	Anaerobic, Anoxic, and Aerobic Treatment System
BNR	Biological Nutrient Removal
BOD_5	Biochemical Oxygen Demand, 5-day
CAS	Conventional Activated Sludge
$CBOD_5$	Carbonaceous Biochemical Oxygen Demand, 5-day
cf/h	cubic feet per hour
cfm	cubic feet per minute
CWA	Clean Water Act
D	diameter
DAF	design average flow
DI	ductile iron
DMF	design maximum flow
DO	Dissolved Oxygen
EBPR	Enhanced Biological Phosphorus Removal
EPA	Environmental Protection Agency
EQ	Equalization
FOG	Fats, Oils, and Grease
FRP	Fiberglass Reinforced Plastic
F/M	Food-to-Microorganism Ratio
ft	feet
gal	gallon
gpd	gallons per day
HRT	Hydraulic Retention Time
IEPA	Illinois Environmental Protection Agency
IFAS	Integrated Fixed Film Activated Sludge
I/I	Inflow and infiltration
in	inch
lbs/day	pounds per day
L	long
MCC	Motor Control Center
MD	Maximum Day
mg	million gallons
mgd	million gallons per day
mg/l	milligrams per liter
min	minute
MLSS	Mixed Liquor Suspended Solids
MLVSS	Mixed Liquor Volatile Suspended Solids
MM	Maximum Month
MOP	Manual of Practice – Design Manual from the Water Environment Federation (WEF)
MRO	Monthly Reporting Operating
MW	Maximum Week
O&M	Operation and Maintenance
NPDES	National Pollutant Discharge Elimination System
NWRI	National Water Research Institute
PAO	Phosphate Accumulating Organisms
PER	Preliminary Engineering Report
psi	pounds per square inch
RAS	Return Activated Sludge
RFP	Request for Proposal
RWW	Raw Wastewater
SCADA	Supervisory Control and Data Acquisition
scfm	standard cubic feet per minute
SLR	Solids Loading Rate
SOR	Surface Overflow Rate
SRF	State Revolving Fund
SPA	State Point Analysis
SS	stainless steel
SVI	Sludge Volume Index
SWD	side water depth
SWPPP	Stormwater Pollution Prevention Plan
TKN	Total Kjeldahl Nitrogen
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UV	Ultraviolet
UVT	Ultraviolet transmittance
VFA	Volatile Fatty Acids
VFD	Variable Frequency Drives
VOC	Volatile Organic Acid
W	wide
WAS	Waste Activated Sludge
WLR	Weir Loading Rate
WWTP	Wastewater Treatment Plant

CHAPTER 1 - EXECUTIVE SUMMARY

1.1 INTRODUCTION

The City of Mattoon is in west central Coles County. The Facilities Planning Area for the City of Mattoon, as delineated by the Illinois Environmental Protection Agency, is shown in Exhibit A in Appendix E. The Facilities Planning Area includes the City of Mattoon and several industries around the City. Presently, industry facilities include Anamet, Inc., Justrite Manufacturing, Mars Pet Care, and Lenders Bagels.

The City of Mattoon Wastewater Treatment Plant discharges to Kickapoo Creek, a tributary of the Embarras River. The Illinois Environmental Protection Agency has issued a National Pollutant Discharge Elimination (NPDES) Permit No. IL0029831 for the City of Mattoon Wastewater Treatment Plant. The plant has design average and peak flow rates of 5.3 mgd and 14.0 mgd, respectively with dry weather flows of approximately 2.5 mgd.

The City's NPDES permit was issued Effective March 1, 2020. A copy is included in Exhibit A of Attachment 1. The Permit has several new Special Conditions related to nutrients in the treated wastewater discharge. Nutrients in wastewater are generally defined as phosphorus and nitrogen. These nutrients are necessary to cellular development but in water bodies, they can lead to significant algal growth, which often causes a degradation in water quality.

The three permit special conditions this Facility plan addresses are 18, 19, and 21, which are summarized as follows:

Special Condition 18: By September 1, 2021, submit a feasibility study that identifies the methods, timeframe, and costs of reducing phosphorus levels in the discharge to consistently meet a potential future limit of 1 mg/l, 0.5 mg/l, and 0.1 mg/l. The study should include O&M costs on a monthly seasonal and annual average basis.

Special Condition 19: By September 1, 2021, submit a Phosphorus Discharge Optimization Plan with a schedule to implement any recommended measures. A progress report needs to be submitted by March 31 of each year. The report should include source reduction, operational improvements, and minor facility modifications to optimize reductions in phosphorus discharges.

Special Condition 21: By January 1, 2030, the facility must meet a 0.5 mg/l annual effluent phosphorus limit unless it is not either technologically feasible using a biological phosphorus removal (BPR) process, can only be met using chemicals, is not economically feasible, or requires a longer timeline. If the limit is considered feasible, then a 0.6 mg/l annual effluent will be applied instead. The deadline can be extended to 2035 if either 1) a new treatment facility is built, 2) the facility can reduce nitrogen using a biological nutrient reduction (BNR) configuration, which also achieves BPR. The deadline will be reduced to December 31, 2025 and the limit will be increased to 1.0 mg/l if the City chooses to meet the effluent phosphorus limit using chemical addition instead of biological treatment. The City must tell IEPA by December 31, 2023 if they plan to take exception to the 1/1/30 limit of 0.5 mg/l using BPR process.

The Feasibility Study (Special Condition 18) and the Phosphorus Discharge Optimization Plan (Special Condition 19) are contained in this report. The preliminary planning needed for the City to decide whether and how they are going to achieve BPR and whether they are going to pursue BNR are also contained herein.

1.2 PREVIOUS FACILITY PLANS

1.2.1 1985 FACILITY PLAN

In 1985 a facility plan, which included an extensive infiltration-inflow analysis, a combined sewer overflow study, and a biological stream survey, was completed for Mattoon's wastewater collection system. Several alternates were evaluated to control combined sewer discharges and reduce pollutant loadings in Little Wabash, Kickapoo, and Riley Creeks. The recommendations from this facility plan were implemented.

1.2.2 1999 FACILITY PLAN

In 1999, Clark Dietz prepared a wastewater Facility Plan for the City of Mattoon to expand the treatment system. At that time, the expanded and upgraded plant was designed to treat wastewater through the 20-year planning period (to 2020). At that time, the design average capacity was increased from 4.5 mgd to 5.3 mgd. Improvements made at that time included:

- Raw sewage pumps,
- Stormflow pumps,
- Combined sewage holding basin pumps,
- Grit tank,
- Aeration basin,
- Final settling tanks, and
- Sludge Storage.

Improvements recommended in that Facility Plan were implemented in a design and construction project in the early 2000s.

1.2.3 2011 FACILITY PLAN

In 2011, Clark Dietz prepared a WWTP Facility Plan for upgrades specifically to:

- Replace the Existing Sand Filter,
- Upgrade the Storm Flow Holding Basin,
- Upgrade the SCADA system, and
- Address Safety Concerns.

The only recommended upgrade from this facility plan that was implemented was upgrades to the SCADA system. The WWTP is able to meet their effluent permit requirements without effluent filtration, therefore the sand filters have been abandoned in place.

1.3 CURRENT OBJECTIVES

This Facility Plan has two objectives:

1. **Meet the planning requirements of the NPDES permit Special Conditions 18, 19, and 21.**
2. **Develop a roadmap with schedule and capital requirements to improve the WWTP to 2050.**

The objective of this current planning effort is to develop a plan for the City to cost-effectively design and construct the treatment plant improvements to satisfy the NPDES permit nutrient limits and address deficiencies in the existing system. To meet these objectives Clark Dietz performed preliminary work including assessing the existing condition of the treatment plan facilities, analyzing water quality and developing design criteria, and then developing and calibrating a treatment plant water quality model (Biowin Model).

Using those preliminary studies, we developed a Phosphorus Discharge Optimization Plan and evaluated several treatment options. Several of the preliminary studies were documented in Technical Memos, which are included in Appendices to this report. Figure 1-1 is a flow diagram that shows how the various assessments were used to develop the Facility Plan and how this plan will be used as the basis for the upcoming design upgrades.

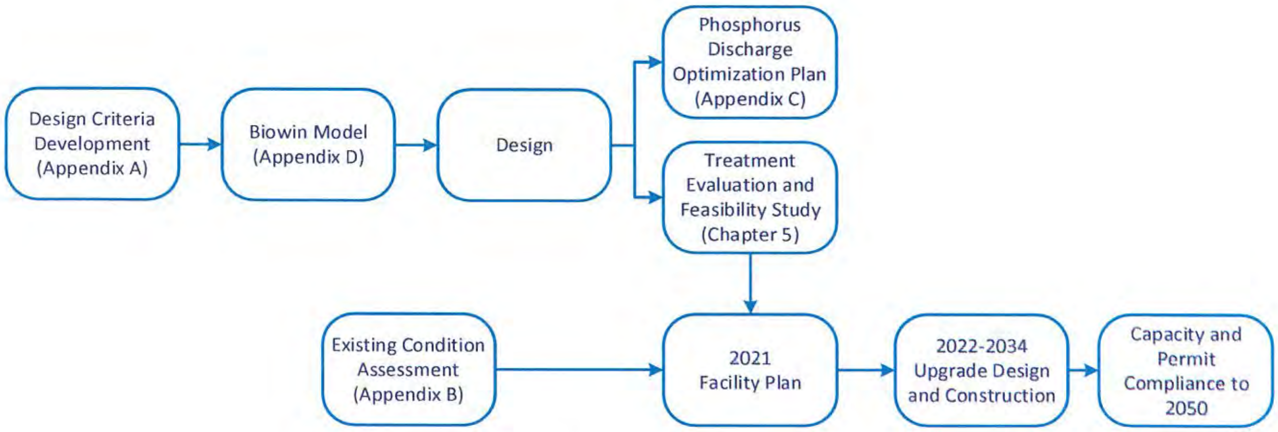

Figure 1-1. Report Development Schematic

CHAPTER 2 - EXISTING CONDITIONS

2.1 POPULATION

2.1.1 HISTORIC POPULATION

As shown in the following table, the U.S. Census found a slight decrease in the population of the City of Mattoon, between 1990 and 2019.

Table 2-1. U.S. Census Population Data for Mattoon, Illinois

Year	US Census Reported Population
1990	18,441
2000	18,291
2010	18,555
2019[1]	17,615

Note:

1. 2020 Census data for Mattoon is not yet available from the U.S. Census Bureau's "QuickFacts" tool as of July 2021. Their estimated July 1, 2019 population is reported here.

2.1.2 POPULATION PROJECTIONS

The Illinois Department of Commerce and Economic Opportunity (DCEO) establishes population projections for Illinois counties. Their estimate, prepared in 2017, for Coles County is summarized in the following table.

Table 2-2. DCEO Population Projections for Coles County, Illinois

Year	DCEO Projected Population
2000	53,285
2005	53,896
2010	54,878
2015	56,317
2020	58,030
2025	59,345
2030	59,746

Comparing the County population in 2000 and Mattoon's census data from 2000, it appears that the City of Mattoon makes up approximately 34% of the Coles County population. It is notable that the County population has increased over the last 20 years and DCEO projects the County's population will increase another 3% from 2020 to 2030.

Given the stable to slightly declining population numbers for the City of Mattoon over the last 40 years, it was assumed that the population for the planning period will be stable.

2.2 FLOW AND LOADING

Existing flows and loadings into the WWTP are summarized in the Design Criteria Technical Memo in Appendix A. In addition to reviewing daily flow, the WWTP's MRO data from 2016 through 2020 was analyzed to determine the number, length, and duration of events that triggered discharges from Outfall 002[1]. In 2016 and 2017 there was 1 event per year, 2018 and 2019 there were 3 events per year, and in 2020 there were 5 events. The events duration, total flow volume, and average daily flow are shown in Figure 2-1. The longest event was in 2018 which lasted 13 days for a total of 102 mg. The average daily discharge for all the events was 7.3 mgd.

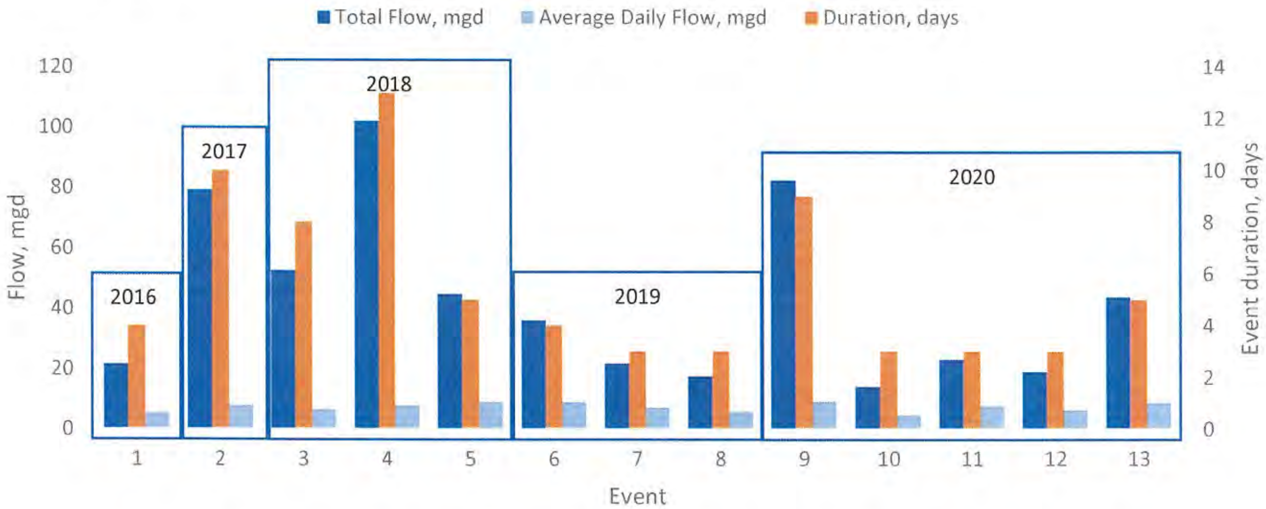

Figure 2-1. Discharge Events from Outfall 002 from 2016 through 2020

2.3 EXISTING LIQUID TREATMENT

2.3.1 DIVERSION STRUCTURE

Flow is conveyed to the WWTP through one of four influent pipes and discharge into an influent diversion structure as shown in Figure 2-2.[2]

The diversion structure has two levels: an upper level where water, when at a high level, can flow to the holding basin and a lower level that directs influent to the primary pumping station. The two levels are separated by a 15-in thick concrete wall. The two levels with the influent interceptor sewers are shown in Figure 2-3 and Table 2-3.

[1] In accordance with the WWTP NPDES permit, Outfall 001 is the WWTP main outfall which discharges treated effluent at a DAF of 5.3 mgd and a DMF of 14.0 mgd. Outfall 002 is the treated CSO outfall, when flow into the plant exceeds 14.0 mgd the facility stormwater holding basin is filled. Once this basin is filled, additional screened influent is pumped to several storm clarifiers where it is disinfected and discharged. The disinfected clarifier effluent is CSO Outfall 002.

[2] The layout and elevation information in this figure was obtained from design plans dated 1981 by Upchurch and Associates.

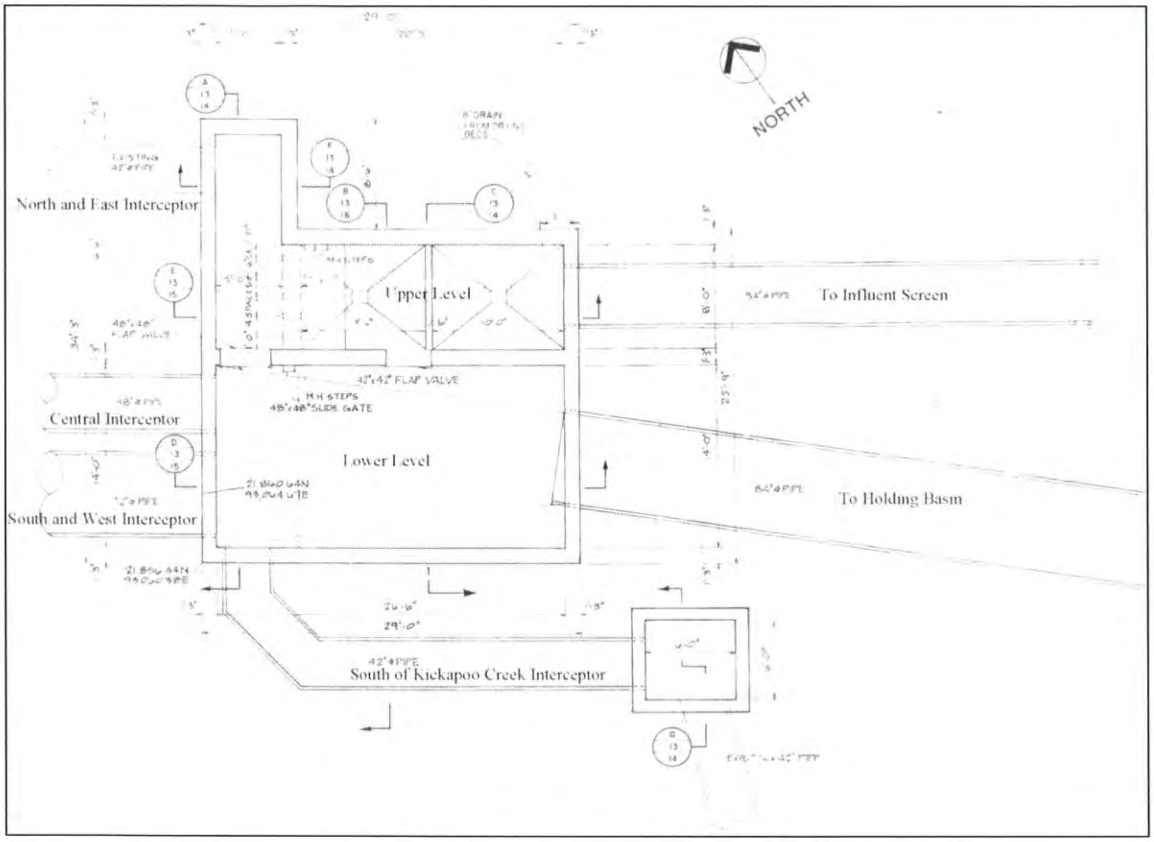

Figure 2-2. Influent Diversion Structure Plan View

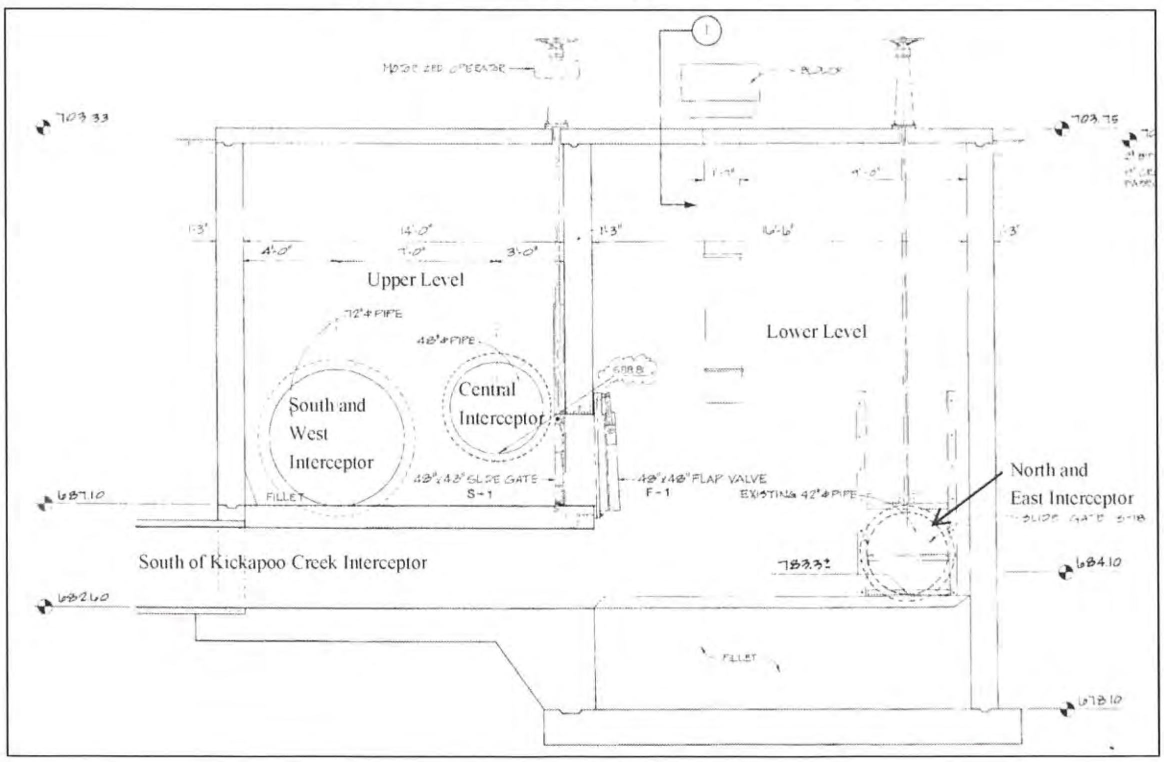

Figure 2-3. Influent Diversion Structure Section View

Table 2-3. Diversion Structure

Interceptor sewer	Size, in	Discharge Location	Invert, ft EL
Influent - North and East	42	Lower level	683.3
Influent - Central	48	Upper level	688.8
Influent - South and West	72	Upper level	687.1
Influent - South of Kickapoo Creek	42	Lower level	682.6
Effluent - Primary Pump Station	54	Lower level	682.1
Effluent - Holding Basin	84	Upper level	687.1

During low flow periods, water flows from the upper level to the lower level. Flow coming into the lower level from the upper level can be stopped by means of a slide gate that is operated from the surface. A flap valve over the discharge side of this opening prevents flow from going from the lower level to the upper level through this opening during periods of high-water levels. During high flow periods, water flows from the lower level to the upper level. There is a flap valve over this hole that prevents flow from going back into the lower level through this opening. Figure 2-4 shows the two flap gates and their elevations, sizes, and controls are summarized in Table 2-4.

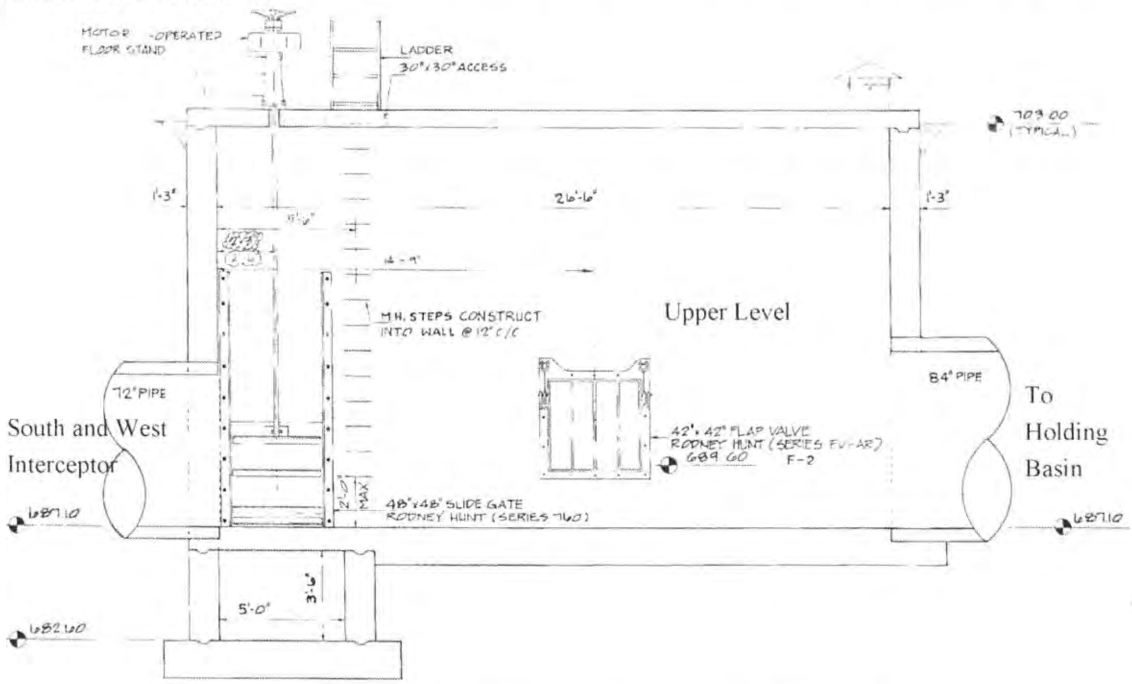

Figure 2-4. Influent Diversion Structure Flap Gates

Table 2-4. Diversion Structure Openings

Opening Description	Used during	Size, in x in	Invert, ft EL	Controls
High-to-low	Low flow	42 x 42	689.6	Flap valve
Low-to-high	High flow	48 x 48	687.1	Flap valve, slide gate

During high flow periods when water is flowing to the holding basin by gravity it must rise from the lower level approximately 3.8-ft (from the invert of the influent interceptor sewers on the lower level to the low-to-high diversion structure opening). This rise may effectively prevent some of the heavier solids from entering the holding basin. However, effectively all flow that enters the upper level of the diversion structure will flow to the holding basin.

Because of the hydraulics, gravity flow from the diversion structure to the holding basin is possible if the water level in the holding basin is less than 696.1-ft. The top of the basin is at approximately 703-ft and to get an additional 7-ft of water to the basin requires pumping.

2.3.2 INFLUENT SCREENS

Two catenary-type mechanical screens remove floating, particulate and fibrous material from the influent wastewater. The screens are such that the drive mechanism is operated 24-hours per day to minimize solids buildup and headloss across the screen. Table 2-5 presents the design criteria for the fine screens.

Table 2-5. Mechanical Screens Design Information

Parameter	Value
Number of Units	2
Screen Openings, in	¼
Screen Angle from Vertical	15
Channel Width, ft	3
Channel Depth, ft	20.9
Minimum Freeboard, ft	1
Capacity per Screen, mgd	20

The screenings conveyor collects raw screenings removed by the bar screens and transports the material to the washer/compactor. The compaction system washes and dewaters the screenings to minimize the disposal volume. The design information for the washer/ compactor is shown in Table 2-6.

Table 2-6. Washer/Compactor Design Information

Parameter	Value
Number of Units	1
Average Capacity, ft^3/hr	30
Maximum Capacity, ft^3/hr	60
Target Dry Solids Content, %	60

A shaftless screw conveyor collects the compacted screenings from the washer/compactor system and carries them to the dumpsters at two discharge locations.

2.3.3 INFLUENT PUMPS

Influent flows to the plant up to 14 mgd are pumped into the WWTP for treatment and discharged under the permitted Outfall 001. Wastewater flows more than 14 mgd are diverted to a 16 mg combined sewage holding basin until that holding basin is full. After the storm event has ended, liquid in the holding basin flows by gravity or is pumped back to the diversion structure at the head of the plant for treatment.

Once the holding basin is full, flows in 14 mgd and up to 26.5 mgd are treated onsite in a CSO treatment facility, which includes settling and chlorination, and then discharged to Kickapoo Creek (Outfall 002).

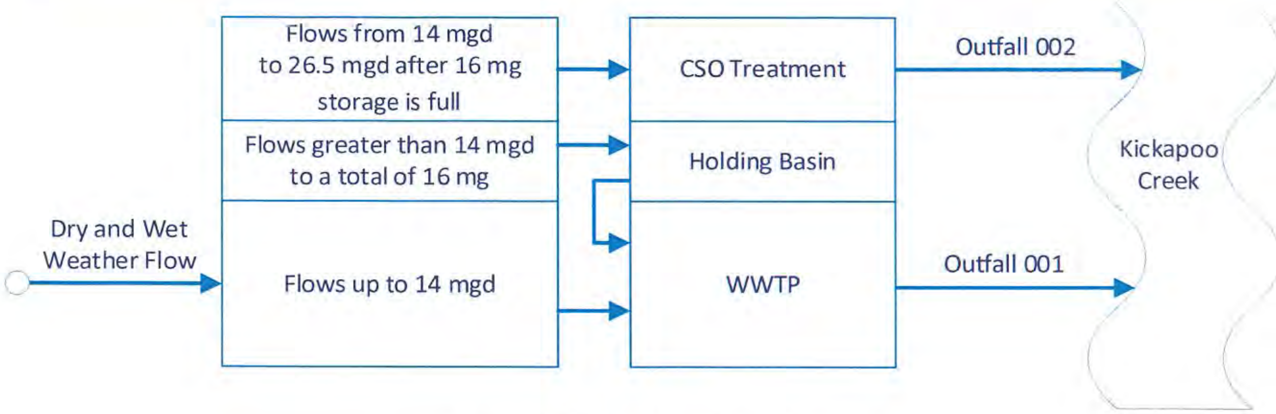

Figure 2-5. Influent Flow Diagram

Raw sewage from the City of Mattoon flows into the influent diversion structure. From there, wastewater passes through to two mechanically cleaned bar screens. The bar screens collect large solids that are compacted and transported to dumpsters via a conveyor system. The screened wastewater flows to the primary pump station which consists of nine pumps: three for the main flow to the WWTP, three for flow to the holding basin, and three for flow to CSO treatment.

The main flow to the wastewater is pumped to the grit tank where heavy inorganics are removed. After the grit removal system, the flow is split between three sets of primary clarifiers, operated in parallel. The primary clarifier effluent flow is split between eight parallel aeration basins, which is the main biological treatment process. From the aeration basins, flow is first combined and then split between four secondary clarifiers. Clarified effluent is then pumped through a UV disinfection system and directed towards Outfall 001. The design criteria for each process is shown in the table below.

Table 2-7. Influent Pump Summary

Primary Influent Pumps	Value
Number	2 duty, 1 standby (1, 2, 3)
Rated Flow, each	8.5 mgd (14 mgd with 2 pumps running)
Power, hp	50
Holding Basin Pumps	
Number	2 duty, 1 standby (12, 13, 14)
Rated Flow, each	13 mgd (18.7 mgd with 2 pumps)
Power, hp	100
Storm Pumps	
Number	2 duty, 1 standby (35, 36, 37)
Rated Flow, each	9.4 mgd (16.1 mgd with 2 pumps running)
Power, hp	60

2.3.4 GRIT TANK

The vortex grit removal system has the parameters shown in the table below. The grit removal system also has a vortex grit classifier. Washed grit is discharged to a dumpster.

Table 2-8. Grit Tank Summary

Parameter	Value
Year Installed	2001
Number	1
Area, sf	532
Diameter, ft	16
Capacity, mgd	20

2.3.5 PRIMARY SETTLING TANK

There are three different sets of primary settling tanks. The tanks are described in the following table.

Table 2-9. Primary Clarifier Summary

Parameter	Set 1 (South)	Set 2 (Middle)	Set 3 (North)
Year Installed	1940	1955	1975
Number	2	2	4
Length, ft	50	64	64
Width, ft	14	16	16
Side Water Depth, ft	9.5	8	8
Surface Area per Tank, sf	700	1,024	1,024
Weir Length per Tank, ft	117	114	384

2.3.6 AERATION BASIN

There are two different sets of aeration basins. The tanks are described in the following table.

Table 2-10. Aeration Basins Summary

Parameter	Set 1 (South)	Set 2 (North)
Number	6	2
Length, ft	38	150
Width, ft	38	30
Side Water Depth, ft	22	15
Surface Area per Tank, sf	1,444	4,500
Volume per tank, gal	216,051	437,639

The existing aeration basins were converted from tube-type diffusers to fine bubble ceramic diffusers for better oxygen transfer as part of 2001 Facility upgrades. The basins are aerated by 10 centrifugal blowers.

9 blowers on site, 6 provide air to aeration tanks

2.3.7 FINAL SETTLING TANKS

There are four secondary clarifiers. The tanks are described in the following table.

Table 2-11. Secondary Clarifier Summary

Parameter	Value
Number	4
Diameter, ft	70
Side Water Depth, ft	10
Surface Area per Tank, sf	3,848
RAS/WAS Pumps	2 duty, 1 standby (7, 8, 9)
RAS/WAS Rated Flow, each	5.8 mgd (8.1 mgd with 2 pumps running)
Power, hp	50

Treated water effluent flow is pumped from the clarified effluent collection box to the tertiary filter distribution channel. The pumps are summarized in the following table.

Table 2-12 Secondary Pump Summary

Parameter	Value
Number	2 duty, 1 standby (4, 5, 6)
Rated Flow, each	10 mgd (14 mgd with 2 pumps running)
Power, hp	100

2.3.8 TERTIARY FILTERS

The WWTP previously had a tertiary filtration system with eight sand filters rated at a maximum filtration of 5 gpm. The system is currently inoperable.

2.3.9 UV DISINFECTION

The WWTP UV Disinfection system is designed for a peak flow of 14 mgd. Preliminary UV Design Criteria is presented in Table 2-13. UV transmittance was confirmed by UV transmittance testing performed at the plant in 2019. The transmittance data is summarized in Figure 2-6 and shows that despite 90% of the UVT transmittance is better than 70%, the standard IEPA design criteria of 65% transmittance was used to assure the WWTP's ability to meet their effluent requirements.

Table 2-13. UV Design Criteria

Parameter	Value
Design Average Flow, mgd	5.3
Design Maximum Flow, mgd	14
UV Transmittance, %	65
Design TSS, mg/l	30
Design UV Dose	20 mJ/cm^2 based on T1 bioassay validation
E. Coli Limit, per 100 mL	235

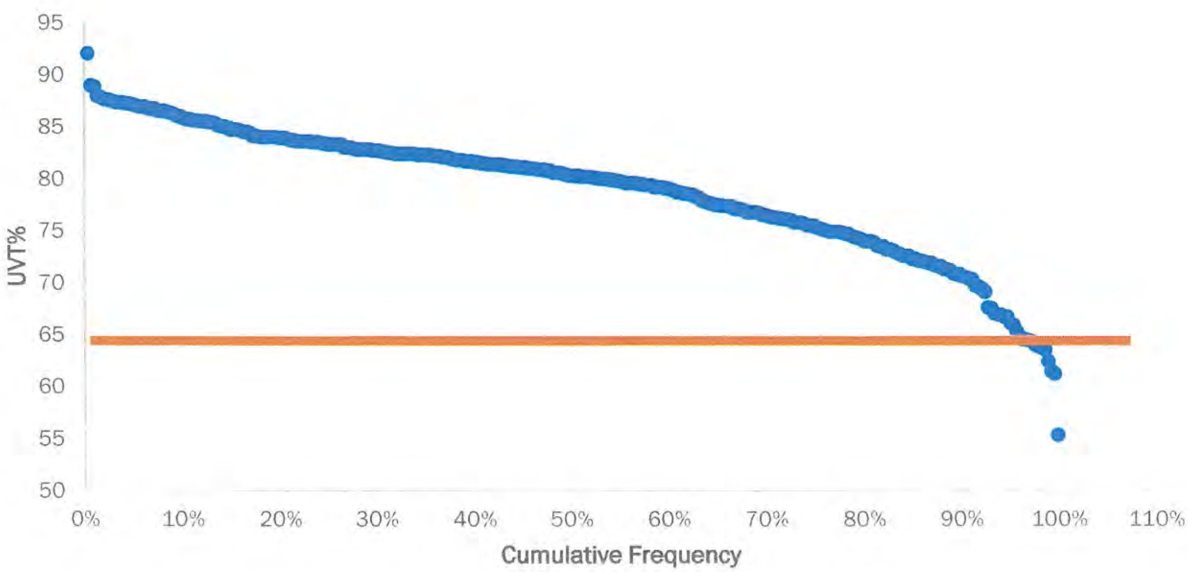

Figure 2-6. UV Transmittance Cumulative Frequency Distribution

The UV system has one channel with a bypass pipe available in case of maintenance needs. The system is a Trojan Signa system with the following configuration.

Table 2-14. UV Design Summary

Parameter	Trojan UV Signa
Year Installed	2021
Type	Inclined
Number of Channels	1
Number of Banks/Channel	2
Number of Modules (Lamp Racks) per Bank	1
Total Number of Lamps	32
Total Head Loss (in) across UV banks	1.69
Lamp life, hrs	15,000
Input power/lamp, Watts	1,000
Power Usage (5.3 mgd), kW	15.2
Maximum power Consumption, kW	33.7

The design does not include peak flow redundancy as it is not a requirement by the State of Illinois and the City agreed it was not needed. However, the channel and electrical components of the new UV system were designed to accommodate a future module.

2.4 SOLIDS TREATMENT

The primary sludge from primary settling tanks is passed sequentially into one primary and two secondary anaerobic digesters. The primary sludge is metered and pumped to the digesters using sludge pumps located in the Grit Building. The waste activated sludge is wasted from the return activated sludge line coming from the final settling tanks and pumped to anaerobic digesters. The digesters are decanted once a day and discharged to the primary settling tanks. The anaerobically digested sludge is thickened using gravity belter thickeners. The thickened sludge is pumped to sludge storage tanks. The sludge is utilized for liquid land application. Existing sludge drying beds are no longer used.

WAS is pumped to 1940 primary clarifier for settling and removal to anaerobic digester via primary sludge pumps

2.4.1 AEROBIC DIGESTERS

The three aerobic digesters are in poor structural condition and are no longer used. The dimensions of existing aerobic digesters are summarized in the table below.

Table 2-15 Aerobic Digesters Summary

Parameter	Value
Year Converted to Digesters	2006
Number	3
Length, ft	99
Width, ft	24
Depth, ft	13
Volume per tank, cf	30,900

2.4.2 ANAEROBIC DIGESTERS

There are three anaerobic digesters – one primary and two secondary digesters. Both primary and secondary digesters are not functioning as designed and have several structural deficiencies outlined in the *Existing Conditions Assessment memo.* The dimensions of existing anaerobic digesters are summarized in the table below.

Table 2-16 Anaerobic Digesters Summary

Parameter	Value
Primary Digester	
Year Installed	1955
Number	1
Diameter, ft	65
Depth, ft	25.50
Volume, cf	76,314
Secondary Digester	
Year Installed	1940
Number	2
Diameter, ft	40
Volume of each digester, cf	21,363
Total Anerobic digester volume, cf	119,000

2.4.3 SLUDGE STORAGE AND HANDLING

There are two circular sludge storage tanks to store the thickened sludge. The dimensions are summarized in the table below.

Table 2-17 Sludge Storage Tanks Summary

Parameter	Value
Year Installed	2001
Number	2
Diameter, ft	90
Depth, ft	24
Volume of each tank, cf	152,681

2.5 FACILITY DEFICIENCIES

As part of this Facility Plan, an engineering evaluation was performed for the WWTP facilities to determine the strengths and deficiencies of the existing systems. A full description of that evaluation is included in Appendix B.

2.6 RECEIVING STREAM

The City of Mattoon's Wastewater Treatment Plant discharges to the Kickapoo Creek, a tributary of the Embarras River and part of the Embarras/Middle Wabash River drainage basin. As described above, there are two outfalls from the WWTP to the receiving stream: "001 STP Outfall" and "002 Treated CSO." Kickapoo Creek, which has an IEPA Assessment Unit ID of IL_BEN-02 is not on the IEPA's Draft 2010 Section 303(d) list of Category 5 impaired waters.

Water levels in the receiving stream are summarized in the following table. The data shown in this table was obtained during previous work at the plant, with the exception of the low flow water level. The low flow water level elevation was assumed to be the bottom of the stream since the NPDES fact sheet reports that the 7Q10 flow rate in Kickapoo Creek adjacent to the Mattoon WWTP is 0 cfs.

Table 2-18. Kickapoo Creek Water Level Elevations

	Elevation, ft
Bottom of Stream	688
Low flow water level	688
25-year flood	701.5
Top of bank at treatment plant	702.5
WWTP Outfall 001 invert	695

2.7 NPDES PERMIT LIMITS

The Illinois Environmental Protection Agency has issued a National Pollutant Discharge Elimination (NPDES) Permit No. IL0029831 for the City of Mattoon's Wastewater Treatment Plant. This permit has an effective date of March 1st, 2020. A copy of the permit is included in Exhibit A of Appendix A. In accordance with the conditions of the NPDES permit, the discharge from the Mattoon WWTP must meet the limitations listed in Table 2-19 and Table 2-20.

Table 2-19. City of Mattoon WWTP NPDES Permit Discharge Limitations for Outfall 001[1]

Parameter	Load Limits (lb/day)			Concentration Limits (mg/l)		
	Monthly Average	Weekly Average	Daily Max.	Monthly Average	Weekly Average	Daily Max.
5-day Carbonaceous BOD_5 ($CBOD_5$)	442		884	10		10
Total Suspended Solids (TSS)	530		1061	12		24
pH	Shall be in the range of 6 to 9 Standard Units					
Fecal Coliform	Daily Maximum shall not exceed 400 per 100 mL (May through October)					
Chlorine Residual						0.05
Parameter	**Load Limits (lb/day)**			**Concentration Limits (mg/l)**		
	Monthly Average	**Weekly Average**	**Daily Max.**	**Monthly Average**	**Weekly Average**	**Daily Max.**
Ammonia Nitrogen as (N):						
March-May/Sept - Oct	35		150	0.8		3.4
June-August	35	88	133	0.8	2.0	3.0
Nov-Feb	66		150	1.5		3.4
Total Phosphorous as P[2]	Monitor and Report					
Total Nitrogen as N[3]	Monitor and Report					
Dissolved Oxygen	**Concentration Limits (mg/L)**					
	Monthly Average not less than		**Weekly Average not less than**		**Daily Minimum**	
March-July	NA		6.0		5.0	
August-February	5.5		4.0		3.5	

Notes:

1. The Plant has design average (DAF) of 5.3 mgd and design maximum flow of 14.0 mgd. Load limits are computed based on DAF is shown in the table.

2. The TP effluent limit will be 0.5 mg/l annual average. The effective date of that limit will depend on the type of treatment process that the City chooses.
3. If the City decides to construct/operate a biological nutrient removal process incorporating nitrogen reduction, the phosphorous limit will not need to be met until December 31, 2035.

Table 2-20. City of Mattoon WWTP NPDES Permit Discharge Limitations for Outfall 002[1]

Parameter	Monthly Average Concentration (mg/l)
Total Flow (MG	Report
BOD_5	Report
Suspended Solids	Report
Fecal Coliform	Daily Maximum Shall Not Exceed 400 per 100 mL
pH	Shall be in the range of 6 to 9 Standard Units
Chlorine Residual	0.75
Ammonia	Report
Phosphorus	Report

Notes:

1. Treated CSO Outfall when plant inflow is between 14 mgd and 26.5 mgd. Sampling is required daily when flow is discharging from CSO treatment.

CHAPTER 3 - DESIGN CRITERIA

3.1 FLOW AND LOADING

3.1.1 DESIGN WASTEWATER FLOW

Wastewater flow to the plant is comprised of two components: dry weather and wet weather flow. Dry weather flow is typically daily flow from homes and businesses in the service area. Wet weather flow is the additional flow into the system during periods of rainfall or snowmelt when precipitation enters the combined sewer system and needs to be treated at the WWTP.

As described in Chapter 2, the population for the City of Mattoon over the next 20 years is not expected to change significantly, this portion of the dry weather flow is expected to be relatively constant. Industrial flow is more uncertain. As industries open and close in the City, there could be a significant impact on the flow. Based on discussions with City staff, we have assumed that there will be no significant impact to dry weather flow and that the average daily flow rate for the purposes of planning to 2050 will remain unchanged.

Wet weather flow into the system is variable and dependent on the amount of rainfall in any given year. Wet weather flow into the system also depends on the number of combined sewers, downspout and sump pump connections to the sanitary sewer system, and the condition of the sewers themselves. According to the Illinois State Climatologist and the Midwest National Climate Association, the rest of the century will have an increased risk of heavy rainfall and flooding. Periods of intense rainfall may increase the frequency and duration of wet weather events for the WWTP. However, for the purposes of this analysis, we have assumed that there will be no significant increase or decrease in storm flow and the operation of the stormflow system will remain the same.

Table 3-1. WWTP Effluent Flow Design Criteria

	Current	2050 Planning Period
Design Average Flow, mgd	5.3	5.3
Design Maximum Flow, mgd	14.0	14.0
CSO Treatment[1], mgd	12.5	12.5

Note:

1. CSO Treatment occurs when influent to the plant is above 14 mgd up to 26.5 mgd.

3.1.2 FLOW PEAKING FACTOR

The WWTP is designed to accommodate peak sanitary flows up to 14 mgd. Flows greater than 14 mgd and less than 28 mgd are directed to the 16 million gallon holding basin. After the storm event has ended, wastewater stored in the holding basin flows by gravity back to the diversion structure at the head end of the WWTP for treatment. Flows greater than 28 mgd are chlorinated and pumped into four stormwater tanks for primary settling then discharged in a separate discharge structure to Kickapoo Creek.

3.2 DESIGN INFLUENT FLOWS AND LOADINGS

Design flows and loadings for the WWTP are described in Appendix A and summarized in Table 3-2.

Table 3-2. Design Influent Flows and Loadings

Parameter	Annual Average	Maximum Month	Maximum Day
Flow, mgd	5.3	10.9	14.0
Loadings			
$CBOD_5$, lb/day	4,500	5,400	8,100
TSS, lb/day	4,900	6,400	10,300
TP, lb/day	120	350	350
Ammonia, lb/day	560	900	1,700
Concentrations			
$CBOD_5$, mg/l	100	59	69
TSS, mg/l	110	70	88
TP, mg/l	2.5	3.8	3.0
Ammonia, mg/l	13	10	15

3.3 PERMIT EFFLUENT REQUIREMENTS

The effluent NPDES permit requirements for Outfall 001 are expected to be the same as the current effluent requirements with several exceptions, as follows:

- **Total Phosphorus:** 0.5 mg/l rolling geometric mean calculated monthly on a 12-month basis
- **Total Nitrogen:** a limit has not been defined by IEPA, but a typical Total Nitrogen limit of 10 mg/l is expected
- **Ammonia:** based on guidance from USEPA, IEPA is likely to reduce effluent total ammonia to approximately half its current concentration.

CHAPTER 4 - PHOSPHORUS DISCHARGE OPTIMIZATION

Special Condition 19: By September 1, 2021, submit a Phosphorus Discharge Optimization Plan with a schedule to implement any recommended measures. A progress report needs to be submitted by March 31 of each year. The report should include: source reduction, operational improvements, and minor facility modifications to optimize reductions in phosphorus discharges.

A Phosphorus Discharge Optimization Plan was prepared to meet the requirements of NPDES Permit Special Condition 19. This plan was prepared as a technical memo, which is included in Appendix C. This Chapter summarizes the conclusions of that memo.

4.1 TP LEVEL AND SOURCE REDUCTIONS

The plant's influent and effluent phosphorous, contributions from four major industrial users, and the existing phosphorous removal achieved by the plant were analyzed and it was found that:

- Influent and Effluent TP: The 5-year average influent TP and effluent TP concentrations are 3.1 mg/l and 2.2 mg/l, respectively. Both influent and effluent TP levels have been on a declining trend over the last five years.
- Industrial Users: The four main industrial users: Mars Petcare, Anamet, Lenders Bagel, Justrite account for about 8% of the total influent flow and 30% of TP. Therefore, the users are not major sources of TP and have low reduction potential for the City of Mattoon WWTP.
- Residential and Commercial Users: Due to the relatively low influent TP concentration in the WWTP influent, there are limited source reduction strategies for residential and commercial users that are applicable to Mattoon.

4.2 EVALUATION OF P REMOVAL METHODS

As part of the optimization plan, a biological process model was developed and calibrated to model the WWTP operations. The existing treatment system was evaluated to determine the various optimization options to meet the future effluent TP limits that are listed below.

- Adjust solids retention time (SRT) for nitrification, denitrification, or biological phosphorous removal.
- Adjust aeration rates to reduce dissolved oxygen and promote simultaneous nitrification-denitrification (SNdN).
- Add baffles to existing units to improve microorganism conditions by creating divided anaerobic, anoxic, and aerobic zones.
- Change aeration settings in plug flow basins by turning off air or mixers at the inlet side of the basin system.
- Minimize impact on recycle streams by improving aeration within holding tanks.
- Reconfigure flow through existing basins to enhance biological nutrient removal.
- Increase volatile fatty acids for biological phosphorus removal.

The results of the analyses summarized in the table below indicate that the Mattoon WWTP has limited options to reduce the TP discharge via existing system optimization. Alternative reduction methods need to be investigated and reviewed to be implemented in large capital projects. This will be further evaluated in the Feasibility Study (Chapter 5).

Table 4-1. Phosphorous Discharge Optimization Summary

Potential Measure	Feasibility Potential at City of Mattoon WWTP	Effluent Nutrients	Costs
1. Adjust SRT for nitrification, denitrification, or EBPR	No: The current SRT rates are within the optimum range.	No impact	None.
2. Adjust aeration rates to reduce DO and promote SNdN	No: Blower speeds are not adjustable with the current blowers.	No impact	High: Blower replacement needed.
3. Add baffles to create anaerobic, anoxic, and aerobic zones	No: Aeration basins 1-6 operate independently. Aeration 7 & 8 have two grids each and have inadequate aeration volume.	Not applicable	High: New valves, piping, baffles.
4. Change aeration settings in plug flow basins	No: Blower speeds are not adjustable with the current blowers.	No impact	High: Blower replacement needed.
5. Minimize impact of recycle streams by improving aeration within aeration tanks	No: Recycle streams have low TP reduction potential.	No impact.	None.
6. Reconfigure flows through existing basins	Yes: Convert to A^2O configuration	TP reduced by 30%-50%.	High and could negatively impact nitrification

CHAPTER 5 - TREATMENT EVALUATION AND FEASIBILITY

Special Condition 18: By September 1, 2021, submit a feasibility study that identifies the methods, timeframe, and costs of reducing phosphorus levels in the discharge to consistently meet a potential future limit of 1.0 mg/l, 0.5 mg/l, and 0.1 mg/l. The study should include O&M costs on a monthly seasonal and annual average basis.

A Feasibility Study was performed to meet the requirements of NPDES Permit Special Condition 18. The technology that was evaluated as part of the feasibility study was then used to develop the plan needed to meet Special Condition 21, which is described in Chapter 8. The first part of this section summarizes the analysis to meet 0.5 mg/l effluent TP and 10 mg/l. The final part of the section reviews modified costs associated with limits of either 1.0 mg/l or 0.1 mg/l.

5.1 BNR TECHNOLOGY OPTIONS – EFFLUENT TP 0.5 MG/L AND TN 10 MG/L

Since it is most likely that the WWTP will have an effluent TP limit of 0.5 mg/l and an effluent TN limit of 10 mg/l, three biological nutrient removal (BNR) removal options were evaluated specifically for the Mattoon Plant. To achieve these effluent limits, we focused on reviewing enhanced biological phosphorus removal (EBPR) with additional treatment zones for total nutrient removal. The advantages and disadvantages of including TN removal are discussed below in Section 5.2.2.

5.1.1 OPTION 1 – A^{2}O

Process Description

The A^{2}O process has an anaerobic zone followed by an anoxic zone upstream of the aerated zone. The anaerobic zone allows for the release of phosphate which is taken in subsequently in the aerobic zone. The denitrification is then accomplished in the anoxic zone. The aerobic zone is used for BOD and ammonia removal. The nitrate-rich liquor is recycled from the end of the aerobic zone to the head of the anoxic zone to enhance denitrification. The RAS stream is returned to the anaerobic zone. The site layout for this option is shown in Exhibit 2 of Appendix E.

Design Criteria

The design criteria and preliminary volumes for A^{2}O system configuration for the City of Mattoon WWTP are shown in Table 5-1 and Table 5-2, respectively.

Table 5-1. A^{2}O Design Criteria[1]

Parameter	Typical Range
SRT, days	5 – 25
MLSS, mg/l	3000 to 4000
Anaerobic HRT, hr	0.5 to 1.5
Anoxic HRT, hr	1 to 3
Aerobic HRT, hr	4 to 8
RAS, % of Influent	25 to 100
Internal recycle, % of Influent	100 to 400

Notes:

1. From Metcalf & Eddy, 5th Edition – Table 8-29

Table 5-2. Preliminary Design for A²O Process

Parameter	2050 Planning Period
Design flow, mgd	5.3
Aeration Volume, MG	1.64
Anoxic Volume, MG	0.65
Anaerobic Volume, MG	0.33
Internal recycle rate	3 Qi
RAS flow rate	70% Qi (same as existing)

Process Modeling

A BioWin model was developed for the A²O process using the design values shown in for preliminary evaluation of this system in terms of effluent TP and TN concentrations. Steady state simulations were performed at 2050 design condition shown in Table 5-4. The results are summarized in Table 5-4. The results indicate that the Plant would be able to remove about 71% of the influent TP at the current wasting rate and could achieve the desired TP level of 0.5 mg/l by increasing the wasting rate by 50%. A chemical feed system will be required as a backup or for polishing purposes.

The calibrated BioWin model created for the PDOP was used with the following updates:

- The existing three sets of primary settling tanks were modeled as one equivalent primary settling tank of 0.47 MG (Total Volume) and 8 ft (Depth).
- Existing six square aeration tanks (1 through 6) were converted to two sets of tanks each with anaerobic, anoxic and aeration zone. Each zone was modeled using a CSTR bioreactor with 'unaerated' option selected for anaerobic and anoxic reactors and DO set point of 2 mg/l for aerobic reactor.
- Existing two rectangular tanks (7 & 8) were converted into two sets of tanks each with anaerobic, anoxic, and aerobic zone. Each zone was modeled using a CSTR bioreactor with 'unaerated' option selected for anaerobic and anoxic reactors and DO set point of 2 mg/l for aerobic reactor.
- One new tank (A²O Tank #1) of size similar to that of rectangle basin (7/8) was included as well.

The flow schematic for A²O system is shown in Figure 5-1. The dimensions of the proposed A²O system used in the model are summarized below:

Table 5-3. A²O System dimensions

Parameter	Value
A²O Tanks (1-3) *(Converted from existing rectangular tanks 7 &8)*	
Size	30' wide x 150' long x 13 SWD
Anaerobic length, ft	19
Anaerobic volume per tank, gal	55,337
Anoxic length, ft	37
Anoxic volume per tank, gal	108,998
Aerobic length, ft	94
Aerobic volume per tank, gal	273,333
A²O Tanks (4 & 5) *(Converted from existing square tanks 1-6)*	
Size	38' wide x 114' long x 20' SWD
Anaerobic length, ft	14
Anaerobic volume per tank, gal	82,016
Anoxic length, ft	28
Anoxic volume per tank, gal	161,547
Aerobic length, ft	72
Aerobic volume per tank, gal	405,109

Table 5-4. BioWin results - A^2O system

Parameter	BioWin Input[1]	BioWin Output WAS 0.04 MGD	BioWin Output WAS 0.06 MGD
Flow, mgd	5.3	5.27	5.27
BOD, mg/l	102	3.6	3.3
TSS, mg/l	111	11.0	8.5
Ammonia, mg/l	13	0.4	0.4
TN, mg/l	18	3.5	3.3
TKN, mg/l	18	1.8	1.7
TP, mg/l	2.5	**0.7**	**0.5**

Notes:

1. Influent concentrations are estimated from 2050 design average loadings.

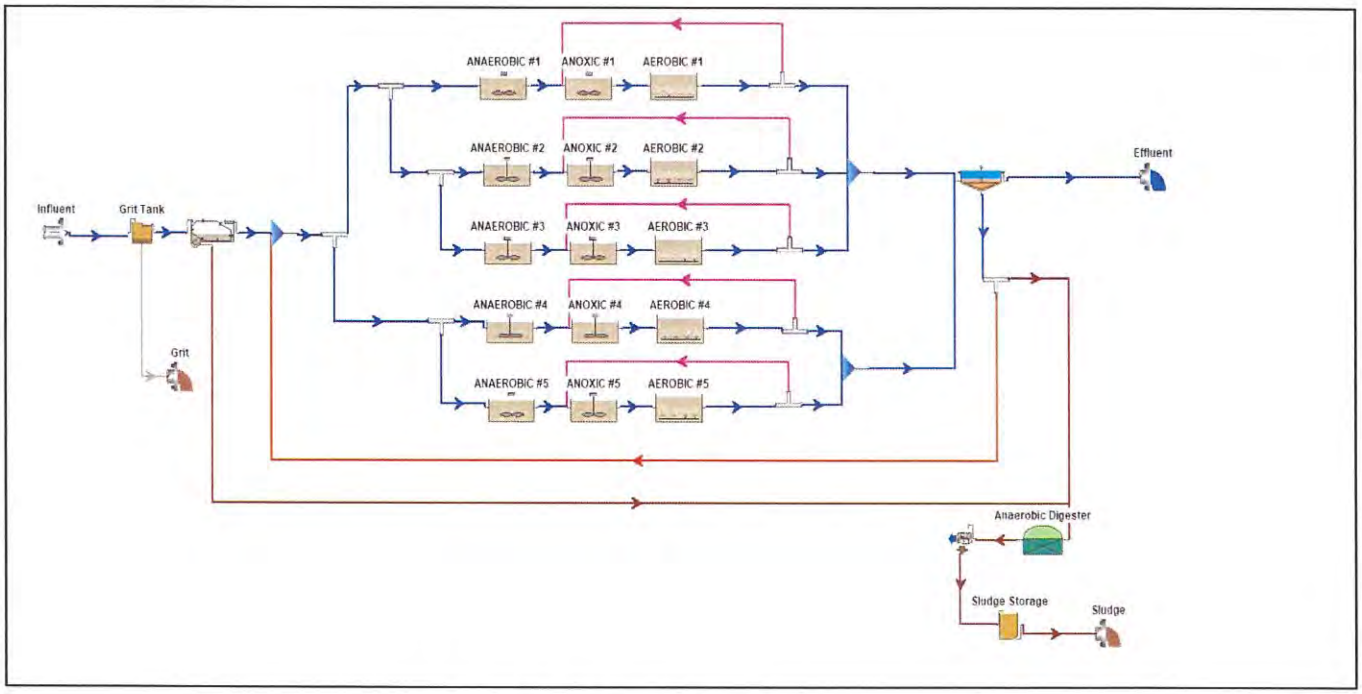

Figure 5-1. A^2O Flow schematic

Additional Simulation Scenarios

Due to carbon limitations of the influent wastewater, we evaluated several optimization methods using the A^2O model to investigate if the Plant can achieve further TP removal and to identify the most feasible method as listed below:

1. Addition of Methanol
2. Elimination of Primary tanks
3. RAS fermentation
4. Addition of FOG and/or Septage

The various simulation scenarios performed in summarized in the table below:

Table 5-5. Steady State Simulation Scenarios

Steady state simulation scenarios	A^2O Model layout
1) Design average concentrations @ 20° C	Supplemental Carbon Addition
2) Design average concentrations @ 20° C	Without Primary tanks
3) Design average concentrations @ 20° C	RAS fermenter
4) Design average concentrations @ 20° C	Addition of FOG and/or septage

1. Supplemental Carbon Addition

Methanol, and other similar carbon-source chemicals, are a common method of adding carbon to a WWTP to increase the production of increasing volatile fatty acids (VFAs) when existing carbon is a limiting parameter in BNR, as is the case with Mattoon. We added this type of external carbon source to our BioWin model to determine the impact of methanol addition on effluent nutrients. The calibrated A^2O BioWin model was setup with design annual average conditions with methanol input added upstream of the existing primary clarifiers. The results are shown in Table 5-6. To reduce TP to 0.5 mg/l from 0.7 mg/l, the Plant would require about 100 gal/d of methanol and would have to increase wasting from 0.04 mgd to 0.06 mgd to maintain MLSS of 2400 mg/l in the aeration basins. Though this option resulted in desired TP concentration, it would cost an estimated $ 41,000 (methanol - $1.13/gal) annually.

Table 5-6. BioWin Results – Methanol addition

Parameter	BioWin Output WAS @ 0.06 MGD
Flow, mgd	5.27
BOD, mg/l	3.3
TSS, mg/l	8.4
Ammonia, mg/l	0.4
TN, mg/l	3.2
TKN, mg/l	1.7
TP, mg/l	0.5

2. Elimination of Primary tanks

We performed an analysis to determine if the carbon removed in the primary tanks is counter-productive in BNR. Eliminating the primary tanks as part of the upgrades would decrease capital costs if there were no impact to the sizing of the aeration basins.

When we modeled the elimination of the primary tanks in Biowin and the results are summarized in Table 5-7. BioWin Results - A^2O without Primary tanks, the wasting rate was adjusted (increased from 0.04 to 0.08 mgd) to improve digester performance. The results indicate that primary tanks have minimal impact on effluent wastewater characteristics. However, elimination of these tanks would result in additional aeration tankage volumes to keep the aeration basin loading rate at or below 15 lb BOD/1000 cf/day.

Table 5-7. BioWin Results - A^2O without Primary tanks

Parameter	BioWin Output WAS@0.08 MGD
Flow, mgd	5.27
BOD, mg/l	3.4
TSS, mg/l	14.2

Parameter	BioWin Output
	WAS@0.08 MGD
Ammonia, mg/l	0.5
TN, mg/l	3.5
TKN, mg/l	1.9
TP, mg/l	**0.6**

3. RAS Fermentation

Fermentation of a portion of the returned activated sludge solids is a viable option and can be used for internal production of VFAs. A RAS fermenter tank was added to the BioWin model to improve biological P removal performance by degrading and fermenting biomass including phosphorous accumulating organisms (PAOs) to generate VFAs. In the model, a fraction of RAS flow was directed to a fermenter tank with the remainder being sent directly to the anaerobic tank. The wasting was adjusted in this model since MLSS increased significantly in the aeration basins. The flow schematic for this setup is shown in Figure 5-2.

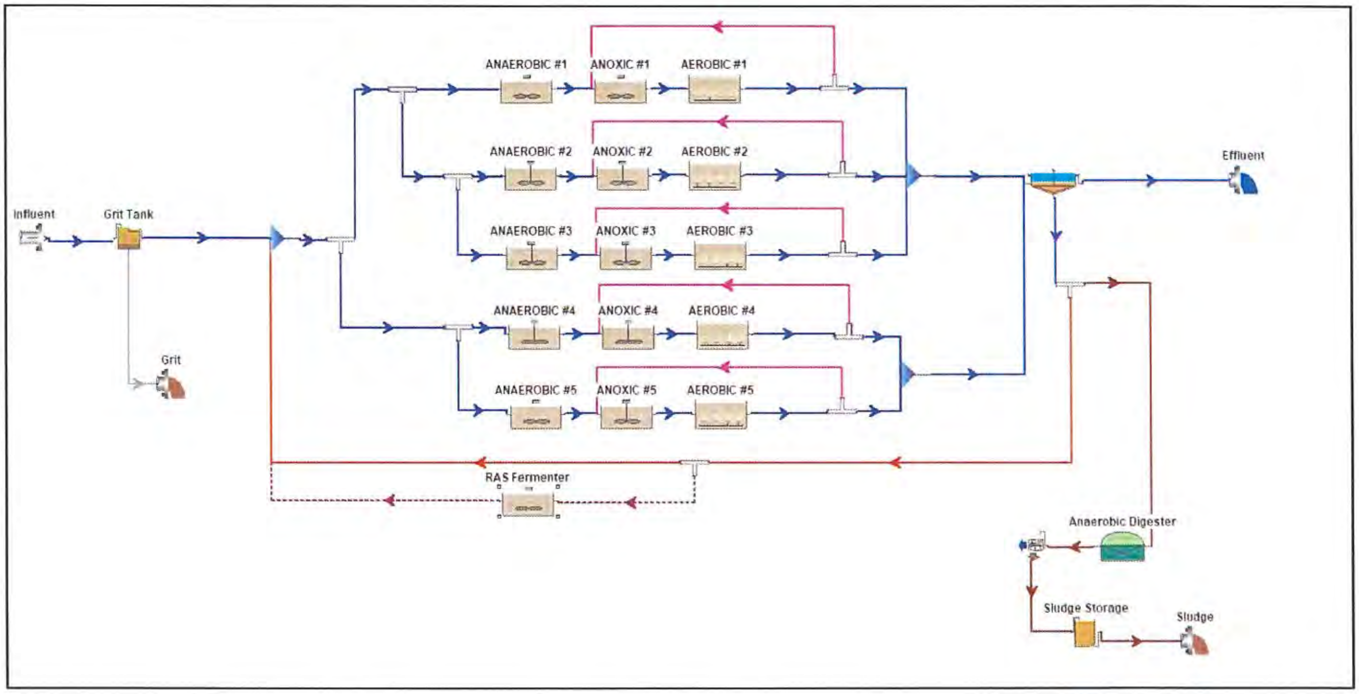

Figure 5-2. A²O with RAS Fermenter

The modeled design fermenter dimenisions are shown in Table 5-8. The results of the model run, shown in Table 5-9, indicate that the fermentation will not result in a significant TP reduction. However, it is recommended that this option be re-evaluated in the final design. One of the main disadvantages of fermenting activated sludge solids is the high nutrient content (phosphorous, ammonia) of the fermentate. However, depending on the circumstances, the overall benefit of the additional VFA source can outweigh any potential negative effect from the return streams.

Table 5-8. RAS Fermenter Design

Parameter	Value
Tank volume, MG	0.80
Fermenter recycle flow	10% of RAS (0.40 mgd)
HRT, hour	48

Table 5-9. BioWin Results - A^2O with RAS Fermenter

Parameter	BioWin Output WAS @ 0.08 MGD
Flow, mgd	5.27
BOD, mg/l	3.4
TSS, mg/l	14.1
Ammonia, mg/l	0.7
TN, mg/l	3.7
TKN, mg/l	2.2
TP, mg/l	0.6

4. Addition of FOG and Septage

Fats, oil, and grease (FOG) is a by-product of cooking foods such as vegetable oils, meats, and dairy products. FOG stream is high in fat, sugar and starch content and therefore a good potential source of VFAs. FOG is often trucked into WWTPs as part of restaurant grease trap cleaning or other industrial and commercial sources. Septage is also trucked into WWTPs from septic haulers cleaning residential septic tanks. Septage often has highly concentrated levels of carbon, nitrogen, grease, grit, and debris.

To look at the impact of FOG and septage on the modeled BNR process and effluent TP and TN concentrations, these waste streams were added to the BioWin model upstream of the anaerobic process tanks in the A^2O system. Two models, one with 4,500 gallons of FOG added upstream of anaerobic zone and one with 4,000 gallons of septage stream added upstream of anaerobic zone were created. FOG and Septage characteristics used in the model are shown in Table 5-10.

Table 5-10. FOG and Septage characteristics

Parameter	FOG	Septage
Flow, mgd	0.0045	0.004
BOD, mg/l	$3x10^4$	2030
TSS, mg/l	9530	629
Ammonia, mg/l	9570	710
TKN, mg/l	672	964
TP, mg/l	48	234
Nitrate, mg/l	40	40
pH	5.5	5.5
Alkalinity, mmol/l	24	24
Ca	$6x10^4$	$6x10^4$
Mg	5000	5000

Table 5-11. BioWin results – FOG and Septage addition

Parameter	BioWin Output	
	FOG @ 0.0045 MGD WAS @ 0.06 MGD	Septage @ 0.004 MGD WAS @ 0.06 MGD
Flow, mgd	5.27	5.27
BOD, mg/l	3.8	3.3
TSS, mg/l	9.5	8.8
Ammonia, mg/l	0.4	0.4
TN, mg/l	3.2	3.5
TKN, mg/l	1.9	1.8
TP, mg/l	0.5	0.6

The results indicate that addition of FOG and increasing wasting would lower TP to 0.5 mg/l. Though septage addition did not necessarily improve nutrient removal, it is recommended that City consider adding this stream to their digesters to improve digester performance in the long term.

Recommendations

Implementation of the A^2O process at City of Mattoon WWTP will require at least the following modifications:

- Reconfigure the existing aeration tanks 1-6 into two single pass systems with curtain walls to define the different zones.
- Install curtain walls in existing aeration tanks 7/8 to provide defined areas for anaerobic, anoxic and aeration zones.
- Provide one new basin similar to existing aeration tanks 7/8.
- Install mixers for anerobic and anoxic treatment zones. Install internal recycle piping for anoxic treatment zones. Install new diffusers and a dissolved oxygen (DO) control system an aerobic zones.
- Reconfigure influent and effluent piping and splitter boxes for the new flow schematic.
- Replace existing WAS flow meter and increase wasting by at least 50%, from 0.04 mgd to 0.06 mgd.

5.1.2 OPTION 2 – OXIDATION DITCH

Process Description

An oxidation ditch is a modified activated sludge biological treatment process that utilizes long solids retention times (SRTs) to remove biodegradable organics. Typical oxidation ditch treatment systems consist of a single or multi-channel configuration within a ring, oval, or horseshoe-shaped basin. As a result, oxidation ditches are called “racetrack type” reactors. Horizontally or vertically mounted aerators provide circulation, oxygen transfer, and aeration in the ditch. Preliminary treatment such as bar screens and grit removal, normally precedes the oxidation ditch.

Oxidation ditches can be configured with anerobic and anoxic zones, very similar to A^2O systems. The need for and the sizing of anaerobic, anoxic, and aerobic zones in an oxidation ditch are very similar to the A^2O system described in Option 1, above. Because of these similarities, the same type of BioWin modeling performed for the A^2O system were not modeled for the oxidation ditch. Because the biology of the two systems are very similar, it is anticipated that effluent water quality for both systems will be similar. It is also anticipated that the same sensitivity to adding external carbon (methanol), eliminating the primary clarifier unit process, RAS fermentation, and FOG and septage addition would yield the same general result when used in an oxidation ditch as when used in the A^2O system.

Design Criteria

Proposals from several vendors were reviewed to determine the feasibility of this treatment system to achieve BNR. The preliminary design values and dimensions of Orbal type system (From Evoqua) were used for modeling, but any oxidation type systems will be similar and considered during design if this is the selected treatment alternative. The Orbal type is summarized in the following tables. The site layout for this option is shown in Exhibit 3 of Appendix E. A conceptual process flow diagram is included in Exhibit 4 of Appendix E.

Table 5-12. Orbal Design Parameters

Parameter	Value
MLSS, mg/l	3,200
Organic loading, lb BOD/1000 ft^3/day	12.7
Solids Retention Time (SRT), d	16.5
RAS % (of Average daily Flow)	100
Sludge Yield, lb WAS/lb BOD	0.97

Table 5-13. Orbal Tank Configuration

Parameter	Channel Width, ft	SWD, ft	Volume, MG
Outer Channel	20	15	1.17
Middle Channel	20	15	0.87
Inner Channel	20	15	0.57
Total Volume	20	15	2.60

Installation of new oxidation ditch treatment system will require at least the following:

- Structural, process piping and instrumentation, electrical and mechanical improvements
- Anoxic/Anaerobic Mixers
- Aerators
- Bypass Channel Gates
- Effluent Weirs
- DO Control System and VFDs

5.1.3 OPTION 3 – AEROBIC GRANULAR SLUDGE (AGS)

Process Description

Aerobic granular sludge (AGS) is a novel microbial community which allows simultaneous removal of carbon, nitrogen, phosphorus and other pollutants in a single sludge system. In an AGS treatment system, biomass is selected for dense floc (granules). Within that granule, stratification of biomass allows for multiple biological treatment processes to occur simultaneously. AGS is distinct from activated sludge in physical, chemical, and microbiological properties and offers compact and cost-effective treatment for removing oxidized and reduced contaminants from wastewater.

Within each granule is an aerobic, anoxic, and anaerobic zone. This allows for BOD, ammonia, TP and TN removal. The AGS reactors are operated like sequencing batch reactors with a fill/draw phase, a reaction phase, and a settling phase. The AGS system would be able to achieve both effluent TP and TN removal. However, the concerns with low relatively concentrations of carbon and therefore VFAs that were present with the A^2O option and the oxidation option would also be true with the AGS system option. If this option is selected, a means of increasing VFAs would also need to be evaluated, however since this system does not have RAS, RAS fermentation would not be an option.

Design Criteria

Proposal for AGS treatment system was obtained from AquaNerada to evaluate the feasibility of this technology. Table 5-14 includes the general design parameters on an AGS system that could be utilized at Mattoon.

Table 5-15 presents a summary of the AGS basin dimensions. A potential site layout for the AGS system is included in Exhibit 5 of Appendix E.

Table 5-14. AGS Process Parameters

Parameter	Values
MLSS, mg/l	8000
SRT, d	~15.7
Airflow rate per basin, scfm	6473
Average power required, kWh/d	2730

Table 5-15. AGS Reactor Design Values

Parameter	AGS Reactor	Water level correction tank	Sludge buffer
Number of rectangular basins	3	1	2
Length, ft	106.1	-	26
Width, ft	75	-	22
Maximum level, ft	-	14.4	15.4
Volume per Basin, MG	1.25	0.084	0.065

Installation of new Aerobic granular sludge system would require the following:

- Influent distribution system
- Effluent weir
- Sludge removal system
- Fine bubble diffusers and Blowers
- Process piping, valves, and instrumentation
- Water level correction tank including transfer pumps, valves, level sensor assemblies
- Sludge Buffer tank including transfer pumps, valves, level sensor assemblies
- PLC Controls

5.2 ANALYSIS

5.2.1 ECONOMIC EVALUATION: CAPITAL AND LIFECYCLE COSTS

Preliminary cost estimates were developed for each nutrient removal alternative as summarized in table below. Detailed cost estimates are included in Appendix F. Since the estimated 20-year present valve costs of the A^2O system and the oxidation ditch are within 10% of each other, non-economic advantages and disadvantages could be the deciding factor in which option the City proceeds with. The Aerobic Granular sludge system is approximately twice the capital cost of options 1 & 2 and annual operating costs are also higher. Therefore, this system is no recommended.

Table 5-16. Economic Evaluation – BNR to 0.5 mg/l

Alternative	Construction Cost	Annual Operating Costs	20-Year Present Value Costs
Option 1: A^2O	$10,500,000	$249,000	$17,453,000
Option 2: Oxidation Ditch	$9,700,000	$239,000	$16,373,000
Option 3: Aerobic Granular Sludge	$19,145,700	$340,000	$28,637,700

Notes:
1. Capital Cost based on 2021 dollars.
2. Annual operating costs include power, supplemental carbon, and O&M estimates for the secondary treatment process.

5.2.2 COST AND BENEFIT OF TN REMOVAL

In the feasibility analysis, the anoxic zones in the proposed A^2O and oxidation treatment systems are used for nitrogen removal. In the AGS system, the biological granules that for naturally include their own anoxic zone.

Costs

There are several costs associated with TN removal:
- A^2O – additional curtain walls, mixers, recycle pumps are required
- Oxidation Ditch – tankage space for anoxic zone required, mixers potentially necessary
- To achieve low levels of TN removal for any of the options will require either a well-managed internal VFA production (consistent FOG addition or RAS fermentation) or an external carbon source. An external carbon source adds long-term chemical costs.

Benefits

There are also several benefits associated with TN removal:
- In TN removal system, anoxic zones result in less aeration requirements in in diffuser grids or oxidation ditch air addition. Eliminating some of the need for aeration saves capital cost in blowers and diffusers, it also results in long-term energy savings.
- Plant effluent has lower effluent TN, which has down-stream benefits.

5.2.3 NON-ECONOMIC EVALUATION: ADVANTAGES AND DISADVANTAGES OF OPTIONS

A summary of the non-economic advantages and disadvantages of the nutrient removal alternatives is presented in table below.

Table 5-17. Non-Economic Evaluation

Advantages	Disadvantages
A^2O system	
• Reuse of existing aeration tanks. • Process equipment available from various manufacturers resulting in competitive process equipment pricing.	• Requires significant structural, mechanical and process improvements. • Complexity of maintaining existing treatment during construction of the new process when reusing existing tankage.
Oxidation Ditch	
• No internal recycle pumping. • New tanks extend the operating life of the system significantly. • Simplifies construction as treatment would not have to be maintained during construction.	• Requires large footprint than other treatment options.

• Simple system to operate and maintain with relatively few motors and actuated valves. • No blowers required. • Process equipment available from various manufacturers resulting in competitive process equipment pricing.	
Aerobic Granular Sludge	
• Possible energy savings due to combination of reduced aeration and mechanical components. • Smaller footprint since treatment takes place in a single reactor.	• Requires additional tanks for Sludge Buffer and Water Correction • High capital costs. • Process technology from a single source vendor.

5.2.4 RECOMMENDED BIOLOGICAL TREATMENT ALTERNATIVE

The capital and operating costs of the AGS system make it the least-feasible option for Mattoon and pursuing this option is not recommended. Either the oxidation ditch or A^2O system are feasible alternatives. Both the oxidation ditch and A^2O system are approximately the same capital and operating costs and either or both options could be evaluated further during preliminary engineering.

Since estimates for the oxidation ditch are slightly lower than the A^2O system and there are a number of non-economic advantages for this option, the oxidation ditch will the basis of our evaluation of the 1.0 mg/l and 0.1 mg/l options.

5.3 FEASIBILITY OF EFFLUENT TP @ 1.0 MG/L AND 0.1 MG/L

This section evaluates the feasibility of achieving effluent TP limits of 1.0 mg/l, 0.5 mg/l, and 0.1 mg/l as required by Special Condition 18. Three different methods: Chemical P removal, EBPR, and a combination of chemical and EBPR were considered and evaluated for each limit.

5.3.1 EFFLUENT TP LIMIT OF 1.0 MG/L

There are two ways in which the Plant can meet an effluent TP limit of 1.0 mg/l:

1. Chemical Phosphorus Removal (CPR),
2. Enhanced biological phosphorus removal (EBPR) – which was discussed in Sections 5.1 and 5.2.

Chemical P Removal

CPR involves use of ferric (ferric chloride, ferric sulfate, etc.) or aluminum (alum, sodium aluminate) based metal salts to precipitate the reactive phosphorus from the wastewater and removal through the sludge. Ferric chloride could interfere with the ultraviolet transmittance at the new UV system. Therefore, alum is considered for this evaluation. Adding chemicals upstream of the secondary clarifiers will facilitate the effluent TP of 1.0 mg/l at the Mattoon WWTP.

Chemical Requirement

The alum dosing requirements to reach effluent TP limit of 1.0 mg/l were evaluated for the 2050 annual average conditions shown in Table 3-2 in terms of chemical consumption, storage, and chemical sludge production and are presented in Table 5-18 .

Table 5-18. Chemical Phosphorus Removal – Dosing requirements

Parameter	Annual Average
Influent Flow, mgd	5.30
Influent TP[1], mg/l	2.5
Target Effluent TP, mg/l	1.0
TP Removed, lb/day	75
Dose[2], gpd	80
Storage Volume[3], gallons	800
Chemical Sludge, lb/day	190

Notes:
1. Design annual average TP concentration used. The Plant currently achieves effluent TP 1.7 mg/l (2020 Annual average, about 10% TP removal). Though the TP concentration in secondary effluent is estimated to be 1.7 mg/l, the CPR will be designed for design annual average values for the purposes of this study.
2. 48.5% alum solution is considered.
3. 10 days of storage is provided per Title 35 – Section 37.1200 – Phosphorus Removal by Chemical Treatment.

Chemical Feed System

The chemical feed system will consist of the storage tanks along with the metering pumps and piping. The storage tanks would need to have a secondary containment system to catch accidental spills. A metering pumping system with associated instrumentation would be useful to monitor and control the chemical dosing. The optimum storage temperature for alum is between 40 and 110 ° F, outside these temperature ranges optimal product stability and shelf life is affected. The freezing point of alum is around 9 ° F, however it crystallizes above this temperature and will not flow well. Therefore, the alum solution will need to be stored in a building or climate-controlled shelter. For this planning-level study, it is assumed that this will be a small fiberglass building.

Liquid alum is corrosive, and precautions should be put into place to prevent contact with the eyes and skin. Access to an eyewash and safety shower is often recommended with alum. To minimize the expense of tempered water to supply an eyewash and safety shower around the alum storage, this study considered installing alum storage near the admin building so that the water supply and water heater used for the lab safety equipment can also be used for the alum safety equipment.

Impact on Sludge Handling System

When using metal salts addition to precipitate phosphorus, the amount of sludge generated and required to be treated, thickened, stored, and disposed of is increased as a function of coagulant dose. Alum generates about ~0.33 lb sludge/lb of Alum added. Chemical sludge production per unit P removed depends on effluent limit, and lower limits increase the amount of sludge produced by the system. As shown in table above, approximately 190 lb/d (35 tons/year) will be generated in a CPR system. This additional sludge will increase the solids loading rate of anaerobic digesters and the sludge dewatering system installed at the Plant.

Costs

For the City of Mattoon, costs of upgrading their existing aeration system including tanks, blowers, air headers, and diffusers were included in the chemical phosphorous removal option. This is because these systems are over twenty years only and will need to be upgraded in the coming years. The buried underground air piping is known to be leaking resulting in significant inefficiencies in the aeration system. Also, the side wall elevation of the tanks is lower than the flood elevation, so they need to be raised to prevent flooding. It is estimated that the costs of upgrading the aeration system as described would be $9 million. In addition, a chemical phosphorus removal system would add $0.5 million. Detailed cost estimates are included in Appendix F.

EBPR

The benefit of having the effluent phosphorus limit raised from 0.5 mg/l to 1.0 mg/l on the EBPR system is that it would eliminate the need for supplemental carbon. This would be a capital cost savings of approximately $225,000 plus the savings associated with not having to purchase supplemental carbon.

5.3.2 LIMIT OF 0.5 MG/L

Based on the results of biological nutrient technology evaluation in Section 5.1, the plant can achieve a limit of 0.5 MG/L of phosphorus using any of the EBPR systems. Using a CPR system would approximately double the chemicals used, the storage required, and the chemical sludge produced and was not considered.

5.3.3 LIMIT OF 0.1 MG/L

Given the carbon limitations of influent wastewater, it would be not biologically possible to reach TP limit of 0.1 mg/l. A combination of biological treatment and chemical addition would be required if an effluent limit of 0.1 mg/l is required. To achieve a limit of 0.1 mg/l, the following systems would need to be added to the EBPR systems discussed in Sections 5.1 and 5.2.

- CPR dosing system upstream of the secondary treatment system. Chemical dosing in the primary clarifiers is not recommended to avoid removing too much carbon in the primary clarifiers
- Tertiary filters are required downstream of the secondary clarifiers. Tertiary filters will allow removal of phosphorus precipitates that are otherwise being discharged in the effluent solids. This low level of effluent TP requires that effluent solids concentrations are very low.

5.4 CAPITAL AND LIFECYCLE COSTS

The capital and operating costs of achieving 1.0 mg/l, 0.5 mg/l, and 0.1 mg/l of effluent phosphorus as discussed in this chapter are summarized below in Table 5-19. Details of the capital and annual operating costs are included in Appendix F.

Table 5-19. Economic Evaluation

Description	Constuction Cost	Annual Operating Costs	Monthly Operating Costs	20-Year Present Value Costs
TP @ 1.0 mg/l				
Option 1: Oxidation Ditch, no supplemental carbon	$10,280,00	$205,000	$17,000	$16,000,000
Option 2: Aeration Basin Rehab, CPR	$9,520,000	$364,000	$30,000	$19,700,000
TP @ 0.5 mg/l				
Oxidation Ditch	$10,500,000	$249,000	$21,000	$17,500,000
TP @ 0.1 mg/l				
Oxidation Ditch, CPR, tertiary filtration	$19,790,000	$389,000	$32,000	$30,700,000

Notes:

1. Capital Cost based on 2021 dollars. Project cost will change based on timeline

CHAPTER 6 - SLUDGE TREATMENT SYSTEM EVALUATION

The sludge treatment system has been identified by the City as an area of the plant in urgent need of upgrade. This analysis was confirmed in the engineering evaluation described in Appendix B. It is beneficial to the City to determine the direction of the sludge treatment system as decisions about the BNR system are made to ensure that sludge treatment improvements are integrated into the liquid treatment and nutrient removal systems.

6.1 SLUDGE TREATMENT

Biosolids are a product of the wastewater treatment process. During wastewater treatment the liquids are separated from the solids both in the primary clarifier ("primary sludge") and in the secondary clarifier. The solids that are removed in the secondary clarifers are either returned to the liquid treatment system and are call return activated sludge (RAS), or they are removed from the liquid treatment system in a waste stream referred to as waste activated sludge (WAS). Primary sludge and WAS are then treated to produce a semisolid, nutrient-rich product known as biosolids.

Biosolids that are to be beneficially used must meet federal and state requirements. Examples of beneficial use include application to agricultural land and reclamation sites (e.g. mining sites). When applied to land at the appropriate agronomic rate, biosolids provide a number of benefits including nutrient addition, improved soil structure, and water reuse. Land application of biosolids also can have economic and waste management benefits (e.g., conservation of landfill space; reduced demand on non-renewable resources like phosphorus; and a reduced demand for synthetic fertilizers). Sludge that is not treated to produce biosolids can be disposed of by incineration or landfilling.

The purpose of sludge treatment therefore is two-fold: 1) to produce a biosolids with beneficial reuse potential while limiting pathogen, vector attraction, and odors, and 2) to reduce the mass of biosolids that need to be disposed by converting some of the carbon in the sludge to carbon dioxide gas.

6.1.1 LAND APPLICATION

Existing regulations are in place to require that biosolids are processed, handled, and land-applied in a manner that minimizes potential risk to human health. Biosolids are divided into "Class A" and "Class B" designations based on treatment methods. The different classes have specified treatment requirements for pollutants, pathogens and vector attraction reduction, as well as general requirements and management practices.

Class B Biosolids

Class B biosolids are treated to significantly reduce, though not eliminate, pathogens. This treatment also reduces the vector attraction (insects, rodents) and odor of the sludge. Class B biosolids have site restrictions that allow time for pathogen degradation should be followed for harvesting crops and turf, for grazing of animals, and public contact. Treatment methods to create Class B biosolids include: anaerobic digestion, aerobic digestion, composting, and lime stabilization.

Class A Biosolids

Class A biosolids are treated to an additional degree to eliminate all pathogens, including viruses. Generally, to produce a Class A biosolid is a two stage process that uses one of the treatment methods to create a Class B biosolid and is then followed by additional treatment step such as: heat drying, steam injection, pasteurization, or thermophilic aerobic digestion.

The City of Mattoon wished to continue land application with a Class B biosolid.

6.1.2 SLUDGE VOLUME REDUCTION

Treating sludge using either anaerobic or aerobic digestion reduces the amount of volatile solids contained in the sludge. This is because the carbon that is bound into cellular and other solids in the sludge is converted by microbes in the digester to produce carbon dioxide and methane gas. Carbon dioxide is released into the atmosphere and methane is burned either in waste gas burners or energy converting equipment (combined heat and power cogeneration engines, microturbines, or boilers). The result is that fewer solids need to be thickened, stored, or land applied which is a cost saving measure for the community.

6.1.3 AEROBIC VS. ANAEROBIC TREATMENT

There are several types of digestion, the two most common and under consideration for Mattoon are anaerobic digestion and aerobic suggestion. Anaerobic and aerobic systems are both forms of biological treatment that use microorganisms to treat organic materials in sludge. While both rely on a process of microbial decomposition to treat wastewater, the key difference between anaerobic and aerobic treatment is that aerobic systems require oxygen, while anaerobic systems do not. This is a function of the types of microbes used in each type of system.

Aerobic Digestion

Aerobic systems require an oxygen supply through forced air. Blowers and diffusers are used to supply oxygen to the system. Diffused air can also be used to mix the digester. Since using aeration to mix a tank often results in over aeration, most modern aerobic digesters use separate aeration and mixing systems. The aeration system is controlled using dissolved oxygen and ORP control are used to prevent-over aeration. Due to the need to aerate an aerobic digester, they tend to be less energy efficient than anaerobic digesters. Aerobic digesters are more common in treating smaller and municipal-only waste streams as they are less capable of processing high strength waste such as septage, fats, oils, and grease (FOG), and industrial waste.

Anaerobic Digestion

Anaerobic systems are enclosed tanks that are heated to maintain temperatures around 98°F and mixed to ensure a good distribution of heated sludge and biomass. Anaerobic digester lids trap gas released by the biomass. This biogas is generally around 60% methane, 35% carbon dioxide, and 5% other such as oxygen, nitrogen, and hydrogen sulfide. The biogas is collected and either burned in waste gas burners or beneficially reused. Anaerobic systems tend to offer a few benefits over aerobic systems, including lower operational costs and energy demands, though they are generally more they also tend to have higher capital costs.

Anaerobic digesters are more common in larger treatment plans and those that have septage, FOG, and industrial waste streams. The anaerobic digestion process can release high concentrations of phosphorus and ammonia in their decant and filtrate. For BNR treatment systems, side-stream phosphorus removal and/or metered release is beneficial for achieving low concentrations of nutrients in plant effluent.

Standard anaerobic digestion systems have two-stages: primary digestion and secondary digestion, which slightly different microbial communities. Primary digesters are heated and mixed, secondary digesters are not. Both stages have gas collection lids.

The City of Mattoon has utilized anaerobic digestion for 80 years. It has been a beneficial system for the City as it has allowed the City to accept septage, FOG, and industrial waste streams with minimal odors released from the digesters. Because of its robust treatment capabilities, it is recommended that the City continue with this type of treatment in the future.

6.2 BIOSOLIDS TREATMENT WITH THE BNR TREATMENT SYSTEM

Properly designed and managed, the solids treatment system can work with the BNR treatment system to meet the permitted effluent nutrient requirements. Several improvements will be considered for the biosolids treatment design, including:

- Dosing alum to digested biosolids to minimize the release and recirculation of TP back to the liquid treatment process
- Thickening of WAS to increase the HRT, decrease reliance on decanting, and improve solids destruction.
- Addition of a dedicated septage, FOG, and industrial waste receiving station to provide rock removal and screening of trucked waste.
- Addition of an equalization/fermentation tank for septage, FOG, and industrial waste to equalize the flow and increase the plant's VFA concentrations, which will improve BNR removal efficiencies and decrease the necessity for supplemental carbon.

Given the age of the existing digesters, there are a number of treatment improvements needed to the existing, including:

- A new primary digester to allow redundancy and provide a longer HRT to increase solids destruction
- New gas mixing and heating equipment - the existing equipment is 50 years old and past its design life
- New biogas safety equipment - the existing equipment is more than50 years old and past its design life and is a potential safety concern
- New digester lids - the existing lids are more than 50 years old and past their design life
- Converting one secondary digester to a gravity thickener

A process flow diagram that includes the improvements discussed here is included as Exhibit 6 in Appendix E. The estimated capital cost of these improvements is $14 million. A breakdown of costs is included in Appendix F.

CHAPTER 7 - CSO TREATMENT EVALUATION

7.1 CSO REHABILITATION NEEDS

The Existing Condition Assessment, described in Appendix B, identified several needs of the CSO Treatment system that are not addressed the other chapters of this report. This evaluation of potential CSO treatment alternatives was prepared to provide the City with options and costs for potential improvements to the system.

The two biggest items identified in the Existing Condition Assessment regarding this system were:

- Chlorine – the existing chlorine gas building has significant safety issues.
- Clarification Equipment – the existing mechanical components of the clarification system are well past their useful life and are largely non-functional.

In addition to these needs, the CSO clarifiers are located in an area of the plant that periodically floods. During these flooding periods there is no barrier between the CSO clarifiers and the surrounding flood water.

The 16 mg stormwater holding basin was reviewed during this assessment as well as for the 2011 Facility Plan. In 2011, deficiencies noting in the holding basin were the deterioration of the existing aerators and the buildup of solids in the holding basin. In 2020, those aeration and grit-buildup deficiencies remain. In addition, the holding basin control building has poor structural conditions of interior walls, doors, coatings, and steel components. The holding basin recirculation/transfer pumps were noted to be in good condition.

7.2 OPTIONS

Three potential alternatives were identified for upgrading the clarification portion of the CSO Treatment facilities at the WWTP: replace in kind, replace in a different location, utilize wetland treatment instead of clarification for CSO Treatment. Given the safety concerns of operating a chlorine gas system, the potential shelf-life concerns with using liquid sodium hypochlorite for disinfection, and discussions with the City, it is recommended that any upgrades to the CSO treatment system utilize UV disinfection system.

7.2.1 OPTION 1: REPLACE CLARIFICATION IN KIND

This option evaluates replacing the existing clarifier equipment of all four storm tanks and performing structural, mechanical, process, electrical, and other ancillary improvements to address the deficiencies noted in detail Existing Condition Assessment Memo and to ensure full functionality of the storm flow tanks. The site layout for this option is shown in Exhibit 7 in Appendix E.

Existing Condition

The existing Storm Tanks 1, 2, 3, and 4 are utilized during major wet weather events when flow into the facility is greater than 14 mgd and the existing stormwater holding basin is full. As the existing clarifier equipment is non-functional this system is used as chlorine contact tanks, not clarifiers. The clarifiers are in poor structural shape with Tanks 3 and 4 having numerous vertical cracks along the circular walls. The process equipment such as valves, level sensors, clarifier equipment is inoperable. The electrical equipment is in poor condition.

Proposed improvements

Implementation of proposed alternative (replace in kind) will require at least the following modifications to the clarification system:

- Increasing tank wall height to be above the flood elevation.
- Installation of new clarifier equipment for each tank.

- Structural repairs and rehabilitation of flume structure and other deteriorated areas.
- Repairs to fix the wide gaps at the entrances to walkway bridges to Tanks 1 and 2.
- Installation of new valves, instrumentation, and control equipment.
- Correcting OSHA code violations noted for all four tanks, yard structure, and other miscellaneous items.
- Installing new electrical and control equipment including but not to limited to disconnect switches, starters, and control stations.

In addition to the clarifier modifications and equipment replacement, two other improvements to the CSO system include;

- Installing a new UV disinfection system to disinfect clarified effluent before discharge to CSO 002 and modifications to the existing stormwater holding basin.
- Upgrades to the Stormwater holding basin. Upgrades were evaluated and discussed in the 2011 Facility Plan including doing nothing, abandoning holding basin aeration, installing new aerators, and installing grit removal ahead of the existing diversion structure. In 2011 it was concluded that replacing the aeration system to improve mixing and reduce grit accumulation was too expensive. At the time it was recommended that the aeration system be abandoned and that a solids dewatering pad be added.

7.2.2 OPTION 2: PROVIDE CLARIFICATION IN A DIFFERENT LOCATION

This option evaluates providing storm flow clarification at a different location that is away from the stream bank and can be constructed while the existing system is operational. Two potential locations were identified as shown in Exhibit 8 in Appendix E and are described below:

1. Reuse existing aerobic digesters - The existing aerobic digesters are no longer used and could be repurposed into storm tanks. The structural condition of the digesters is in poor shape as described in Existing Condition Memo. As such, significant structural improvements, process, mechanical, electrical, and other ancillary improvements will be required if the City decides to move forward with this option. In addition, it may be useful to reuse these tanks as trucked septic/FOG/industrial waste equalization.
2. Near existing sludge beds area - The area north of the sludge beds could be utilized for the installation of new storm tanks. This option, however, will be the most expensive compared to other options.

Improvements that would be made under this scenario include:

- Adding new CSO clarifiers in a different location with new clarifier equipment.
- Installation of new valves, instrumentation, and control equipment.
- Installing new electrical and control equipment including but not to limited to disconnect switches, starters, and control stations.
- Installing a new UV disinfection system
- Making minor upgrades at the 16 mg holding basin control building.

7.2.3 OPTION 3: PROVIDE WETLAND TREATMENT IN A DIFFERENT LOCATION

This option evaluates providing constructed wetland around the perimeter of the WWTP site for CSO treatment. Utilizing wetland treatment could have several potential benefits:

- Grey infrastructure (concrete tanks) that are utilized 1 to 5 times per year would be eliminated,
- Electrical loads would be reduced,
- Habitat created by wetlands could be a benefit to the community and create a visual separation between residential neighbors and the WWTP,
- Grit removal would happen either using grit removal equipment (Options 3a and 3b) or in a wetland forebay and would have a smaller removal area (Option 3c) keeping the 16 mg stormwater holding basin cleaner.

- The existing CSO clarifiers and associated equipment could be removed and this section of the streambank could potentially be re-graded to allow additional in-stream flood storage.

Description

Constructed treatment wetlands are engineered wetland systems created and constructed to utilize the natural functions and combination of wetland vegetation, soil, and associated microbial life to reduce pollutants and improve water quality in surface water, municipal wastewater, groundwater, stormwater runoff, or various waste streams.

Of the different types of wetlands, free water surface (FWS) constructed wetlands can typically achieve high removal of suspended solids, moderate removal of pathogens, nutrients, and other pollutants, and tolerate variable water levels and nutrient loads and is therefore the recommended choice here.

Features

The new wetland system of approximately 12 acres will be designed to treat CSO discharges up to 16 MG. A site layout for this option is shown in Exhibit 9 in Appendix E. As conceptualized, the CSO treatment wetland will include:

- Pumping facility – Replace existing CSO and holding basin to convey flow to the wetland.
- Pretreatment – There are several options for pretreatment:
    - Mechanical Grit Removal: The plant's existing grit removal system is 20 years old. In the 30 year planning period considered here, the grit system will likely need to be replaced. Modern grit removal systems utilize stacked trays to achieve a high amount of grit removal efficiency in a small space. If the future grit removal system not only is used to remove grit from the plant influent but is also sized to remove grit from the CSO flow, then less grit removal will be required in the holding basin and potential wetland.
    - Primary Treatment: The plant's primary clarifiers are also between 45 and 80 years old, are below the flood elevation, and require considerable upgrades or replacement. Like the grit removal system, if a future primary treatment system is upgraded to accept CSO flow in addition to plant flow it will improve the water quality, and potential for odor generation, in the wetland.
    - Sediment Forebay– The capital cost of mechanical grit removal are high. As an alternative, a wetland forebay can be used. A sedimentary forebay is an area of deep water to lessen scour and damage to wetland plants. It will also collect grit and can be design for easy grit removal.
- Constructed Wetland – Free water surface (FWS) type wetland treatment to interact with the atmosphere and replicate the naturally occurring processes of a natural wetland removing suspend solids, BOD, and ammonia and providing a natural area adjacent to the WWTP.
- UV Disinfection – UV Disinfection facility to disinfect filtered wetland effluent prior to final discharge.

Operation

Influent flows greater than 14 mgd and up to existing combined sewage holding basin capacity (16 MG) will be sent to a new grit removal system to capture grit particles and then be discharged to the wetland for treatment. The wetland effluent will then be discharged to the holding basin. After the storm event has ended, liquid in the holding basin will flow by gravity or be pumped back to the diversion structure at the head of the plant for further treatment like the current operation.

The wetland portion of the CSO treatment facility will continue to operate after the combined sewage holding basin reaches capacity. Following the treatment, the wetland effluent will pass through a UV disinfection system and then be discharged to Kickapoo Creek (Outfall 002). The proposed process flow diagram for this option is shown in Figure 7-1.

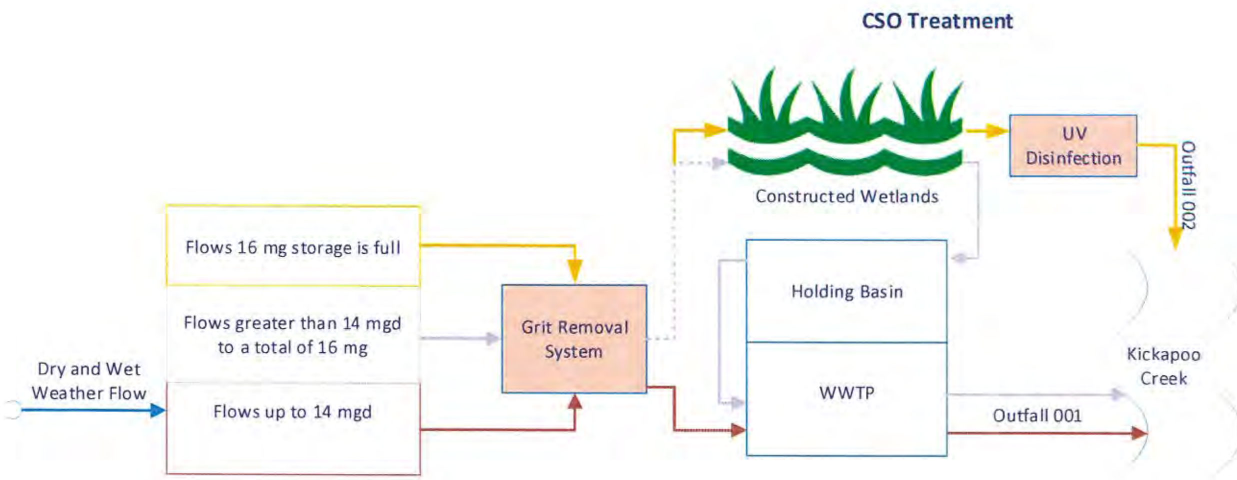

Figure 7-1. Option 2 – Wetland Treatment flow schematic

Triple Bottom line Analysis

Of the numerous ways of managing CSO events, the traditional engineering approaches that rely largely on physical infrastructure such as storage systems and treatment at WWTP are often expensive and maintenance intensive. Alternatively, constructed wetlands rely more on green infrastructure to help divert, store, and promote infiltration of stormwater and help restore and enhance natural systems. They provide treatment without significant chemical costs and mechanical equipment. Compared to traditional approaches, green infrastructure approach as the wetlands generates important environmental, social, and other benefits to local watershed and nearby community.

7.3 COSTS

Preliminary cost estimates were developed for each option and summarized in table below. Detailed cost estimates are included in Appendix F.

Table 7-1. Preliminary Opinion of Probable Costs

Description	Construction Costs
Option 1: Replace Clarification in Kind[1]	$6,300,000
Option 2: Replace Clarification In a different location	$7,900,000
Option 3a: Constructed Wetlands with primary treatment	$12,400,000
Option 3a: Constructed Wetlands without primary treatment	$8,400,000
Option 3a: Constructed Wetlands without primary treatment, grit settling in wetland forebay	$6,100,000

Notes:

1. The conditions of the existing clarifiers need to be fully evaluated drained to properly evaluate the extent of the structural repair needed.
2. Initial Capital Cost based on 2021 dollars. Project cost will change based on timeline

CHAPTER 8 - WASTEWATER TREATMENT AND BIOSOLIDS HANDLING IMPROVEMENT PLAN

Special Condition 21. By January 1, 2030, the facility must meet a 0.5 mg/l annual effluent phosphorus limit unless it is not either technologically feasible using a biological phosphorus removal (BPR) process, can only be met using chemicals, is not economically feasible, or requires a longer timeline. If the limit is considered feasible, then a 0.6 mg/l annual effluent will be applied instead. The deadline can be extended to 2035 if either 1) a new treatment facility is built, 2) the facility can reduce nitrogen using a biological nutrient reduction (BNR) configuration, which also achieves BPR. The deadline will be reduced to December 31, 2025 and the limit will be increased to 1.0 mg/l if the City chooses to meet the effluent phosphorus limit using chemical addition instead of biological treatment. The City must tell IEPA by December 31, 2023 if they plan to take exception to the 1/1/30 limit of 0.5 mg/l using BPR process.

Based on the analysis contained in this report, it is recommended that the WWTP utilize BNR treatment so that the 0.5 mg/l TP effluent can be deferred to 2035. There several different categories of improvements needed at the plant. These improvements are summarized in Table 8-1.

Table 8-1. Overall Improvement Construction Costs in 2021 dollars

Improvement	Preferred Option	Construction Cost
Aeration System Upgrades	Option 2 – Oxidation Ditch with BNR	$9,700,000
Biosolids Improvements	As described	$14,000,000
Primary Treatment Improvements	As described	$4,700,000
Grit System Improvements	Mechanical system in a new building	$4,700,000
CSO Treatment Upgrades	Option 3c – Wetland treatment without primary treatment and grit settling in forebay	$6,100,000
Total		**$39,200,000**

It is assumed that these five major projects will be implemented separately between now and 2035 to meet the IEPA permit deadline. A potential schedule that includes the costs noted above with a 3.5% inflation and assuming 8% design engineering costs is included in Table 8-2.

Table 8-2. Improvement Schedule and Costs

Year	Value	Description
2021	--	Planning
2022	$1,160,000	Biosolids Improvement Design
2023	$7,520,000	Biosolids Construction
2024	$7,520,000	Biosolids Construction
2025	$560,000	CSO Improvement Design
2026	$3,630,000	CSO Improvement Construction
2027	$3,630,000	CSO Improvement Construction
2028	$480,000	Grit Improvement Design
2029	$3,090,000	Grit Improvement Construction
2030	$3,600,000	Grit Improvement Construction and Primary Treatment Design

Year	Value	Description
2031	$3,310,000	Primary Treatment Construction
2032	$4,440,000	Primary Treatment Construction and Oxidation Ditch Design
2033	$7,330,000	Oxidation Ditch Construction
2034	$7,330,000	Oxidation Ditch Construction
2035	--	BNR system optimization to meet permit limits