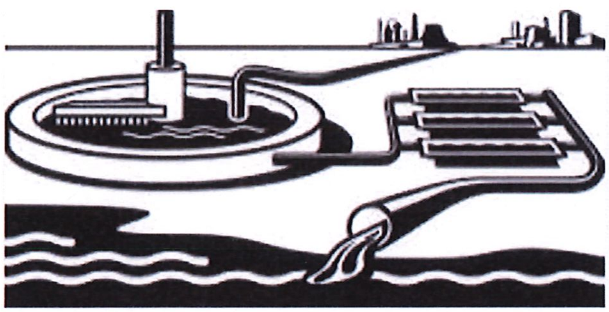
NUTRIENT ASSESSMENT REDUCTION PLAN (NARP)

City of Greenville, IL



Submitted by:

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GREENVILLE ILLINOIS

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1. Introduction

A. Purpose

In an effort to reduce nutrient discharge from point sources, the State of Illinois has, as a part of their National Pollutant Discharge Elimination System (NPDES) permitting program, begun requiring all publicly owned treatment works (POTWs) classified as major contributors to develop a Nutrient Assessment Reduction Plan (NARP). This requirement is limited to POTWs permitted to discharge ≥1 MGD to a receiving body of water which is listed as impaired or at "Risk of Eutrophication" (RoE) in accordance with section 303(d) of 40 CFR 130.7 commonly referred to as the Clean Water Act (CWA). In lieu of a NARP, POTWs may join a Watershed Action Group whose stated objective is the reduction of nutrient discharge within the basin.

The intent of the NARP is to identify methods to reduce nutrients, specifically phosphorus and nitrogen, that increase algal growth in waterways, in turn reducing the amount of Dissolved Oxygen (DO) available in the body of water, be it a lake, stream, or river. Increased algae is detrimental to intended uses such as fishing, boating and swimming, while low DO impacts aquatic life. As all of Illinois eventually drains to the Mississippi River, nutrient loading is also a major contributor to the Gulf of Mexico Hypoxic Zone; an area of decreased DO in the northern gulf known as the "dead zone". The Gulf Hypoxia Task Force has developed an action plan to reduce the dead zone to 1,900 square miles by 2035 from its current 5-year average of 4,347 square miles. This requires partnership with individual states in the Mississippi River Basin and is a driving factor behind the development of the NARP.

As the Shoal Creek Watershed does not contain a Watershed Action Group, the City of Greenville has hired Milano and Grunloh Engineers to develop a NARP to meet the requirements stated in the NPDES for their Wastewater Treatment Plant (WWTP).

B. NARP Development

The Shoal Creek watershed is a drainage basin identified by Hydrological Unit Code 8 (HUC8) HUC07140203 and is contained primarily in the Illinois counties of Montgomery, Bond, and Clinton Counties. The City of Greenville is located in the central portion of this watershed in the Beaver Creek sub-basin (HUC0714020305) with the WWTP discharging to the basin's namesake receiving stream.

Beaver Creek was listed as impaired for the 2020/2022 303(d) listing for a portion of its reach from approximately 12.5 miles upstream to its confluence with Shoal Creek, which is also listed as impaired. This listing is due to a low DO concentration, with no listed causation. The City of Greenville WWTP is located approximately 17 miles upstream of the impaired portion of the stream. Figure 1 displays the Shoal Watershed HUC8 and major waterways, while Figure 2 shows the Beaver Creek HUC10 and all tributaries.

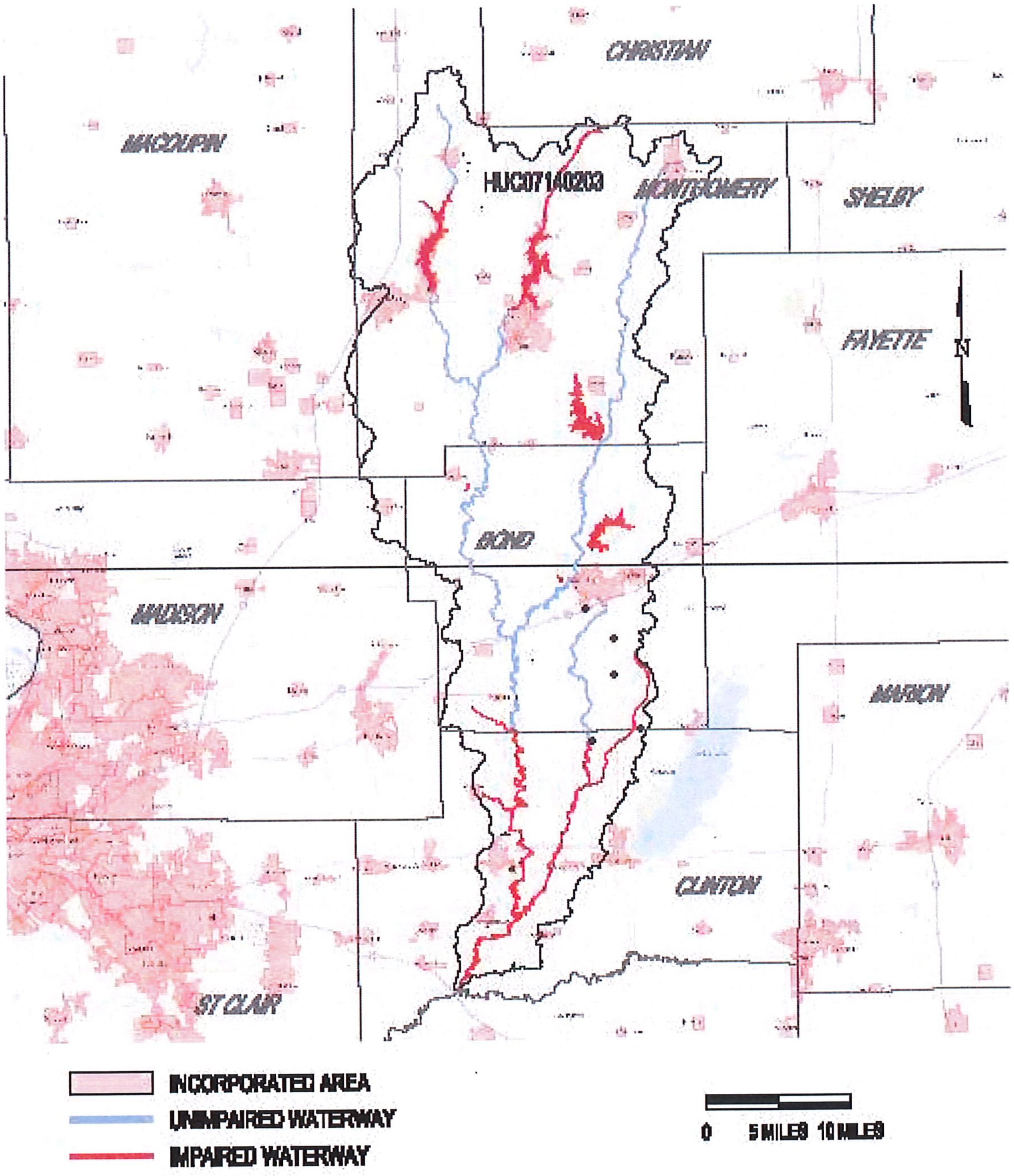

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FIGURE 1
SHOAL CREEK WATERSHED
HUC07140203

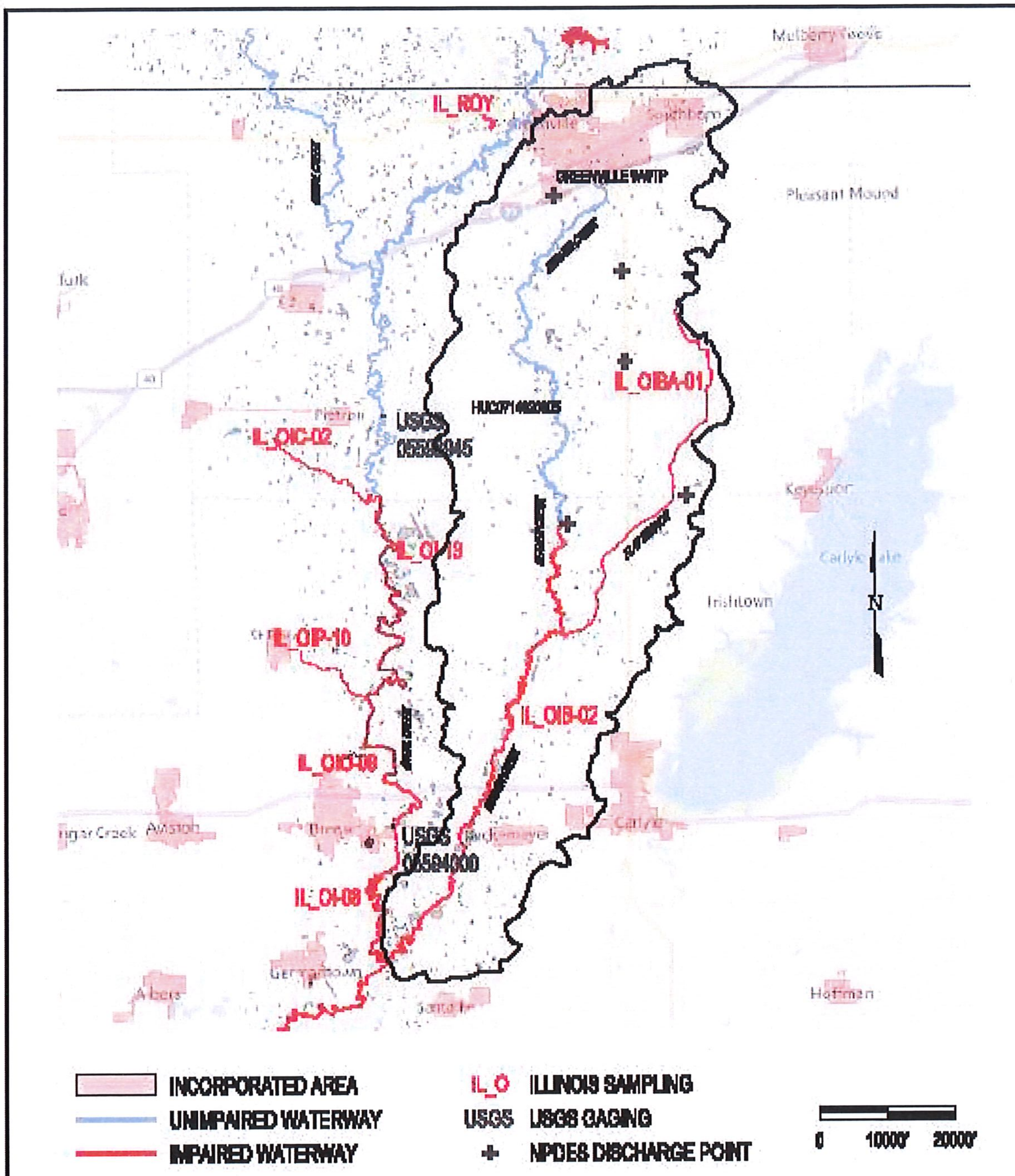

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FIGURE 2
BEAVER CREEK WATERSHED
HUC0714020305

The NARP was developed along the following procedures as indicated by the IEPA language in the NPDES permit. The development process is linear, with each step requiring completion prior to moving to the next step. The process is demonstrated below in Figure 3.

Figure 3: Nutrient Assessment Reduction Plan Development Strategy

Milano and Grunloh worked with the city to develop an achievable strategy to develop and implement the NARP by identifying current flows and concentrations, discussing potential outcomes and obstacles, determining objectives of the plan, setting realistic targets for objectives, and reviewing the completed plan.

C. NARP Objectives

The objectives required for the NARP directly support the development strategy. The objectives developed are as follows:

1) *Objective 1: Determine the extent and source of impairment in the receiving stream. Establish realistic nutrient discharge targets to improve stream quality and protect non-impaired portions of the water body.*

The NARP is intended to be used as a tool to assist in evaluation of the receiving stream. While Beaver Creek is considered impaired in its lower reaches, the upper portion, where the Greenville WTP discharge is located, is considered fully supporting. As monitoring is limited within this waterbody, additional monitoring is expected to further the understanding of the cause of Dissolved Oxygen impairment in the lower reaches, and whether the upper reach is in danger.

2) Objective 2: Examine current discharge concentrations, evaluate their impact, and determine appropriate steps to reduce the amount of nutrients released.

A baseline discharge quantity for nutrients will be developed using the WWTP historical data to include a rolling 12-month average to determine possible reduction amounts. This data will be examined with the current stream data to gain a better understanding of the impact of the nutrients on the receiving stream, and if the discharge is impacting the downstream low DO levels indicated in the 303(d) listing.

3) *Objective 3: Develop a plan to implement the steps identified in an acceptable timeframe.*

After identifying the appropriate steps to reduce the nutrient loading, a timeline will be developed to implement the proposed measures. The timeline will consider factors such as immediate need, IEPA requirements, and funding.

D. NARP Organization

This document is the result of a collaboration between the City of Greenville and Milano and Grunloh Engineers to develop a Nutrient Assessment Reduction Plan for the Greenville Wastewater Treatment Plant. Section 2 will review existing data from plant discharge records, as well as information gathered from other sources such as USGS, IEPA, and NLRS. Section 3 will examine means and methods of monitoring and assessing the gathered information to make informed decisions regarding plant improvements. Section 4 will include recommendations and options for reduction in nutrient loadings.

2. Watershed Characterization and Assessment – Objective 1

The Beaver Creek watershed (HUC#0714020305) contains approximately 144 square miles in Southern Illinois in Bond and Clinton counties and is a portion of the larger Shoal Creek watershed (HUC 07140203). The Beaver Creek headwaters begin near the City of Greenville and flow approximately 38.5 miles south to its confluence with Shoal Creek east of Germantown, IL. Shoal Creek joins the Kaskaskia River, which in turn Joins the Mississippi River south of St Louis, Missouri. Flat Branch Creek contributes to the flow of Beaver Creek at its confluence located approximately three miles north of Carlyle, IL.

A. Land Use and Cover

1) The watershed is primarily agricultural, however also contains limited mining operations. The cities of Greenville, Carlyle, and the village of Beckemeyer are contained within its boundaries.

B. Point Discharges

1) Per CWA §502(14) a point source is described as:

"any discernible, confined and discrete conveyance, including any ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation [CAFO], or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agriculture storm water discharges and return flow from irrigated agriculture."

Under the CWA, all point sources are regulated under the National Pollutant Discharge Elimination System (NPDES) program. A municipality, industry, or operation must apply for an NPDES permit if an activity at that facility discharges wastewater to surface water. Point sources can include facilities such as municipal wastewater treatment plants (WWTPs), industrial facilities, concentrated animal feeding operations (CAFOs), or regulated storm water including municipal separate storm sewer systems (MS4s).

2) The IEPA ECHO website lists 55 NPDES permit holders discharging to Beaver Creek. Three of these permit holders are municipal wastewater treatment plants; Greenville, Keyesport, and Beckemeyer.

C. Monitoring

1) There is no active monitoring on this segment.

3. Existing Data Examination – Objective 2

A. Sources

1) Milano and Grunloh gathered information from several sources for review in the preparation of this report. Existing discharge data was provided from the city, as well as being available on the EPA ECHO website. Geographical data, including stream flowlines, was obtained from the USGS National Map and StreamStats websites. Impairment data was drawn from the Illinois Nutrient Loss Reduction Strategy Biennial Report for 2021. Nitrogen and Phosphorus annual yields were sourced from the Great Lakes to Gulf Dashboard and the USGS National Water Dashboard. The Illinois Integrated Water Quality Report and Section 303(d) List was referred to for impairments.

B. Plant Effluent

1) As an initial step, effluent data was collected for the previous three years to determine the plant nutrient contributions to the stream. This information was gathered both from operator records and the ECHO website. Data was compiled for flow, nitrogen, phosphorus, and dissolved oxygen. Data compilation dates for all parameters are from 10/31/2020 through 11/30/2023.

a) Flow

The Greenville WWTP has a design average flow of 1.57 MGD, with a maximum design flow of 3.93 MGD. For the dates examined, an average monthly flow of 0.8 MGD was determined, with a one-time daily maximum of 3.2 MGD in March of 2022. This indicates that the plant is running an average of approximately 50% capacity. Figure 4 below provides a graphical representation of the flow during the three-year period.

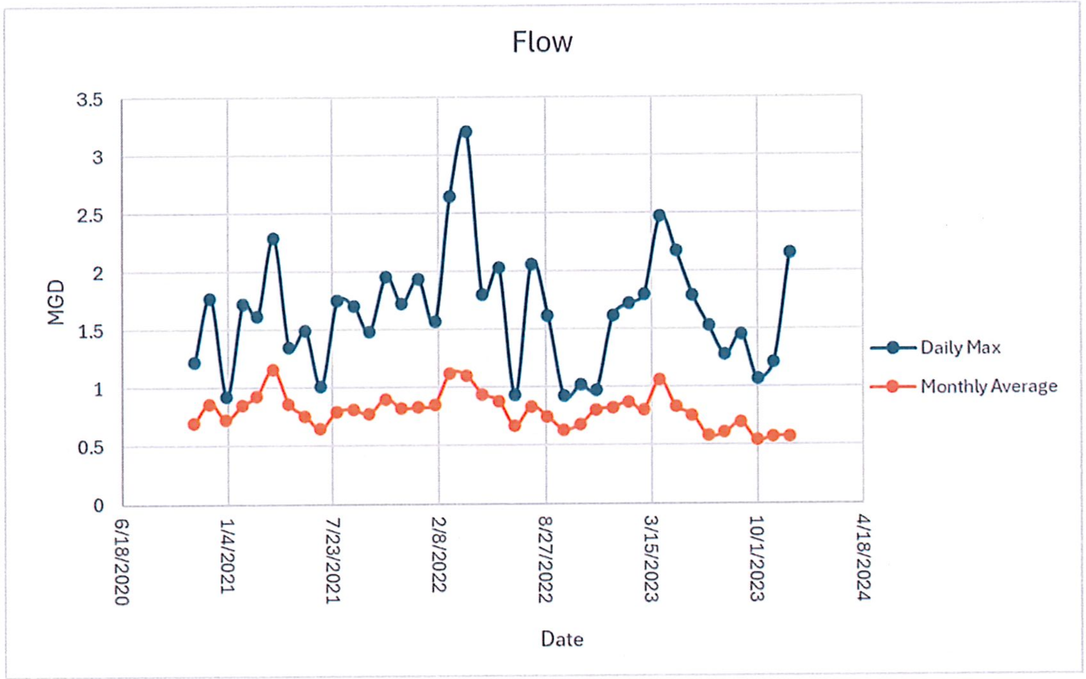

Figure 4: Greenville WWTP 3-Year Flow

b) Nitrogen

Nitrogen was assessed both as Ammonium (as N), and Total (as N). Total nitrogen as ammonium indicated a three-year average of 0.46 mg/L, with a maximum daily concentration of 5.44 mg/L. Plant effluent permit parameters are set at a weekly average limit of 3.9 mg/L. The total nitrogen 3-year average was 7.2 mg/L with a one-time daily maximum of 15.6. There are no discharge limits for total nitrogen and is a monitored parameter only. These values can be seen in Figure 5 for Ammonium and Figure 6 for Total Nitrogen.

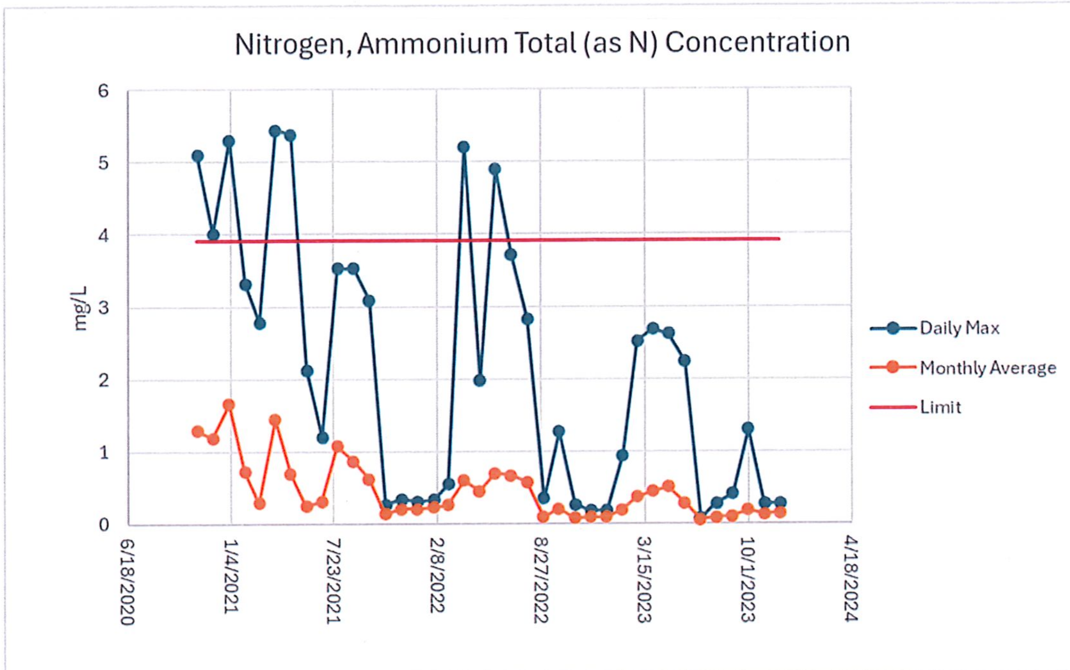

Figure 5: Greenville WWTP 3-Year Ammonium

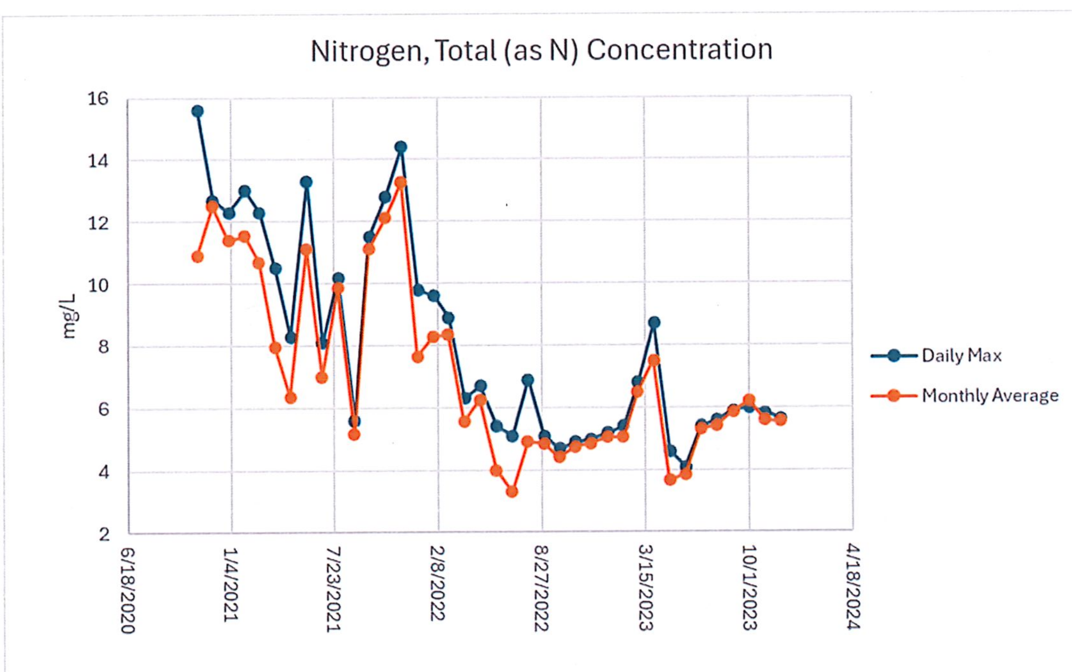

Figure 6: Greenville WWTP 3-Year Total Nitrogen

As demonstrated in the graphs, Greenville had high nitrogen discharge levels, but has made large improvements to their effluent levels in recent years.

c) Phosphorus

Phosphorus was examined as monthly average, 12-month rolling average, and daily maximum in mg/L over the same three-year period. Greenville currently does not have a discharge limit on phosphorus and is required only to monitor. The daily maximum value reported a high of 6.3 mg/L, while the three-year monthly average calculated at 2.85 mg/L The collected data was used to develop Figures 7 and Figure 8.

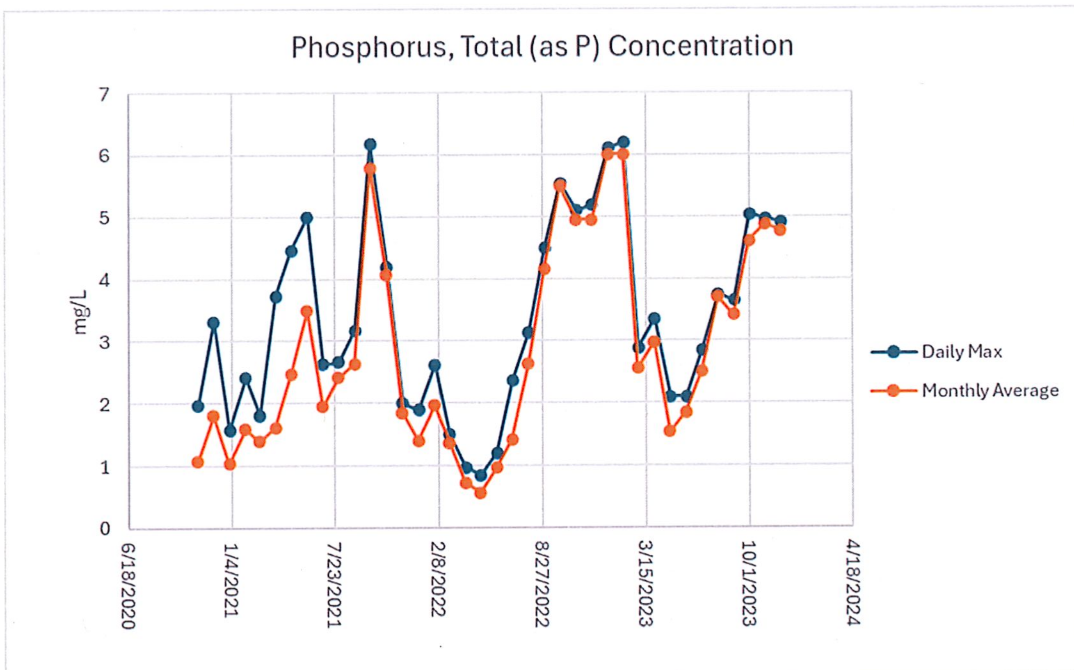

Figure 7: Greenville WWTP 3-Year Total Phosphorus

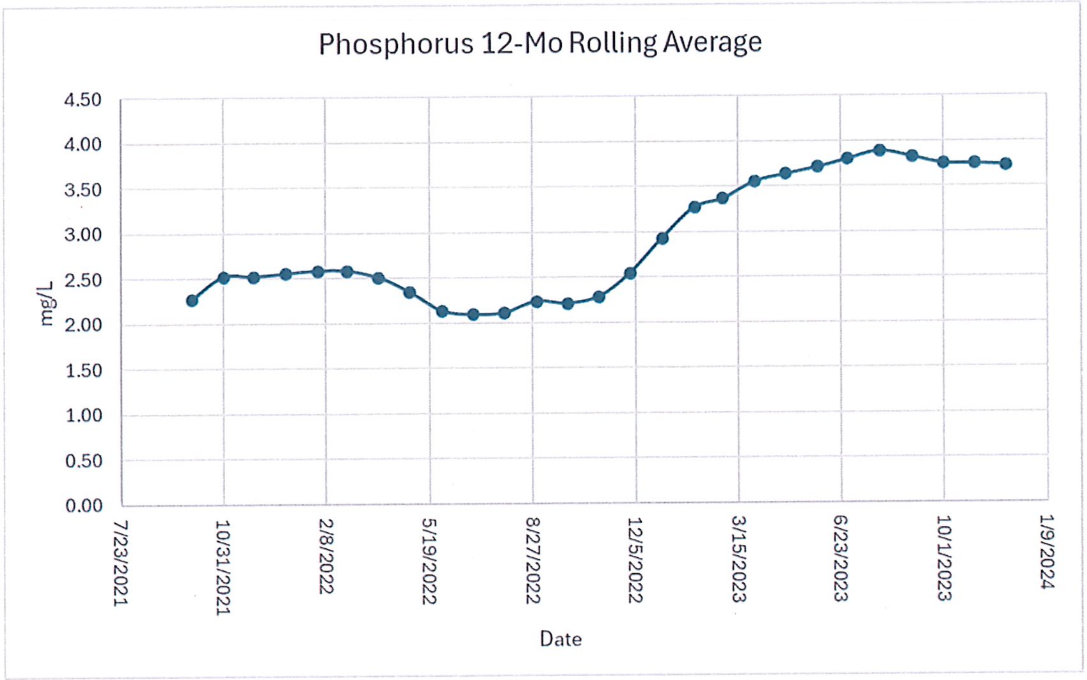

Figure 8: Greenville WWTP 12-Month Total Phosphorus Rolling Average

Graphing the data helped identify an emerging pattern of phosphorus spiking in the autumn months, then declining. This would seem to indicate an external event creating issues, and the city is expected to reach out to large industrial users and the federal penitentiary, as well as any other possible sources to attempt to determine the cause of the spike. The 12-month rolling average indicates a gradual increase in phosphorus concentrations leaving the plant. With the pattern emerging in Figure 7, it is expected to see a gradual decline in the average, however it is unlikely it will reach the previous low averages, but rather stay somewhat elevated.

d) Dissolved Oxygen

Dissolved Oxygen (DO) was examined as both a daily minimum and a weekly minimum average. Greenville has maintained their minimums for both above the established minimum limits, with the exception of one daily limit in February of 2022. This appears to be an outlier that was likely entered as 1.6 mg/L as opposed to 6.1 mg/L, which would be consistent with other data points. Graphical representation of DO levels in the discharge can be seen below in Figures 9 & 10.

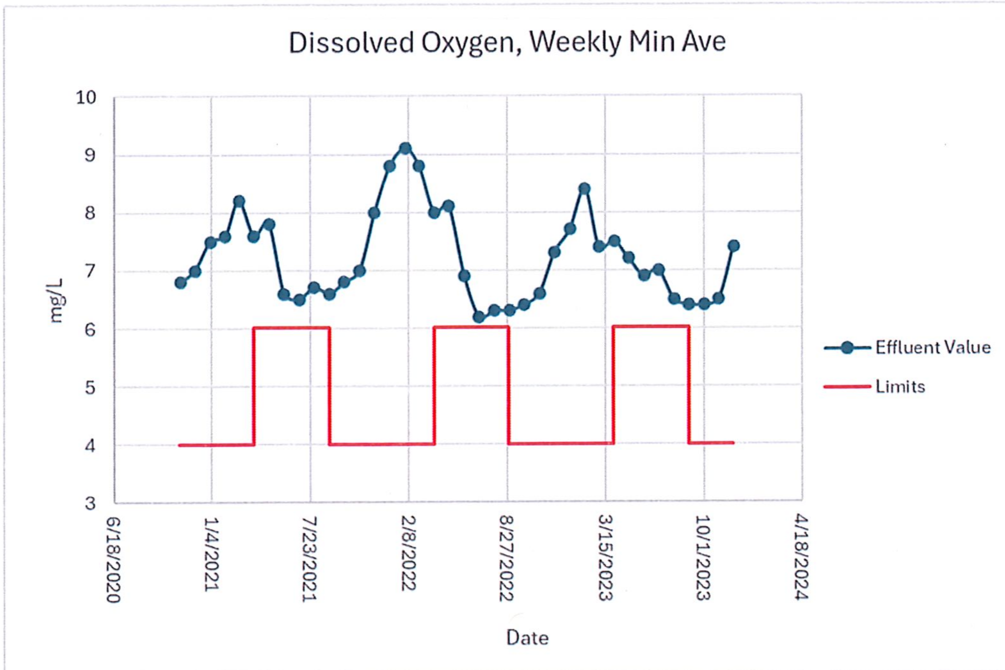

Figure 9: Greenville WWTP Dissolved Oxygen, Weekly Minimum Average

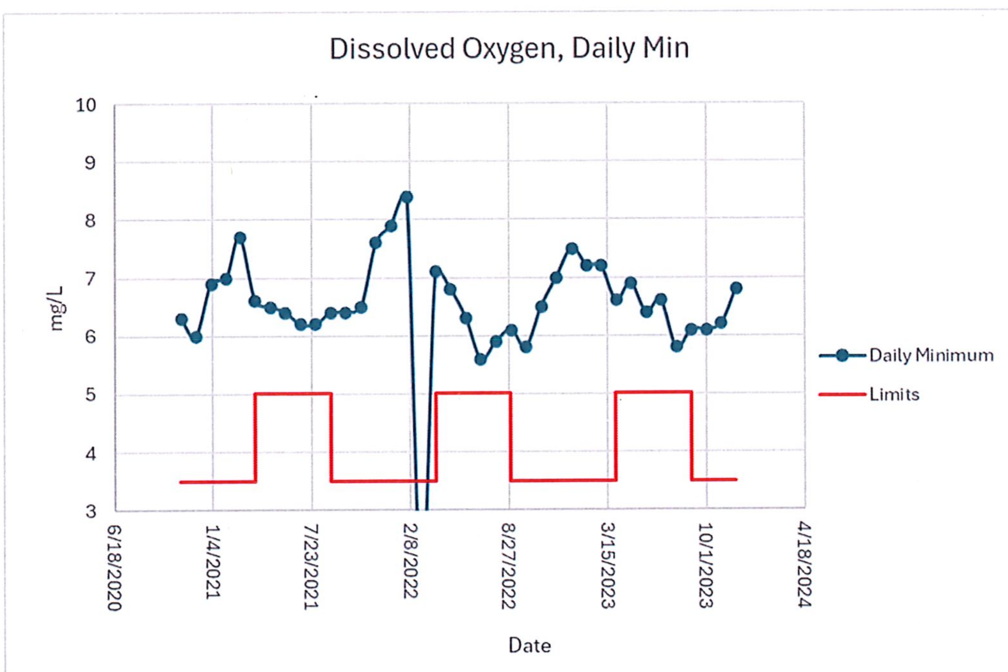

Figure 10: Greenville WWTP Dissolved Oxygen, Daily Minimum

C. IEPA

1) While Beaver Creek in its entirety was assessed as impaired for dissolved oxygen in 2018, the 2020/2022 listing removed segment IL_OIB-01 from the impairment listing, while maintaining the status for segment IL_OIB-02. This assessment states that the upper portions (IL_OIB-01) of the reach are fully supporting for both aquatic life and aesthetic quality. It is notable that the watershed also contains the entire reach of Flat Branch (Segment IL_OIBA-01), which is tributary to Beaver Creek, joining the flow in the impaired section. Flat Branch is listed on the 303(d) listing as impaired for its entire reach for Total Phosphorus. As flat branch traverses all agricultural land with no riparian borders, this is somewhat expected. It also lend credence to the theory that the depressed DO levels in the lower reaches of Beaver Creek are due to phosphorus loadings creating excessive algal blooms, however this is likely occurring in Flat Branch itself as there is no evidence of high concentrations of algae in Beaver Creek itself. It is probable that increased algae growth in Flat Branch is producing a decline in DO, which is then combined with the Beaver Creek flow, thereby reducing its DO levels. As both are low flow channels, a small addition of oxygen depleted waters could make a substantial impact.

D. Illinois Integrated Water Quality Report

1) This report was utilized as a reference to determine impaired waters, as well as the level and cause of impairment. USEPA's latest Integrated Report guidance (USEPA 2005) calls for all waters of the state to be reported in a five-category system as below. Although the guidance allows waters to be placed into more than one category, Illinois EPA treats all categories as mutually exclusive.

Category 1: Segments are placed into Category 1 if all designated uses are supported, and no use is threatened. (Note: Illinois does not assess any waters as threatened)

Category 2: Segments are placed in Category 2 if all designated uses that were assessed are supported. (All other uses are reported as Not Assessed or Insufficient Information).

Category 3: Segments are placed in Category 3 when there is insufficient available data and/or information to make a use support determination for any use.

Category 4: Contains segments that have at least one impaired use but a TMDL is not required. Category 4 is further subdivided as follows based on the reason a TMDL is not required.

Category 4a: Segments are placed in Category 4a when a TMDL to address a specific segment/pollutant combination has been approved or established by USEPA. Illinois EPA places water bodies in category 4a only if TMDLs have been approved for all pollutant causes of impairment.

Category 4b: Segments are placed in Category 4b if technology-based effluent limitations required by the Act, more stringent effluent limitations required by state, local, or federal authority, or other pollution control requirements (e.g., best management practices) required by local, state or federal authority are stringent enough to implement applicable water quality standards (40 CFR 130.7(b)(1)) within a reasonable period of time.

Category 4c: Segments are placed in Category 4c when the state demonstrates that the failure to meet an applicable water quality standard is not caused by a pollutant, but instead is caused by other types of pollution (i.e., only nonpollutant causes of impairment). Water bodies placed in this category are usually those where Aquatic Life use is impaired by habitat related conditions. (See discussion in Section C-2 Assessment Methodology, Aquatic Life-Streams.)

Category 5: Segments are placed in Category 5 if available data and/or information indicate that at least one designated use is not being supported and a TMDL is needed. Water bodies in Category 5 (and their pollutant causes of impairment) constitute the 303(d) List that USEPA will review and approve or disapprove pursuant to 40 CFR 130.7.

Category 5-alt: Waters are placed in category 5-alt when alternative restoration approaches are used to address impairments instead of traditional TMDLs. An alternative restoration approach is a plan or a set of actions pursued in the near-term designed to attain water quality standards. Waters in category 5-alt remain on the 303(d) list until water quality standards are achieved or a TMDL is developed. When a State decides to pursue an alternative restoration approach for waters on its 303(d) list, USEPA expects the State to provide documentation that such an (TMDL) is required. The approach is designed to meet water quality standards and is a more immediately beneficial or practicable way to achieve water quality standards than the development of a TMDL in the near future. USEPA considers the adequacy of the State's documentation for pursuing an alternative restoration approach in determining whether to give credit to such an approach. For this cycle, Illinois has no waters in category 5-alt.

Evaluation of the current 2020-2022 listing in Appendix A-1: Specific Assessment Information for Streams shows Flat Branch as a Category 5 stream due to Total Phosphorus impairment. Likewise, The Beaver Creek segment IL OIB-02 to which Flat Branch connects is a Category 5 stream for DO impairment. Beaver Creek segment IL OIB-01, to which Greenville WWTP discharges via unnamed tributary, is listed as a Category 2 stream, and is fully supporting for the two assessed parameters of Aquatic Life and Aesthetic Quality.

The previous IWQP for 2018 was referenced, which showed segment IL OIB-01 had previously been listed as impaired for DO quality reasons. Further research showed the receiving segment delisted for 2020 in Appendix C-4 as it was deemed fully supporting.

E. USGS Data

1) Beaver Creek has no USGS monitoring station, therefore any data used from these sources are speculative. As the Greenville WWTP has established effluent limits for ammonium as nitrogen, and as a point source, phosphorus contribution is more prevalent than in the agricultural sector, it was decided to concentrate the research efforts on phosphorus. Data sourced from the USGS Water Dashboard used in conjunction with data from the Illinois Ambient Water Quality Monitoring Network enabled the development of an approximation of phosphorus loading on the Kaskaskia River in the portion of the reach in question. Data was drawn for three monitoring stations. Station 5594100 near Venedy Station represents the first monitoring station downstream from Beaver Creek. From this, the loading reported at the next upstream station, Station 5593000 at Carlyle was deducted to provide the amount of loading added to the Kaskaskia between the two stations. From this, the loading data was compiled from Station 5594000 on Shoal Creek near Breese, IL to negate the loadings from further up the watershed. This left the loadings contributed in the areas shown in Figure 11. It should be noted that there are two HUC 10 drainage basins (HUC 0714020208 and HUC0714020207) upstream of the Shoal Creek – Kaskaskia confluence that cannot be discounted from the contribution as there is no monitoring station available. The total recorded loading was charted for the Venedy Station monitoring, and also for the Carlyle and Shoal monitoring stations combined. The results are shown in Figure 12.

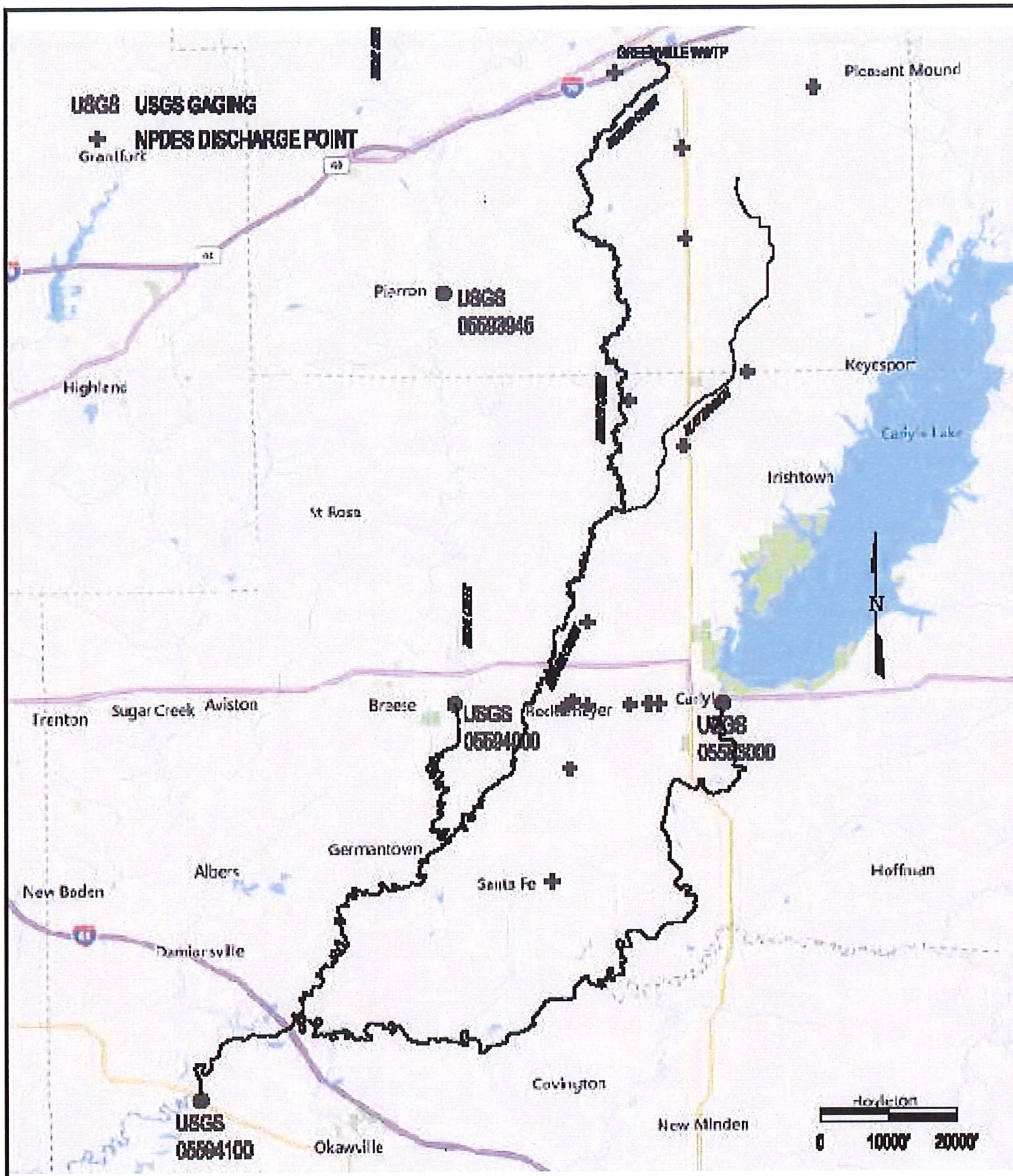

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FIGURE 11
PHOSPHORUS LOADING
EXAMINED REACHES

The area unaccounted for is located to the southeast of Carlyle Lake, and includes the communities of Centralia, New Mindon, Covington, and Hoffman.

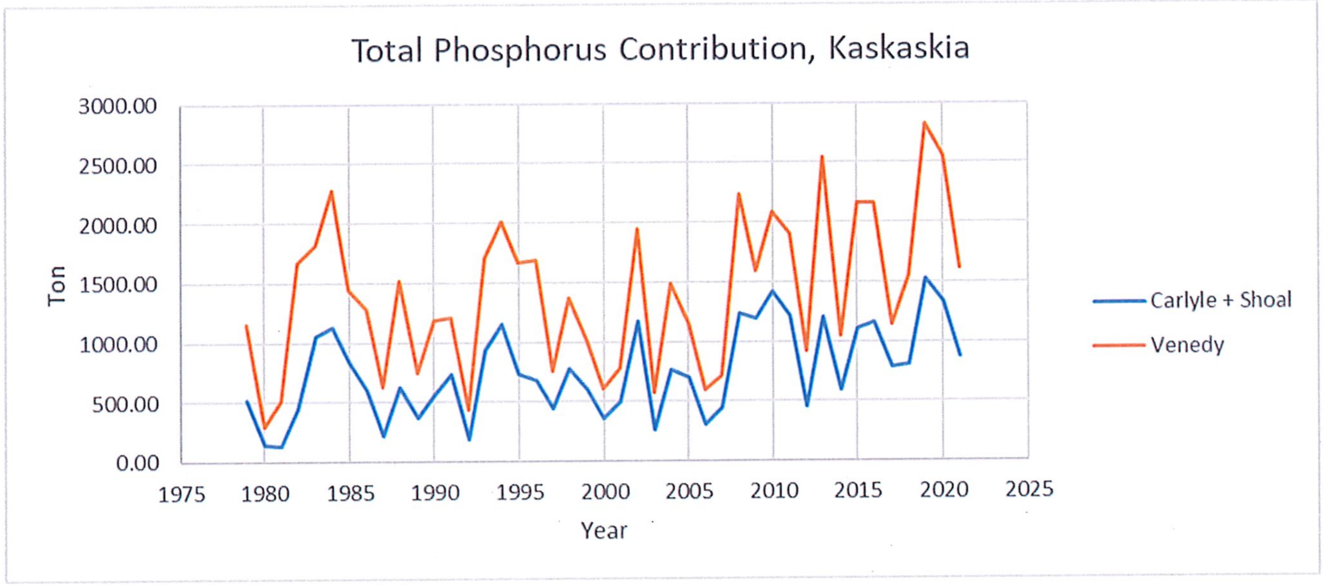

Figure 12: Loadings Reported at Venedy, Carlyle, and Shoal Creek

This allowed a comparison to determine the delta value between the two, estimating a contribution from the area displayed in Figure 11. This value is graphed in Figure 13.

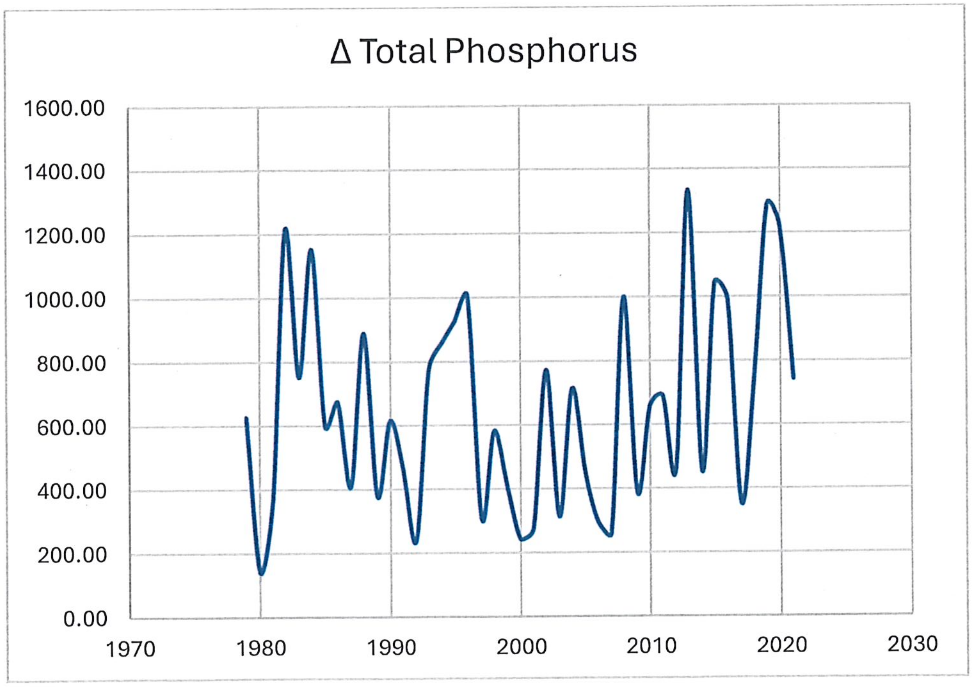

Figure 13: Phosphorus Contribution of Figure 11, Tons/Year

The most recent data available computed a ΔP of 744.28 tons per year being added to the loading. Examining the data from Greenville indicates an average contribution of 3.17 ton during this same time period, accounting for 0.4% of the loading. Average phosphorus discharge has remained relatively constant for the plant since the examined date of 2021.

F. Data Summary

Upon evaluation of the data, it appears that while phosphorus from the Flat Branch stream is likely contributing to the reduced DO in the lower reaches of Beaver Creek, the lack of impairment in its upper reaches indicates that phosphorus discharge from the Greenville WWTP is not a significant contributor. This is likely due to a long riparian discharge ditch located immediately after the outfall, which leads to a wetland area. This wetland area then drains to an unnamed tributary traversing woodlands before reaching Beaver Creek. Greenville is experiencing periodic increases in their phosphorus concentrations, increasing to approximately 4 mg/L in the autumn months before dropping back to approximately 1 mg/L in the spring. No correlation has been found to rainfall or temperature, indicating an outside influence. DO has consistently been above that required by their discharge permit, and nitrogen discharge as ammonium has been negligible for the last three years.

G. Water Quality Targets

Examination of previous phosphorus discharges from the Greenville WWTP indicates the plant is capable of achieving phosphorus concentrations of 1 mg/L utilizing the current treatment train and process, however portions of the plant may need updating to regain lost efficiency due to aging equipment. Short term goals include returning to these previous effluent quantities and a concentration on maintaining these levels. Longer term goals are to reduce the phosphorus concentration of the discharge to 0.5 mg/L through a combination of organic, chemical, and mechanical means.

Recent reduction of Total Kjeldahl Nitrogen (TKN) by the facility by 42% in the previous 24 months has made great strides in reducing the average TKN concentration to 5.48 mg/L for 2023. This concentration has mostly leveled but continues to decline slightly. With the EPA recommendation of a TKN discharge concentration of 2 – 6 mg/L, the City of Greenville intends to retain their existing nitrogen treatment as currently configured and maintain these levels.

4. Planned Nutrient Reduction Steps – Objective 3

A. Existing facility

The Greenville WWTP is an aging facility, but remains functional. The plant receives wastewater discharge from the municipality, as well as a federal prison and several industrial discharges. Wastewater is received at an intake structure where grinder pumps transfer the waste to a Parkson screen to remove any large debris. After the Parkson screen, waste passes through a grit chamber before entering an oxidation ditch. From the oxidation ditch, waste moves through two clarifiers, passing over a weir, and being discharged.

B. Planned Improvements

The city has begun retrofitting the treatment plant to repair aging items, and to rectify issues identified in the operation. Phase 1 included cleaning and sealing the clarifiers to correct minor spalling of the concrete, and replacement of the existing sludge tank as it is beginning to show signs of failure. As funds are applied for, the following items intend to be addressed in the order they are listed. Not all items are expanded upon as they are maintenance/upkeep/age issues.

1) Influent screen and grease removal

   Large quantities of trash and grease are introduced from the prison. The prison possesses a grease separator on its property, but maintenance issues resulted in it being bypassed. The large amount of debris collects in the intake structure, requiring it to be suctioned out, and also puts undue stress on the pumps, reducing their longevity. A traveling screen for trash removal, and a safe system of grease removal are a high priority for both safety and budgetary reasons.

2) Automatic screen for the center island for more consistent flow to the clarifiers.

   During high flow events, screens can become plugged, overloading one clarifier while effectively blocking flow to the other. An automatic screen is desired for reliability.

3) Overhaul effluent well, new pumps and phosphorus removal.

   Effluent pumps are aging and will need to be replaced soon. Different methods of Phosphorus removal are being examined and will be discussed later in this section.

4) Replace valves for dewatering the clarifiers.
5) Overflow \ by-pass channel for the Parkson screen.
6) More efficient grit removal.
7) New screen building
8) Replace worn out parts and items in the press building and the sludge handling facilities.
9) New concrete pad for the sludge roll-offs.
10) New press building, and sludge handling facilities
11) Replace broken mud valves in the oxidation ditch.
12) Clarifier covers.
13) SCADA system

C. Monitoring

Localized testing and monitoring in the collection system would help identify primary sources of phosphorus in the city's wastewater. Multiple manufacturers produce monitors capable of being deployed in manholes to record phosphorus concentrations in the wastewater. In addition, these monitors are easily transferred from one location to another, allowing the city to strategize placement, then move monitors upstream to follow nutrients to their source. As there is no current means for testing influent concentrations, there is no means of determining the effectiveness of treatment and the implementation of a monitoring system would be a great benefit. A special emphasis should be placed on monitoring of the prison, as this is likely a major contributor of phosphorus.

D. Community Outreach

Prevention of phosphorus reaching the plant should always be considered as the primary method of reduction. In concert with the proposed monitoring, Greenville should begin community outreach to all business users; Industrial, commercial and institutional, to include agricultural co-ops, car/truck washing facilities, dairies, food processing plants, meat packing and locker plants, metal finishing facilities⍰ municipal water treatment plants that add phosphorus to drinking water, nursing homes, restaurants, schools and other businesses or institutions with phosphorus sources to provide tips for reducing the phosphorus load. Suggested methodology should include:

- Establish purchasing criteria for cleaning products.
- Use low or non-phosphorus cleaners and detergents.
- Use proper concentrations of cleaners and detergents.
- Use cleaners and detergents as directed by the manufacturer.
- Do not accept sample cleaners from vendors.

Municipal sources should also be examined for practices that may impact the amount of phosphorus reaching the facility. Examples of municipal action include:

- Institute environmentally preferred purchasing with policies to limit phosphorus containing products for municipal operations.
- Institute a public education campaign to raise awareness about phosphorus issues and sources.
- Optimize the addition of phosphorus to the drinking water supply to prevent pipe corrosion.
- Evaluate the use of water treatment plant filter backwash residuals as a possible mechanism for phosphorus removal at the WWTF.
- Optimize stormwater management policies, such as minimizing run-off from parking lots and other surfaces.

E. Phosphorus Removal

Although the Greenville WWTP is capable of reaching phosphorus concentrations of 1 mg/L, it will likely need additional, dedicated removal methods to reduce beyond this level. A number of methods are being considered for use, both organic and mechanical/chemical. These options are discussed below.

1) Organic

Optimizing the existing activated sludge biological process of the plant should be the first step in increasing phosphorus removal. The current phased plan of improvements should make steps toward achieving this goal, while simultaneously increasing the reliability of the facility. It is expected that by replacing equipment near the end of its life cycle, while making adjustments to the treatment process, that a return to the previously seen concentrations of 1 mg/L can be achieved. Methods of adjusting the treatment process may include the following:

- Adjusting the recirculation and/or wasting rates and testing the efficiency of variations in Mixed Liquor Suspended Solids (MLSS) concentrations.
- Test different filamentous bacteria control techniques, as excessive amounts can reduce efficiency. Shock chlorination may be used to control the growth of filamentous bacteria by using small, frequent doses of chlorine as these are reported to effectively control the growth of filaments while having a less deleterious effect on the treatment efficiency.
- Adjusting the depth of sludge blankets in clarifiers as lower solids in secondary clarifiers prevent wash out. This also can create a anaerobic conditions which favor biological phosphorus removal. A one-hour anaerobic detention time is optimal.

2) Chemical

Chemical treatment for the removal of phosphorus is commonly utilized as it is arguably the simplest method to implement, and often the most economical, however the existing biological treatment should be optimized prior to chemical addition to limit the amount of chemicals required to be fed, in turn reducing operating costs. This removal method is almost always required to reach very low concentrations and is best used to enhance the biological process. Upon optimizing the existing processes, the effluent will be tested to determine the most efficient chemical feed system. Chemicals for consideration include:

- alum (aluminum sulfate)
- sodium aluminate
- ferric chloride
- ferric sulfate
- ferrous sulfate
- ferrous chloride

3) Mechanical

Should the above steps fail to remove phosphorus at an adequate rate, the use of a Dissolved Air Flotation System (DAF) or Moving Bed Biological Reactor (MBBR) may be required. Both of these systems are able to be piloted prior to committing to full installation. With Greenville's current efforts to upgrade and modernize their WWTP, these systems could be easily included into the phased improvements.

F. Nitrogen Removal

1) Current nitrogen removal from the plant meets the current requirements and no additional steps for additional removal are currently proposed. It is expected that as improvements are completed and the plant is adjusted for phosphorus removal, nitrogen will be closely monitored to maintain, or improve, the discharge concentration of TKN. If monitoring indicates a need for improvements not listed in this report, alternate treatment options will then be evaluated for effectiveness and implemented as needed.