Monmouth, IL Nutrient Assessment Reduction Plan

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1. NUTRIENT ASSESSMENT REDUCTION PLAN

As a result of a settlement between Illinois Environmental Protection Agency (IEPA) and environmental organizations, permit language was developed and adopted requiring a phosphorus discharge limit of 0.5 mg/L starting in the year 2030 for all major dischargers. The primary exception to this requirement is to develop a Nutrient Assessment Reduction Plan (NARP) that will evaluate if the likely cause for a watershed or stream phosphorus or eutrophication impairment is point source phosphorus discharge. Impairments for total phosphorus are based on a narrative condition. Impairments for eutrophication are based on chlorophyll levels, days with very high pH, or days with slightly high pH and over saturation of dissolved oxygen (DO). In watersheds where IEPA has data to support one or both impairments, a special requirement to develop a NARP was added to wastewater treatment facility (WWTF) National Pollutant Discharge Elimination System (NPDES) permits. This NARP has been developed to satisfy this special requirement in the City of Monmouth's NPDES permit.

The Mississippi North Central Watershed (MNCW) is located in the central northwest region of Illinois and drains to the Mississippi River. The MNCW crosses multiple counties including Hancock, Henderson, Mercer, Rock Island, Henry, Knox, and Warren County. The City of Monmouth and Galesburg Sanitary District (GSD) are located within Warren and Knox County, respectively. A map of the MNCW is included as Figure 1-1. This watershed is primarily agricultural with some land use devoted to residential and industrial. Based on a September 2009 IEPA Watershed Map and NPDES listing, the MNCW contains 41 NPDES permitted facilities. Only seven of these facilities directly influence Cedar Creek's water quality. Two of the NPDES permits are for the City of Monmouth's WWTFs which have been consolidated under one permit since, resulting in only 6 NPDES facilities which could be impacting Cedar Creek water quality. A copy of the IEPA Watershed Map with NPDES discharge locations is included as Figure 1-2.

IEPA has sampled within the MNCW, and their data includes one sampling location, 18 river miles downstream from the City of Monmouth WWTF's outfall, that reflects slightly elevated pH and over saturation of DO. This sampling location, LDD-11, is located on Cedar Creek. Cedar Creek's water quality could be impacted by discharge from the City of Monmouth WWTF, Galesburg Sanitary District (GSD), four other permittees (see Table 1-1), and likely other unpermitted or non-point sources. The 2014 data from LDD-11 has triggered the phosphorus limit and NARP requirements in both the City of Monmouth's and GSD's permits. Figure 1-3 shows the IEPA sampling locations in relation to the City of Monmouth and GSD discharges. It also shows the locations of additional sampling (in green) performed for this assessment.

TABLE 1-1: CEDAR CREEK NPDES PERMITTED FACILITIES

NPDES ID	Facility Name	DAF (MGD)	DMF (MGD)
IL0023141	Galesburg SD STP	11	28
IL0035688	Koppers Inc-Galesburg		
IL0036218	Monmouth North and Consolidated WWTF	4.62	10.23
IL0060836	Yorkwood School District #225	0.0194	0.0485
IL0071633	Heat and Control-Galesburg	0.0011	
IL0077704	Little York WTP		
ILG840005	Monmouth Stone Co-Monmouth		

Source Data: September 2009 IEPA Report. Permits as available on IEPA website. City of Monmouth Permitted Facilities updated based on current permits.

Figure 1-1: Mississippi North Central Watershed Map

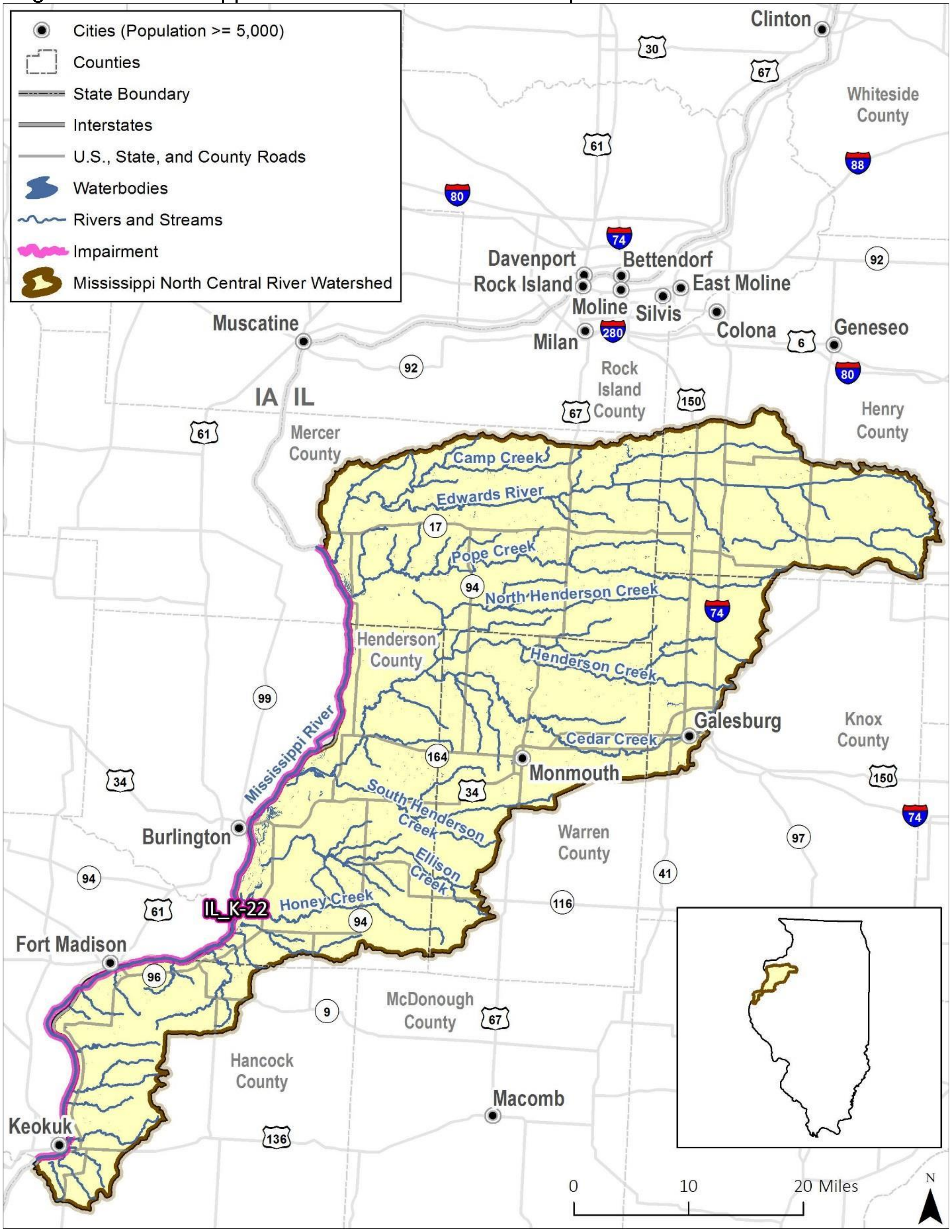
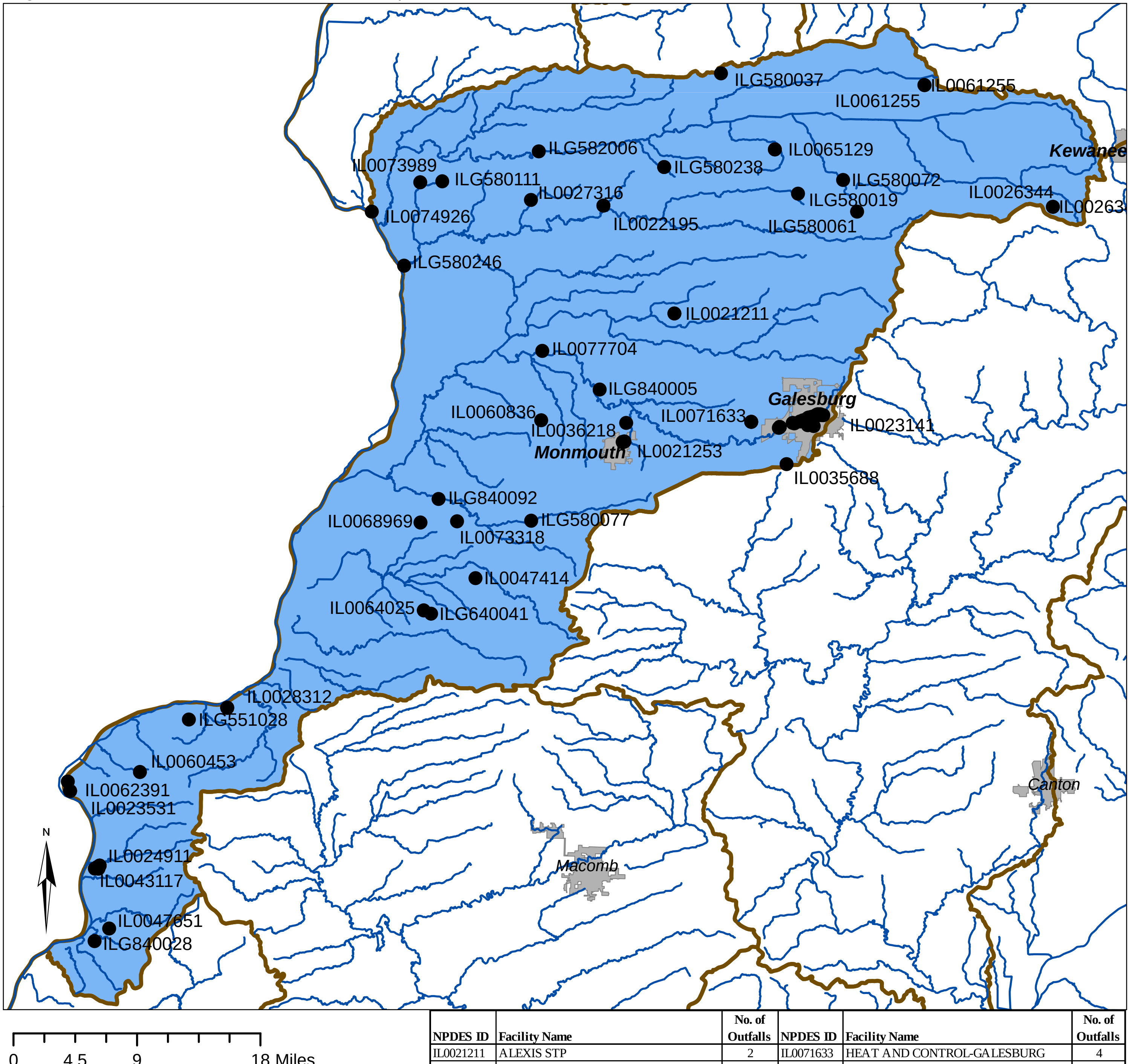
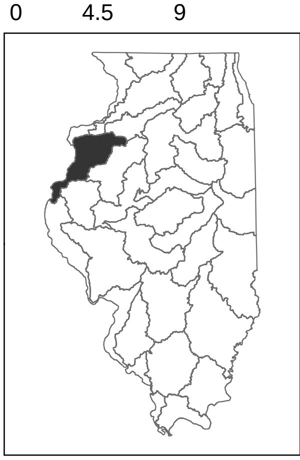


Figure from IEPA Mississippi River Watershed Total Maximum Daily Load and Load Reduction Strategies Final Stage 1 Report, January 2017

Figure 1-2: Mississippi North Central Watershed NPDES Facilities Map

Figure from IEPA NPDES Facilities in Illinois, September 2009





NPDES ID	Facility Name	No. of Outfalls	NPDES ID	Facility Name	No. of Outfalls
IL0021211	ALEXIS STP	2	IL0071633	HEAT AND CONTROL-GALESBURG	4
IL0021253	MONMOUTH MAIN STP	8	IL0073318	BIGGSVILLE STP	1
IL0022195	BRADFORD STP	2	IL0073989	ALEDO WTP	1
IL0023141	GALESBURG SD STP	50	IL0074926	NEW BOSTON STP	1
IL0023531	NAUVOO STP	2	IL0077704	LITTLE YORK WTP	1
IL0024911	HAMILTON STP	3	ILG551028	LEISURELAND PLEASURE PARK	1
IL0026344	GALVA NORTHEAST STP	2	ILG580019	ALPHA STP	1
IL0027316	ALEDO SOUTH STP	1	ILG580037	SHERRARD STP	1
IL0028312	DALLAS CITY WWTP	3	ILG580061	WOODHULL SOUTH STP	1
IL0035688	KOPPERS INC-GALESBURG	1	ILG580072	WOODHULL NORTH STP	1
IL0036218	MONMOUTH NORTH STP	1	ILG580077	KIRKWOOD STP	1
IL0043117	CAMP EASTMAN	3	ILG580111	JOY STP	1
IL0047414	WEST CENTRAL CUSD #235-MEDIA	1	ILG580233	VIOLA STP	1
IL0047651	HAMILTON WTP	1	ILG580238	MATHERVILLE STP	1
IL0060453	NAUVOO COLUSA SCHOOL DISTRICT	1	ILG580246	KEITHSBURG STP	1
IL0060836	YORKWOOD SCHOOL DISTRICT #225	1	ILG582006	ALEDO NORTH STP	1
IL0061255	CAMBRIDGE STP	2	ILG640041	STRONGHURST WTP	1
IL0062391	NAUVOO WTP	1	ILG840005	MONMOUTH STONE CO-MONMOUTH	1
IL0064025	STRONGHURST STP	1	ILG840028	GRAY QUARRIES, INC.	1
IL0065129	ANR PIPELINE CO-NEW WINDSOR	2	ILG840092	CESSFORD CONSTRUCTION-BIGGSVIL	1
IL0068969	WEST CENTRAL CUSD #235-BIGGSVL	1			

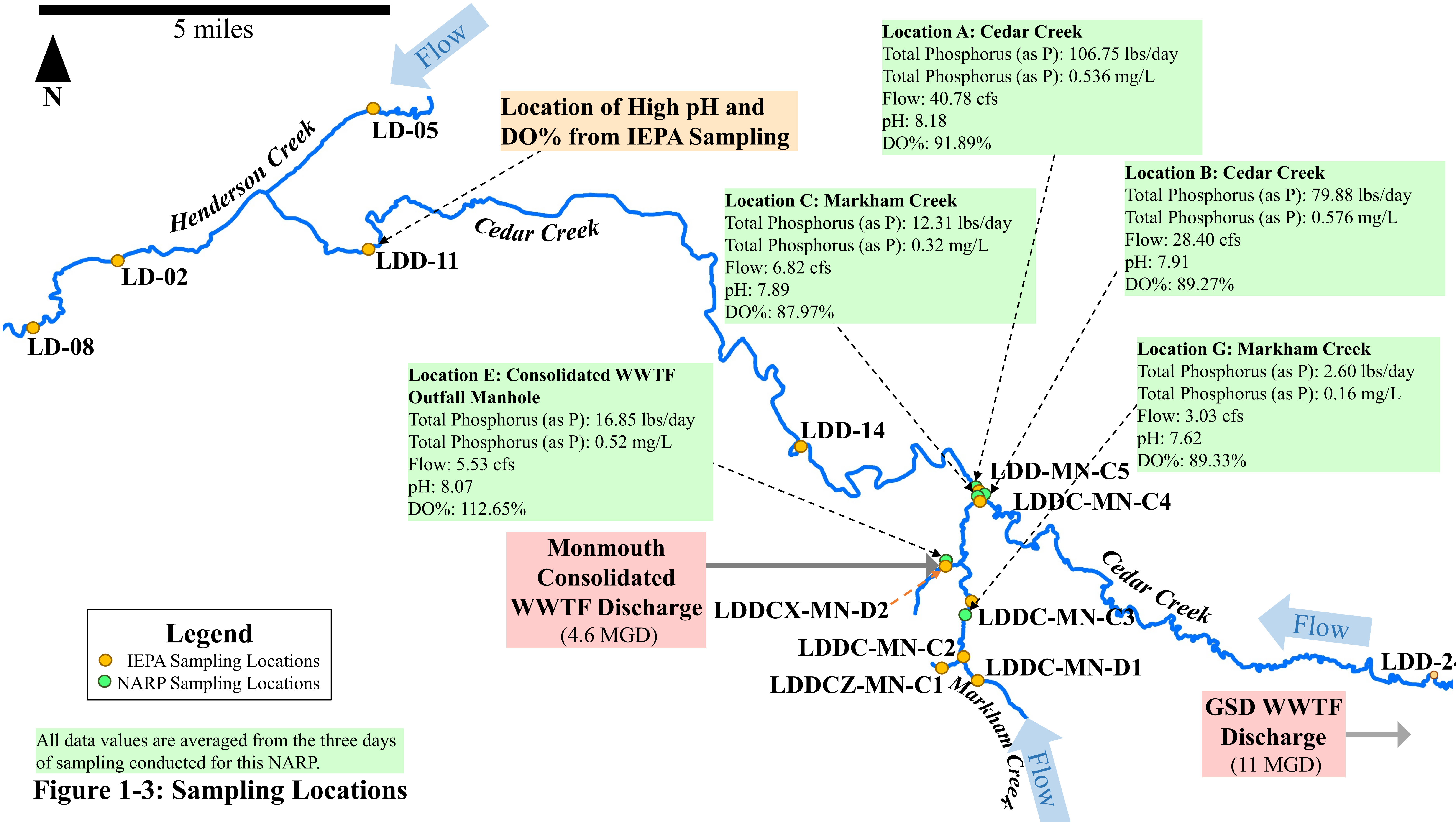


Figure 1-3: Sampling Locations

2. CEDAR CREEK STAKEHOLDERS

2.1 Monmouth, IL

The City of Monmouth, IL is located in Warren County roughly 15 miles west of Galesburg, IL. The City of Monmouth was founded in 1831 and contains both combined sewer systems and separate storm and sanitary sewer systems. The City of Monmouth is home to a population of 8,902 (2020 Census), Monmouth College, and a Smithfield Foods processing plant. The Smithfield Foods processing facility (Smithfield) in the City of Monmouth operates six days per week processing hogs for market. The industrial wastewater produced at Smithfield is preliminarily treated on site and then pumped to a treatment facility.

2.1.1 Monmouth Wastewater Treatment Facilities

The City of Monmouth has two WWTFs: North Plant WWTF and the Consolidated Sewage Treatment Facility (Consolidated WWTF). The North Plant is a pretreatment plant that serves only Smithfield. The North Plant can handle approximately 1.1 million gallons per day (MGD) and has storage lagoons for emergency overflows. The North Plant discharges to the Consolidated WWTF. The Consolidated WWTF treats municipal flow and the effluent from the North Plant. The Consolidated WWTF has a design average flow (DAF) of 4.62 MGD and a design maximum flow (DMF) of 10.23 MGD. The Consolidated WWTF discharges to an unnamed tributary of Markham Creek.

2.2 Galesburg, IL

The City of Galesburg, IL is located in Knox County, roughly 45 miles northwest of Peoria, IL. The City of Galesburg is located in the same watershed as the City of Monmouth, approximately 19 river miles upstream along Cedar Creek. The City of Galesburg has a population of 30,052 (2020 census). The GSD WWTF has a design max flow of 28 MGD and discharges to Cedar Creek upstream of its confluence with Markham Creek. GSD is currently constructing a new WWTF adjacent to its existing WWTF. The new WWTF will include biological nitrogen and phosphorus reduction with chemical reduction backup. The new GSD WWTF is anticipated to be completed around 2026.

2.3 Initial Watershed Group Meeting

On October 26th, 2023, a meeting was hosted by the City of Monmouth and the GSD to discuss NARP requirements set forth in their respective NPDES Permits. One of the requirements in the NARP is to "Cooperate with and work with other stakeholders in the watershed to determine the most cost-effective means to address the risk of eutrophication." The meeting was advertised to potentially interested stakeholders via email. There were 26 attendees including representatives of the City of Monmouth, GSD, Smithfield, Koppers Inc., BNSF Railroad, Knox County Soil and Water Conservation District, Knox County Landfill, USDA-National Resource Conservation Service, Woodard & Curran, and Crawford, Murphy, & Tilly. During the meeting, NARP requirements were discussed, and a consensus was reached that the entities would work together moving forward. Meeting notes and sign-in sheet are included in Appendix A.

Both the City of Monmouth and GSD are interested in gathering more data to best determine if capital upgrades, beyond those already planned, will improve the health of the watershed.

3. PERMIT REQUIREMENTS FOR NUTRIENT DISCHARGE

The City of Monmouth's Consolidated WWTF currently has permit limits on nutrients. These limits are for total phosphorus and ammonia nitrogen. There is no limit for total nitrogen, but monitoring is required. The City of Monmouth's NPDES Permit (No. IL0036218) has required the City of Monmouth to meet an effluent total phosphorus (as P) monthly discharge permit concentration of 1.0 mg/L since September 27, 2010. Monmouth both constructed a new WWTF (the Consolidated WWTF) and upgraded a chemical dissolved air flotation process at the North Plant in order to meet this requirement. Monmouth has demonstrated consistent compliance with this limit since implementing the required upgrades.

3.1 Ammonia Nitrogen

The monthly average discharge limit for ammonia nitrogen varies depending on the month. The monthly limit for March through May, September, and October is 1.5 mg/L measured as nitrogen. The monthly limit for June through August is 0.9 mg/L. The monthly limit for November through February is 3.0 mg/L. Monmouth's WWTFs currently meet the ammonia nitrogen limits, and the NARP is not focused on ammonia nitrogen. Therefore, ammonia nitrogen will not be discussed further in this report.

3.2 Total Nitrogen

The permit requirement for total nitrogen is only monitoring. Since no limit exists, total nitrogen will not be discussed further in this report.

3.3 Total Phosphorus

The City of Monmouth's WWTFs currently meet its monthly average total phosphorus limit of 1.0 mg/L reported as phosphorus via chemical addition in the North Plant DAF unit as well as through chemical addition at the Consolidated WWTF's oxidation ditch.

3.4 Future Limits

Based on the special requirements in the NPDES permit, this NARP assesses the potential to reduce phosphorus discharge from the City of Monmouth's WWTFs to meet a future limit of 0.5 mg/L total phosphorus 12 month rolling geometric mean. This NARP does not evaluate potential future lower limits such as 0.1 mg/L which has been enforced in other states, nor does it evaluate any reduction in nitrogen discharge. Permit Requirements

The City of Monmouth's NPDES permit has four special conditions focused on phosphorus reduction.

<u>Special Condition 17:</u> States the permittee shall prepare and submit to IEPA a feasibility study identifying the method, timeframe, and costs of reducing phosphorus discharge levels to meet potential future effluent limits of 0.5 mg/L and 0.1 mg/L. The City of Monmouth's feasibility study can be found in Appendix B.

<u>Special Condition 18:</u> States the permittee shall develop and submit to IEPA a Phosphorus Discharge Optimization Plan that includes the evaluation of a range of methods for reducing phosphorus discharges from the WWTF through possible source reduction measures, operational movements, minor facility modifications, and a schedule for the implementation of the plan. The City of Monmouth's Phosphorus Discharge Optimization Plan can be found in the appendix of the feasibility study in Appendix B.

Special Condition 21: Sets a schedule for phosphorus effluent limit with timelines and exceptions. The permittee shall reach an effluent limit of 0.5 mg/L total phosphorus 12 month rolling geometric mean by January 1, 2030, unless the permittee meets the outlined exceptions.

Special Condition 22: States the permittee's WWTF effluent is located upstream of a waterbody or stream segment that has been determined to be at risk of eutrophication and a NARP is required.

TABLE 3-1: SPECIAL CONDITION DELIVERABLES

Special Condition	Deliverable	Date Delivered
18	Phosphorus Discharge Optimization Plan	January 31, 2022
17	Feasibility Study	August 1, 2022
22	NARP	Due: December 31, 2023
21	0.5 mg/L total phosphorus effluent limit enforced	TBD

3.5 Previous Investigations

In August of 2022, Woodard & Curran (W&C) conducted an analysis on the feasibility of the City of Monmouth's WWTFs achieving lower total phosphorus limits to meet Special Requirement 17 of the NPDES permit. The goal of this study was to see if lower phosphorus limits would be possible, both technically and economically. The Feasibility Study concluded that a phosphorus limit of 0.5 mg/L would be technically feasible if the WWTFs used higher chemical dosing and added tertiary filtration at the Consolidated WWTF. This study is included in Appendix B. The economic feasibility of this implementation is discussed further in Section 6.4.

An investigation was performed by W&C to meet Special Requirement 18 of the NPDES permit which was documented to the IEPA in a Phosphorus Discharge Optimization Plan. This investigation determined that there were minimal opportunities to reduce or optimize phosphorus discharge through influent controls or treatment operations. This report is attached as an appendix to the Phosphorus Feasibility Study included in Appendix B.

4. WATERSHED DATA ANALYSIS

4.1 Data Gathering

In order to understand the potential causes for eutrophication that IEPA identified, a Freedom of Information Act (FOIA) request was submitted by W&C to the IEPA on June 27, 2023. The request was for any data and/or maps of sampled locations associated with triggering the NARP requirement for the City of Monmouth's Consolidated WWTF permit. The IEPA responded with a figure showing approximate sampling locations and a data set of the chlorophyll, dissolved oxygen, and pH sampling results covering thirteen locations and nine sampling dates. The data received included two samples of high pH and high dissolved oxygen percentage (DO%) at one sampling location downstream of the Consolidated WWTF discharge out of approximately 173 samples along Cedar Creek and Markham Creek. The data did not indicate what ranges constituted as high pH or DO%; the data was only highlighted in red to show exceedances. It is assumed from the highlights that a pH above 8.35 combined with a DO% above 114.9% constituted an exceedance. The sample data indicating possible eutrophication received from the FOIA request is summarized in Appendix C.

The IEPA data indicated that Cedar Creek showed a potential for eutrophication in 2014. The sampling location showing these indicators was LDD-11, 9 miles directly northwest, and 18 river miles downstream from the City of Monmouth's WWTF discharge. It was determined that additional sampling should be conducted to determine if these indicators would be present closer to the City of Monmouth's discharge and to identify the relative loading of phosphorus from the City of Monmouth's WWTF to Markham and Cedar Creek.

4.2 Stream Sampling

Stream sampling was conducted by W&C on three different days over a two-month span: July 20th, August 3rd, and August 17th of 2023. Samples were taken from five different locations. The relative location of the NARP sampling points and the IEPA sampling points are shown in Figure 1-3. The NARP sampling points shown in Figure 4-1 indicate the surrounding terrain in the satellite imagery. The original sampling plan, included in Appendix D, was to sample at seven locations. This was infeasible due to various reasons, primarily access to the locations. For this reason, sampling Locations D and F are not included in figures or tables since samples were not collected at these locations.

Location A is within Cedar Creek, downstream of its confluence with Markham Creek. Location A was the furthest downstream location where samples were collected. Upstream, Location B is within Cedar Creek, upstream of its confluence with Markham Creek, and therefore should not be impacted by the Consolidated WWTF's outfall. Location C is within Markham Creek, upstream of its confluence with Cedar Creek, but downstream of the Consolidated WWTF's outfall, and therefore could be impacted by effluent concentrations. The Consolidated WWTF's outfall is located near Location E; samples were taken directly from the WWTF's effluent via manhole before it entered an unnamed tributary of Markham Creek. Location G is upstream of the Consolidated WWTF's outfall located within the Gibson Woods Golf Course. Being upstream of the Consolidated WWTF's outfall means Location G is not impacted by the effluent concentrations.

The following constituents were measured at each location:

- Ammonia†
- Organic nitrogen†
- Nitrate†
- Nitrite†
- Phosphates†
- Orthophosphate†
- Total phosphorus†
- Total nitrogen†
- Alkalinity†
- pH*
- Conductivity*
- DO%*

*Measured in the field
†Sample collected/measured in laboratory

Grab samples were collected from downstream to upstream so as not to disturb the stream before sampling. After collecting the grab samples and properly storing them on ice, a multi-meter was used to find pH, conductivity, and DO%. Finally, the stream velocity was recorded at regular intervals along the width of the stream to calculate flow.

4.3 Stream Sampling Results

None of the samples taken triggered the interpreted exceedance values of both pH greater than 8.35 and DO greater than 114.9%. As can be seen in Table 4-1, the pH rarely exceeds 8.3 and the DO rarely exceeds 100%. Location E is an exception which exceeds a DO of 100% saturation. This is expected. As the final step in the treatment process, the Consolidated WWTF uses a cascade aerator to increase the dissolved oxygen in the effluent. The Consolidated WWTF's discharge effluent flows approximately a half mile downstream in an enclosed, gravity pipe system, before discharging into a waterway. This is a sample taken from a manhole across the street from the discharge into the open waterway due to property access concerns. The multimeter was not used on this sample for the first sampling date accidentally. These sampling results indicate the aeration process appears to be meeting its goal.

If eutrophication is occurring, the combination of high DO and pH would be most prevalent at the time of greatest sunlight during the period of maximum photosynthesis, which is assumed to be mid-day. All samples were taken between dawn and 1 pm, beginning with Location A and sampling upstream to Location G. Due to best practices to sample sequentially from downstream to upstream, samples at all locations were not able to be taken at midday. Therefore, it cannot be conclusively stated from pH and DO% results that eutrophication is not occurring. The results also do *not* indicate that eutrophication is strongly occurring.

TABLE 4-1: MULTIMETER SAMPLE RESULTS, PH AND DO

Multimeter Sample Results, pH and DO										
	Location A		Location B		Location C		Location E		Location G	
Date	pH	DO%	pH	DO%	pH	DO%	pH	DO%	pH	DO%
7/20/2023	7.80	80.2	7.11	82.0	7.05	92.5	NA	NA	6.74	89.1
8/3/2023	8.30	106.0	8.33	98.2	8.30	80.0	8.15	123.0	7.98	88.3
8/17/2023	8.43	89.5	8.29	87.6	8.31	91.4	7.99	102.3	8.13	90.6
Average	8.18	91.9	7.91	89.3	7.89	88.0	8.07	112.6	7.62	89.3

In both Figure 1-3 and Table 4-2, it can be seen that generally loadings increase with flow, which is to be expected. Theoretically, the summation of the loading from Locations E and G should result in the loading at Location C. The summation of the loading at Locations C and B should result in the loading at Location A. Sampled loadings at location C nearly matched the theoretical value for one sampling date, however they were lower on two out of three dates. Several things could contribute to lower sampled loading than anticipated including: uptake by aquatic vegetation or algae, chemical or physical removal through soil adsorption, precipitation and/or settling, and limits of measurement accuracy or error. Further downstream the theoretical loading at Location A varies both higher and lower than the loading as sampled. This indicates there may be an introduction of more phosphorus to the waterway somewhere between the confluence of Markham and Cedar Creek and Location A, but it could also be due to measurement error.

TABLE 4-2: TOTAL PHOSPHORUS LOADING

Phosphorus, Total (as P)							
Date	Location A (lbs/day)	Theo-retical A (lbs/day)	Location B (lbs/day)	Location C (lbs/day)	Theo-retical C (lbs/day)	Location E (lbs/day)	Location G (lbs/day)
7/20/2023	95.85	100.21	86.94	13.27	24.84	22.22	2.62
8/3/2023	86.11	69.89	63.64	6.25	6.27	4.92	1.35
8/17/2023	138.29	106.48	89.07	17.42	27.26	23.43	3.83
Average	106.75		79.88	12.31		16.85	2.60
Std Dev.	27.74		14.11	5.64		10.36	1.24

The concentration of phosphorus at all sampled locations and all dates is less than 1.0 mg/L. This sampling confirms the operation of the WWTF within current permitted parameters. It is interesting to note that flow rates were generally lower on the August 3rd, 2023 sampling date, however this did not impact the overall trend of higher concentration within Cedar Creek. Total phosphorus concentrations were generally lower within Markham Creek (Locations C, E, and G), than within Cedar Creek (locations A and B). One potential explanation for this could be additional loading from upstream sources, both point and non-point. As GSD's WWTF is upgraded, this loading may change.

TABLE 4-3: TOTAL PHOSPHORUS (AS P) CONCENTRATION AND FLOW RESULTS

Total Phosphorus (as P) and Flow Results										
	Location A		Location B		Location C		Location E		Location G	
Date	TP (mg/L)	Flow (cfs)	TP (mg/L)	Flow (cfs)	TP (mg/L)	Flow (cfs)	TP (mg/L)	Flow (cfs)	TP (mg/L)	Flow (cfs)
7/20/2023	0.49	36.0	0.52	31.3	0.34	7.2	0.63	6.5	0.14	3.6
8/3/2023	0.71	22.4	0.79	15.0	0.27	4.3	0.30	3.0	0.17	1.5
8/17/2023	0.40	64.0	0.43	38.9	0.36	8.9	0.61	7.1	0.18	4.0
Average	0.54	40.8	0.58	28.4	0.32	6.8	0.52	5.5	0.16	3.0

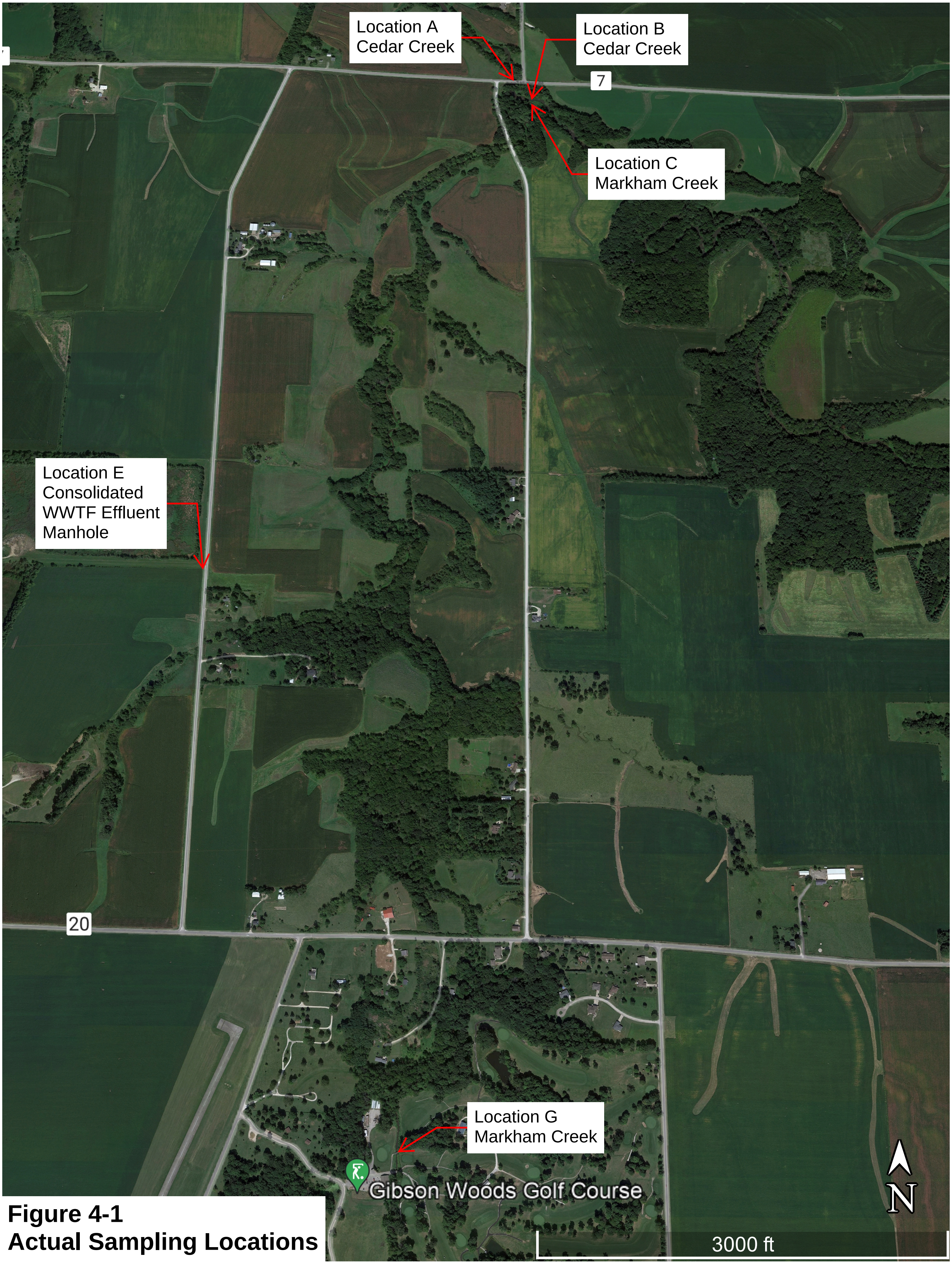


Figure 4-1
Actual Sampling Locations

5. TREATMENT APPROACH AND ECONOMIC EVALUATION

Based on the information presented in the previous sections, the evaluation following will be focused on the scenario to meet an effluent discharge of 0.5 mg/L total phosphorus at the Consolidated WWTF. Point and non-point sources are not considered in this evaluation. This evaluation draws information from the previous feasibility study found in Appendix B. By determining the potential treatment approach and developing a cost estimate, the impact to the City of Monmouth's residents can be determined. For projects with a high cost impact to the residents of the City of Monmouth, the benefit should also be demonstrably high.

5.1 Possible Treatment Technology

Alternative treatment technologies were discussed in the Phosphorus Feasibility Study in Appendix B. In summary, due to the high proportion of industrial flow, the characteristics of the influent to the Consolidated WWTF are such that it is not amenable to biological nutrient removal. The City of Monmouth currently uses chemical addition to precipitate phosphorus from the wastewater. To reliably reduce the total phosphorus to below 0.5 mg/L as opposed to the current limit of 1.0 mg/L would require an exponential increase in chemical use, as well as the implementation of tertiary filtration into the treatment train. The new facility would be located on the Consolidated WWTF site. One potential layout for the filtration technology is shown in Appendix E. According to the USEPA's *Nutrient Control Design Manual* (2010), reliably achieving phosphorus limits below 0.5 mg/L often requires tertiary filtration (pp. 3-6 and 8-10). For the purposes of this report, it is assumed that tertiary filtration is required.

5.2 Capital Costs

Capital costs for implementing tertiary filtration with increased chemical dosing were estimated for this report. An itemized capital cost estimate can be found in Appendix F. This cost estimate includes cloth media disc filtration units, and other items necessary to implement the filters including, a building to house the filtration units, a chemical cleaning system, piping and fittings, concrete structures, instrumentation/SCADA, site work, and labor. The cost for a pilot study for chemical optimization is also included to see if changes can be made on where the chemical is added to aid in the phosphorus precipitation. The filter and chemical cleaning system equipment costs were provided by WesTech; see Appendix G for WesTech proposal. Unit prices were based on previous costs from other W&C projects. Engineering fees, a 30% construction contingency, and other indirect costs were included in the capital cost estimate. The capital cost estimate has been adjusted to 2027 dollars which is the estimated time that the project would be bid if the NARP determined this project was beneficial and necessary for the watershed. The capital cost estimate is $10.7 million. It is assumed the City of Monmouth would apply for a State Revolving Fund (SRF) loan in order to fund this implementation. User rates would increase to help pay off the SRF loan.

5.3 Operation and Maintenance Costs

The operation and maintenance (O&M) cost estimate includes costs associated with the additional supplies, equipment, and labor needed if a phosphorus limit of 0.5 mg/L were implemented. An itemized cost estimate can be found in Appendix H. Major items include additional ferric sulfate solution, waste disposal, replacement parts, and routine maintenance of mechanical and SCADA systems. Chemical calculations were performed to determine the quantity of additional chemical required. To reduce the discharge concentration by half requires more than doubling the chemical. The ratio of how much ferric sulfate is needed to precipitate phosphorus out of the water is not linear. The probable ratio of ferric sulfate solution to effluent Total P to achieve 0.5 mg/L total P is 1.75 as shown in Figure 6-1 (adopted from Metcalf & Eddy, Wastewater Engineering 5th ed.). The estimated amount of ferric sulfate needed to meet the 0.5 mg/L phosphorus limit was calculated to be approximately 235 gallons per day; that is approximately 175 gallons per day more than what is currently used. Calculations on ferric sulfate dosing can be found in Appendix J.

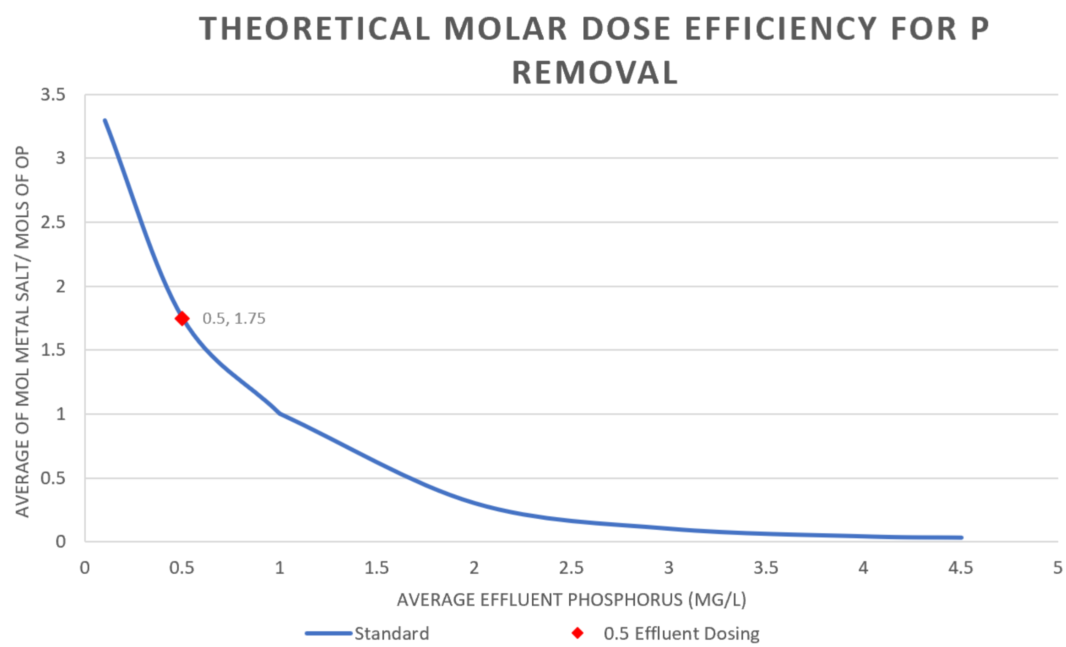


FIGURE 5-1: THEORETICAL MOLAR DOSE EFFICIENCY FOR PHOSPHORUS REMOVAL

Calculations on sludge production were also completed to determine the amount of additional sludge the WWTF would have to process due to an increase in phosphate precipitates. The sludge production rates resulting from the current and future theoretical phosphorus limits (1.0 and 0.5 mg/L, respectively) were calculated. The current rate was subtracted from the future theoretical rate resulting in an additional sludge production rate of approximately 619 pounds per day (ppd). This future sludge production rate adds up to approximately 113 additional tons per year of sludge needing processing. Calculations for sludge production can be found in Appendix K.

Replacement parts and time required to work on the filter units was based on an operational manual provided by WesTech. The O&M cost estimate totals $135,000 annually. Dedicated funds would have to be identified for these costs out of the City of Monmouth's budget.

5.4 Economic Evaluation

The following section details the economic impacts on the City of Monmouth for implementing treatment systems to meet NARP requirements. This evaluation follows the USEPA's 2023 Clean Water Act (CWA) Financial Capability Assessment (FCA) Guidance released in February 2023, used to demonstrate financial impacts to communities and increase the USEPA's consideration of the impacts when negotiating compliance schedules to meet CWA controls. The FCA for the City of Monmouth uses Alternative 1 of the guidance to evaluate financial capability of regulatory driven implementation schedules. This alternative evaluates the City of Monmouth's financial capability through three indicators: the Residential Indicator, the Financial Capability Indicators, and the Lowest Quintile Poverty Indicator Score.

The results of this assessment clearly demonstrate that the costs associated with meeting 0.5 mg/L total phosphorus discharge requirements will create substantial difficulties for the City of Monmouth for the time period evaluated. The overall findings indicate this project will have a high financial impact for the City of Monmouth, following the benchmarks and ranges established by the USEPA in this guidance. The components leading to this overall score are detailed below and the calculations for the full evaluation can be referenced in Appendix L.

The Residential Indicator Impact for the City of Monmouth is "High" which indicates that the costs to meet the lower discharge limit have a substantial financial impact on residential users. This indicator is the City of Monmouth's average cost per household for wastewater treatment and CWA controls as a percentage of Median Household Income (MHI). The City of Monmouth's annual cost per household would be 3.73% of MHI, reflecting a high financial impact. This is a 12% increase to support the construction, operation and maintenance of chemical addition and filtration for phosphorus removal.

The Financial Capabilities Indicators for the City of Monmouth reflect a "Mid-Range" score of 2.33. This is an overall score generated from six indicators which examine the City of Monmouth's debt burden, socioeconomic conditions, and financial operations.

The Lowest Quintile Poverty Indicator for the City of Monmouth reflects a "Medium" impact score of 1.6. This is the overall weighted score of six poverty indicators. The indicators (except trend in household growth) are evaluated using a +/- 25% benchmark to national values. The components include the upper limit of lowest quintile income, percentage of population with income below 200% of the Federal poverty levels, percentage of households receiving Food Stamps/SNAP benefits, percentage of vacant housing units, trend in household growth, and percentage of unemployed population 16 and over in civilian labor force.

As shown in Appendix L, Exhibit 3, the overall result of these components when compiled in the FCA matrix reflect a High Impact to the City of Monmouth. This result illustrates that the costs to comply with a 0.5 mg/L TP effluent discharge will have a high financial impact to the City of Monmouth and create an undue burden for its residents, at this point in time.

6. CONCLUSIONS & RECOMMENDATIONS

6.1 Conclusions

Sampling data provided by IEPA is limited and suggests there may be eutrophication occurring downstream from two major point sources, the City of Monmouth and GSD. Additional sampling performed on the City of Monmouth's behalf does not show strong evidence of an imminent eutrophication problem closer to the point sources. The majority of the phosphorus load to the identified location of potential eutrophication comes from the major branch of Cedar Creek, due to higher flows and phosphorous concentration as compared to the tributary of Markham Creek. GSD discharges into Cedar Creek and is actively constructing upgrades to the WWTF to reduce phosphorus discharges. It is reasonable to conclude that phosphorus loading to the creek will substantially change at the conclusion of that project.

6.2 Recommendations

It is recommended to gather additional sampling data to establish a baseline for the watershed and compare this to the impacts anticipated with the construction of the upgraded WWTF for GSD. The City of Monmouth would also like to establish a partnership with GSD and other interested parties to develop and fund a mutually beneficial sampling plan.

6.2.1 Continue Development of Watershed Group

On October 26th, 2023, GSD and the City of Monmouth hosted an Inaugural Watershed Group Meeting. The purpose of this meeting was to introduce the concept of the NARP to stakeholders in the watershed. Additionally, some stakeholders expressed an interest in remaining informed about ongoing progress. Contact information was gathered through sign in sheets. Meeting sign-in sheets and notes are attached in Appendix A.

The City of Monmouth and GSD have agreed to work together as the two permit holders in the watershed with the largest flows and the only two with NARP permit requirements. However, the NARP permit requirements are due a year apart. Therefore, both the City of Monmouth and GSD have committed to developing their own initial NARP. Subsequently, both NARPs can be combined and coordinated into one living document.

6.2.2 Continue Data Sampling

The data collected by W&C was sufficient for the purposes of this high-level preliminary report. The City of Monmouth would like to develop a sampling plan in conjunction with GSD during 2024. Sampling during 2024 and 2025 will provide a baseline of current conditions. Sampling should continue for several years after GSD implements its biological nutrient removal systems. Sampling results will then be analyzed to determine the impact of the upgraded WWTF and whether reduced total phosphorus discharge from the City of Monmouth's WWTF would improve stream water quality without causing undue financial hardship on the residents of the City of Monmouth.

6.3 Capital Improvements

For all of the reasons discussed above, capital upgrades are not recommended at this time. Based on the economic evaluation, capital upgrades would have a high impact to the residents of the City of Monmouth, and the evidence for eutrophication within Cedar Creek is limited. The City of Monmouth WWTFs are already using chemical addition to remove phosphorus to 1.0 mg/L or less. This correlates with the stream sampling results, which indicated that more of the phosphorus load is occurring upstream along Cedar Creek than Markham Creek. Along Cedar Creek, GSD is upgrading their WWTF to reduce phosphorus load. The recommendation to proceed with watershed group development and coordinated stream water quality monitoring will determine if the need for additional capital improvements at the City of Monmouth WWTFs after GSD's capital improvements is greater than the financial impact to the residents of the City of Monmouth. This will allow the City of Monmouth to use its limited resources in the most efficient means possible to protect water quality.

APPENDIX A: NARP INAUGURAL WATERSHED GROUP MEETING NOTES & SIGN-IN SHEET

MEETING AGENDA NUTRIENT ASSESSMENT REDUCTION PLAN WATERSHED GROUP

MEETING DATE AND TIME: October 26th, 2023 at 1:30 PM

HOSTS: City of Monmouth and Galesburg Sanitary District

LOCATION: The Galesburg Sanitary District, 2700 West Main Street, Galesburg, Illinois 61401

Attendees – See Sign In Sheet

Meeting Objectives

1. Provide Background on NARP requirements.
2. Determine Interested Parties

Agenda

1. Introductions
2. National Pollutant Discharge Elimination System Permit Cycle Overview
3. NARP Requirements

    a. "Cooperate with and work with other stakeholders in the watershed to determine the most cost-effective means to address the risk of eutrophication."

    b. "The NARP shall identify phosphorus input reductions from point sources and non-point sources in addition to other measures necessary to remove the risk of eutrophication characteristics that will cause or may cause violation of a water quality standard."

    c. Monmouth NARP is due Dec. 31, 2023

    d. Galesburg NARP is due Dec. 31, 2024

Discussion

Both the City of Monmouth and Galesburg Sanitary District have NPDES (National Pollutant Discharge Elimination System) Permits. These are part of a federal system that allows an entity to discharge pollutants to the environment. These limit what can be discharged and provide additional specific requirements for the entities that are permitted. These are renewed every five years and re-evaluated during that process.

The USEPA issues federal guidance which is promulgated via the state. The USEPA has required that states address nutrient pollution, which is the discharge of phosphorus and nitrogen. This often occurs in non-point sources, but the current regulations from the state are addressing point sources, specifically the wastewater treatment plants throughout the country.

Environmental groups sued Illinois Environmental Protection Agency (IEPA) and Metropolitan Water Reclamation District (MWRD) of Chicago alleging that IEPA has not done sufficient work to regulate nutrients and MWRD and discharging more nutrients than should be allowed.

In 2015, the court ruled in favor of environmental groups. This led to greater negotiations to develop an agreeable course of action and prevent further lawsuits. Part of this negotiation focused the nutrient of concern to be Phosphorus, which can be found in higher concentrations from WWTFs compared to nitrogen which predominates in farmland runoff.

Permit language was developed which requires all major dischargers (with exceptions in some circumstances) to reduce their phosphorus discharge to 0.5 mg/L P starting in the year 2030. This is a compromise both on who it applies to and what the concentration limit should be. Surrounding states have both higher (1.0 mg/L) and lower (0.1 mg/L) phosphorus discharge limits.

A question was asked regarding if industrial discharge will be regulated on percent removal rather than 0.5 mg/L concentration limit. Crawford, Murphy and Tilly's understanding is that IEPA determined if all major dischargers (including the industrial ones that fit that category) discharge at 0.5 mg/L, then the state of Illinois will achieve the 45% reduction required by the hypoxia taskforce. Therefore, a percent reduction is unlikely. For industries discharging to a publicly owned treatment works (POTW), IEPA is encouraging plants to consider local limits for phosphorus as part of their pretreatment program, but the final decision on how to handle phosphorus will be up to each POTW.

In addition to a phosphorus limit, the compromise also included provisions for addressing nutrients using a watershed-based approach. IEPA is responsible to perform an assessment at each NPDES permit renewal to identify plants that either discharge to a stream with a phosphorus impairment, or plants that discharge to streams at risk of eutrophication. Whenever, IEPA determines that a plant meets one of these criteria they then include an additional permit condition requiring the permit holder to develop a Nutrient Assessment Reduction Plan (NARP) that will evaluate if the stream has an eutrophication issue, and is so what actions should be taken to address it.

Impairments for total phosphorus are based on a narrative condition. Impairments for eutrophication are based on chlorophyll levels, days with very high pH, or days with slightly high pH and over saturation of dissolved oxygen. This phosphorus rule is only being applied in watersheds where IEPA has data to support one or both of these impairments.

From a Freedom of Information Act (FOIA) request, IEPA provided the data used to determine that the City of Monmouth and Galesburg Sanitary District would be subject to this permit requirement. The full data set of the watershed includes one sampling point, 29 miles downstream, that reflects slightly elevated pH and over saturation of dissolved oxygen. This data point, from 2014, has triggered the requirements in both the City of Monmouth and Galesburg Sanitary District's permits.

As a group, the special conditions in the permits, which are the same for the City of Monmouth and Galesburg Sanitary District, were reviewed. Some highlights include:

1. Public Involvement, in the sense that stakeholders involved in the watershed, should cooperate to develop the NARP.
2. Numeric limits for phosphorus that will address the risk of eutrophication should be developed.
3. Projects to address the risk of eutrophication with a schedule of implementation should be identified.
4. If the City of Monmouth and Galesburg Sanitary District do not participate in development of a NARP, then IEPA will mandate a phosphorus discharge limit. There is also a risk of the Environmental Law Center moving forward with their treat to file further lawsuits against communities not in compliance with the compromise agreement.

The City of Monmouth's NARP is due by the end of 2023. The Galesburg Sanitary District's NARP is due by the end of 2024. The intent is to write separate documents at this time. However, both will coordinate and possibly lead toward a future combined NARP that documents ongoing efforts watershed wide.

Galesburg Sanitary District was originally built in 1930 as a trickling filter wastewater treatment facility (WWTF). Trickling Filters are very cost and energy efficient treatment, but they can't do sufficient nutrient removal to meet the limits of today. Galesburg Sanitary District is currently constructing a new WWTF across from the existing WWTF. Galesburg Sanitary District is in the second phase, $23 million, and will be entering the third phase, $30 million, next year. Biological phosphorus reduction and biological nitrogen reduction will be designed for with chemical reduction backup. Galesburg Sanitary District anticipates project completion around 2026. Galesburg Sanitary District finds the NARP requirement to be premature because of these construction projects and the impact they will have on the downstream.

The City of Monmouth has had a phosphorus limit since 2010 and has been meeting a phosphorus discharge of less than 1.0 mg/L. Woodard & Curran on behalf of the City of Monmouth has performed some sampling this summer and preliminary analysis does not indicate eutrophication. Both the City of Monmouth and Galesburg Sanitary District are interested in gathering more data in the near term before committing to any capital upgrades.

Action Items

Woodard & Curran will develop the draft NARP for the City of Monmouth. Woodard & Curran will contact stakeholders who are interested in reviewing, noted at meeting that includes Smithfield, to provide an opportunity to review the draft memo before submission to IEPA.

Crawford, Murphy, & Tilly will develop the NARP for the Galesburg Sanitary District in 2024.

Other

In 2024, the City of Monmouth and Galesburg Sanitary District will collaborate on next steps to comply with this permit requirement.

NUTRIENT ASSESSMENT REDUCTION PLAN WATERSHED GROUP
INTEREST MEETING
OCTOBER 26, 2023 @ 1:30 PM

LIST OF ATTENDEES

NAME	COMPANY	TITLE	TELEPHONE NUMBER	E-MAIL ADDRESS
Terry Taylor	Smithfield	Plant Engineer	309-337-6286	tltaylor@smithfield.com
Bruce Rundle	Smithfield	General Manager	309-255-0000	brundle@smithfield.com
Thomas Lytle	Smithfield	Env. Coordinator	309-642-4989	tlytle@smithfield.com
Andy Jackson	City Monmouth	PW Director	309-734-4026	ajackson@woodardcurran.com
Emma Molburg	USDA-NRCS	Soil Conservationist	309-342-5138	emma.molburg@usda.gov
Cathy Froelich	USDA-NRCS	Soil Conservationist	309-415-0401	cathy.froelich@usda.gov
Connie Cowan	USDA-NRCS	Soil Conservationist	309-734-9308	connie.cowan@usda.gov
Kindra Pruett	USDA-NRCS	Soil Conservationist	309-342-5138	kindra.pruett@usda.gov
Tim Blackwell	IDOA	Conservation Planner	309-342-5138	timothy.blackwell@illinois.gov
Katie Ingle	SWCD (Soil & Water Conserv. District)	Admin + Education Coordinator	309-342-5138	knoxcoilswcd@gmail.com

NUTRIENT ASSESSMENT REDUCTION PLAN WATERSHED GROUP
INTEREST MEETING
OCTOBER 26, 2023 @ 1:30 PM

LIST OF ATTENDEES

NAME	ORGANIZATION	TITLE	TELEPHONE NUMBER	E-MAIL ADDRESS
Kara Downin	Knox. Co. Soil and Water Cons. District	Resource Conservationist	309-342-5138 (Ext. 3)	kara.downin@il.nacdnet.net
Rod Cleair	Knox County Landfill	Director of Solid Waste	305-375-6045	rcleair@knoxcountyil.gov
Josh Gabehart	Foth	Senior Client Manager	309-683-1660	josh.gabehart@foth.com
Justin Harlan	Inn Pro	Operation Manager	309-221-3004	justin@innprousa.com
Nate Davis	CMT	Project Manager	217-572-1137	ndavis@cmtengr.com
Brandi Young	Galesburg Sanitary District	Plant Superintendent	309-343-9087	byoung@gbgsd.org
Marshall Schrader	Galesburg Sanitary District	Superintendent	309-342-0131	marshall@gbgsd.org

NUTRIENT ASSESSMENT REDUCTION PLAN WATERSHED GROUP
INTEREST MEETING
OCTOBER 26, 2023 @ 1:30 PM

<u>LIST OF ATTENDEES</u>

NAME	ORGANIZATION	TITLE	TELEPHONE NUMBER	E-MAIL ADDRESS
Jason Lindquist	Smithfield			jlindquist@smithfield.com
Elizabeth Ardell	BNSF Railroad			eardell@trccompanies.com
Bill Hart	City of Monmouth (W&C)	WWTP Superintendent	309-734-7188	bhart@woodardcurran.com
Jeff Boeckler	Northwater	Principle Water Resource Specialist	309-734-7188	jeff@northwaterco.com
Ted Kratschmer	Northwater	Sr. Environmental Scientist	618-781-6629	ted@northwaterco.com
David Buchannan	Koppers Inc.	Zero Harm Manager	309-343-5157	buchanand@koppers.com
John Meyer	Smithfield			jwmeyer@smithfield.com
Greg Frieden	Woodard & Curran	Area Manager	636-389-6128	gfrieden@woodardcurran.com
Samantha Weidenbenner	Woodard & Curran	Project Manager	636-223-8062	sweidenbenner@woodardcurran.com

APPENDIX B: PHOSPHORUS FEASIBILITY STUDY

PHOSPHORUS FEASIBILITY STUDY

NPDES Permit IL0036218 Special Condition 17

LICENSED PROFESSIONAL ENGINEER
ERIK CJ OSBORN
062-071367
OF ILLINOIS

Date signed: 7/27/2022
Expiration: 11/30/2023

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St. Charles, Missouri 63303
800.426.4262

woodardcurran.com

232960.01

City of Monmouth, IL

August 1, 2022

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TABLES

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1. BACKGROUND

In September 2021, Illinois Environmental Protection Agency (IEPA) issued the final NPDES Permit (No. IL0036218) for the Monmouth Consolidated Wastewater Treatment Facility to discharge to the Waters of the State. The permit was issued with several phosphorus related special conditions. The first step was developing a Phosphorus Discharge Optimization Plan included in Appendix A. The City of Monmouth submitted the Phosphorus Discharge Optimization Report per the permit requirements on January 31, 2022. This Phosphorous Feasibility Study is the second step required by the special conditions. A Nutrient Assessment Reduction Plant (NARP) is due December 31, 2023.

The goal of this Feasibility Study is to identify the feasible alternatives for reducing phosphorus concentration in treated effluent and develop a conceptual cost estimate for each alternative.

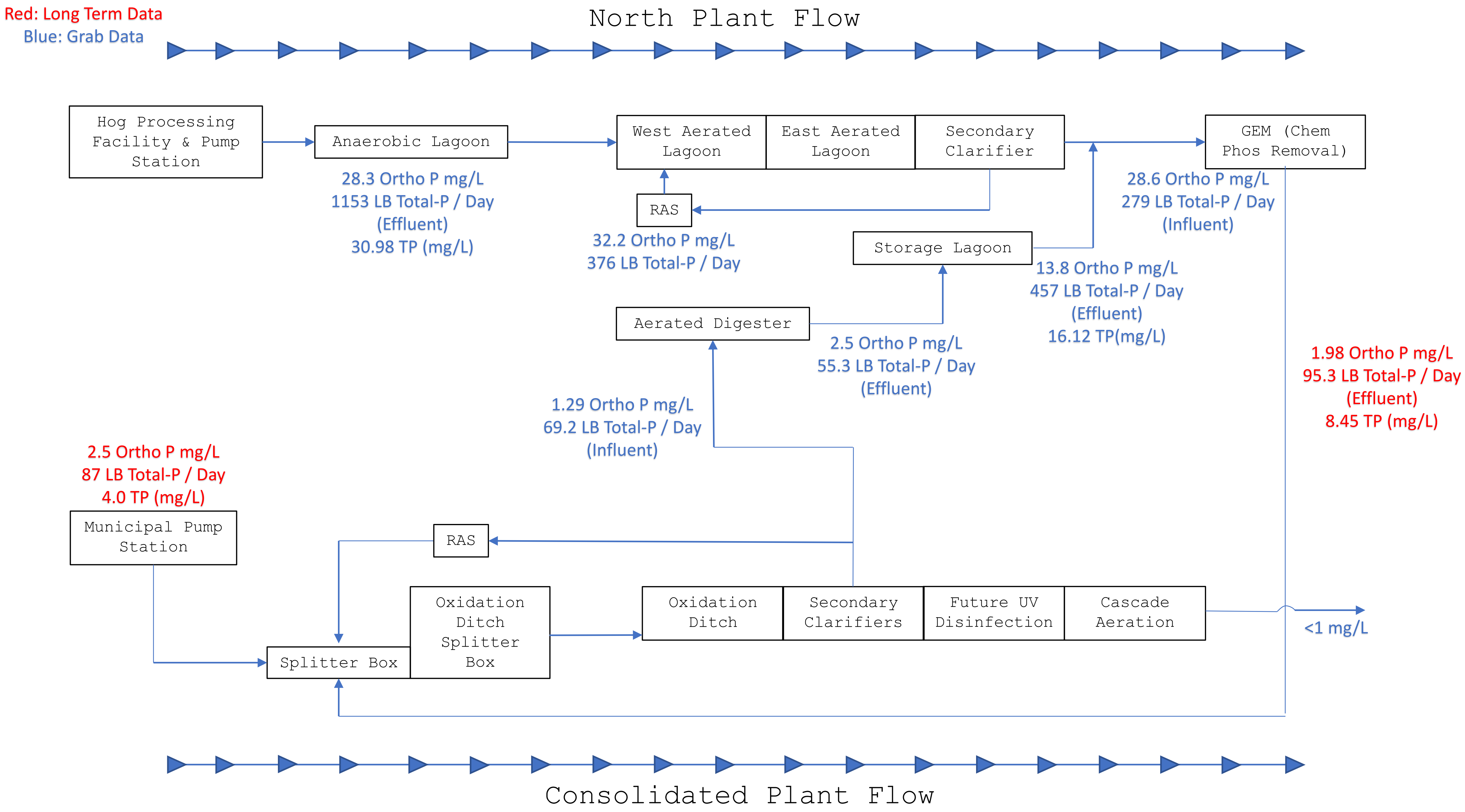
The City of Monmouth (City) owns and operates two wastewater treatment facilities (WWTF); North Plant WWTF and the Consolidated Plant. The North Plant is a pretreatment plant that serves only the Smithfield Foods processing facility (Smithfield), a hog slaughterhouse harvesting roughly 12,000 hogs/day and operating six days/week. The treated North Plant effluent is conveyed to the Consolidated Plant where it is combined with municipal flow pumped from the city.

The existing permit limit for total phosphorus (1.0 mg/L monthly average) is currently being met by chemical addition in the North Plant GEM unit and at the Consolidated Plant oxidation ditch. The permit also sets limits on CBOD and TSS (monthly averages of 10 and 12 mg/L respectively) and ammonia nitrogen. The ammonia limit varies seasonally, from 0.9 mg/L monthly average in the summer to 3.0 mg/L in the winter.

During the Phosphorus Optimization Plan phase, it was determined that both plants are optimized to the best of the operator's ability. Additional plant optimization options are limited based on plant configurations and influent characteristics.

This study will investigate the feasibility of several phosphorus discharge reduction options for Monmouth which include capital upgrades. The feasibility will be based on technical feasibility, spatial feasibility, and economic feasibility. Technical feasibility will be determined by whether the treatment can reduce phosphorus below the IEPA proposed limit given the influent load currently experienced by Monmouth. Spatial feasibility will be determined by whether the treatment option has the space to be installed at the treatment plant. Lastly, economic feasibility will be determined by the capital cost, as well as the reoccurring operation and maintenance cost associated with the treatment option.

Figure 1 indicates phosphorus concentrations and flow paths through the two plants. It is provided as a reference for the discussion to follow.


Red: Long Term Data
Blue: Grab Data
North Plant Flow
Hog Processing Facility & Pump Station
Anaerobic Lagoon
28.3 Ortho P mg/L
1153 LB Total-P / Day
(Effluent)
30.98 TP (mg/L)
West Aerated Lagoon
East Aerated Lagoon
Secondary Clarifier
RAS
32.2 Ortho P mg/L
376 LB Total-P / Day
GEM (Chem Phos Removal)
28.6 Ortho P mg/L
279 LB Total-P / Day
(Influent)
Storage Lagoon
13.8 Ortho P mg/L
457 LB Total-P / Day
(Effluent)
16.12 TP(mg/L)
Aerated Digester
2.5 Ortho P mg/L
55.3 LB Total-P / Day
(Effluent)
1.29 Ortho P mg/L
69.2 LB Total-P / Day
(Influent)
1.98 Ortho P mg/L
95.3 LB Total-P / Day
(Effluent)
8.45 TP (mg/L)
2.5 Ortho P mg/L
87 LB Total-P / Day
4.0 TP (mg/L)
Municipal Pump Station
RAS
Oxidation Ditch Splitter Box
Splitter Box
Oxidation Ditch
Secondary Clarifiers
Future UV Disinfection
Cascade Aeration
<1 mg/L
Consolidated Plant Flow

2. PHYTOREMEDIATION PHOSPHORUS REMOVAL METHODS

The Monmouth WWTFs are located near several large storage lagoons which grow algae successfully. Therefore, several phytoremediation (plant-based treatment) techniques were investigated to determine if they could work to reduce Monmouth's phosphorus discharge.

2.1 Open Water Based Treatment

The first plant-based alternative considered is open water-based treatment technology which consisted of High-Rate Ponds and Constructed Wetlands. Both require a large footprint, and the existing lagoons could potentially be repurposed to grow algae for nutrient removal. However, the removal of algae from large scale surface water lagoons is challenging to the point of infeasibility. Constructed Wetlands require periodic re-construction. Approximately every 3-5 years, depending on site factors including loading, the plants and soil material must be excavated and rebuilt. Both Constructed Wetlands and High-Rate Ponds add new biomass management challenges for disposal of the plants and soil or algae biomass.

Phytoremediation phosphorus removal depends on the season. This temperature variability affects the ability to meet permit limits consistently. During winters, the phosphorus removal efficiency reduces.

Both of these technologies discussed herein are used for primary phosphorus reduction, and it is not typically used for targeted phosphorus removal. Monmouth is attempting to reach a specific target level and is already achieving phosphorus removal through their current plant with chemical addition. Therefore, these techniques are not optimal for further reducing Monmouth's phosphorus below 1.0 mg/L.

2.2 In-Vessel Algae treatment

The second algae-based treatment alternatives considered were in-vessel technologies; I-Phyc and Clearas Resource Recovery System. The two technologies require a smaller footprint as compared to open water based treatments and require more energy. These technologies would be installed in a large building and currently, the facility does not have the space. Both these technologies have been tested at pilot-scale. I-Phyc is currently only available in the UK and is setup at pilot-scale. Clearas Resource Recovery System has been installed on a larger scale once (according to their website) and shows 95-99% removal at pilot-scale, however we do not have enough information on the technology to recommend it.

It is useful for Monmouth to continue to monitor these emerging technologies as they are tested at larger scales and their long term reliability and operating costs are better understood.

3. ENHANCED BIOLOGICAL PHOSPHORUS REMOVAL

Enhanced biological phosphorus removal (EBPR) is a common treatment method for reducing phosphorus effluent. Employing this technique at Monmouth could help reduce the costs associated with chemical removal. This section reviews the requirements for EBPR and discusses the feasibility of its implementation at Monmouth.

EBPR takes advantage of the ability of certain bacteria to accumulate high amounts of phosphorus under the right conditions. These phosphorus-accumulating organisms (PAO) can use stored phosphorus as an energy source for uptake of volatile fatty acids (VFA) under anaerobic conditions. When the PAO move to aerobic conditions, they use this stored carbon for metabolism and, importantly, uptake of additional phosphorus. Stored phosphorus is removed from the system with the waste sludge.

EBPR is implemented by creating an anerobic zone in the treatment process. This zone encourages the growth of PAO and can also be used for fermentation of organic carbon to generate additional VFA. The anerobic zone can be inserted either into the forward flow, typically as the first step in the secondary process, or into the RAS stream. The latter option is known as "side stream" EBPR and has the advantages of requiring less volume and being less susceptible to influent variations.

Several factors impact the performance of EBPR:

Carbon-to-Phosphorus Ratio: There must be sufficient carbon (in the form of VFA) available for uptake by the PAO. A BOD to TP ratio of 20:1 is typically required.

Anerobic Conditions: The presence of either dissolved oxygen or nitrate in the anaerobic zone will inhibit EBPR.

SRT: Long SRT processes such as oxidation ditches have higher levels of endogenous decay. When micro-organisms including PAO break down, they release their stored phosphorus. This reduces the effectiveness of EBPR.

Secondary Clarifier Performance: Clarifier sludge blankets should be minimized to prevent anaerobic conditions that could cause PAO to release stored phosphorus into the secondary effluent. Clarifier solids capture performance also needs to be effective. Because secondary solids from EBPR contain a high level of phosphorus, even a modest effluent TSS concentration can result in an elevated effluent TP concentration. Chemical addition ahead of the secondary clarifiers can be helpful for precipitating any remaining dissolved phosphorus and minimizing effluent TSS.

Solids Handling: Waste-activated sludge should be processed and removed from the plant quickly to prevent breakdown of PAO and phosphorus release. Long term storage and/or digestion should be avoided.

3.1 Feasibility of EBPR at Monmouth

High nitrate concentrations present in both the North Plant and Consolidated Plant pose a challenge for implementing EBPR at Monmouth. Table 1 shows concentrations of wastewater constituents, including nitrate, in both plants. This table is based on dry weather periods in 2021. It was first presented in the Optimization Study and is included here for reference.

Table 1: Influent and Effluent Concentrations [mg/L]

Parameter	Average			5th Percentile			95th Percentile		
	Muni* Influent	NP Effluent	CP Effluent	Muni Influent	NP Effluent	CP Effluent	Muni Influent	NP Effluent	CP Effluent
Total P	3.08	9.86	0.77	1.20	2.7	0.4	5.20	24.4	1.15
BOD	77.0	18.4	NS	19.5	5.0	NS	166.5	56.45	NS
CBOD	NS	NS	2.36	NS	NS	1.0	NS	NS	4.45
TSS	145.0	145.9	11.0	45.0	50.4	6.0	292.5	317.6	16.8
NH_3-N	7.69	13.1	0.24	1.67	0.57	0.0	15.35	41.3	0.87
NO_3-N	NS	80-100[1]	21	NS	NS	3.6	NS	NS	39

* Muni = Municipal, NP = North Plant, CP = Consolidated Plant, NS = Not Sampled

[1] Operator Estimated value from historical sampling

The North Plant effluent has high nitrate concentrations typically between 80 and 100 mg/L. The North Plant RAS will have similar concentrations, which makes it infeasible to perform EBPR at the North Plant. With the recently improved aeration controls at the North Plant, operators have had some success in reducing nitrate concentrations in the effluent, though performance has been inconsistent and additional pilot testing would be necessary to validate this approach.

The nitrate in the North Plant effluent would also impact the ability to perform EBPR at the Consolidated Plant. Nitrate in the municipal influent was not sampled, but is typically near zero for municipal wastewater. The municipal average flow of 4.62 MGD is nearly three times the North Plant's weekday average flow of 1.65 MGD (per the Optimization Study). Even at this dilution rate, the combined influent has a nitrate concentration of 20 to 25 mg/L, which is too high for influent to an anaerobic zone. The RAS also has a nitrate concentration of approximately 20 mg/L (based on the effluent nitrate) and would not help dilute the influent.

Another possibility would be to create an anaerobic zone that receives only municipal influent. Low influent nitrate and a more favorable BOD:TP (calculated to be 24:1 in the Optimization Study) make this a potentially attractive option. North Plant effluent could be step-fed into the process after the anaerobic zone. High nitrate in the Consolidated Plant RAS would still preclude this option, however.

Nitrate in the Consolidated Plant RAS could be reduced by adding biological nitrogen removal, but this would involve significant process upgrades. Successful EBPR would also likely require solids handling upgrades to move from the current practice of long-term storage to mechanical thickening/dewatering for more rapid processing. Combined with the upgrades necessary for EBPR, these projects would represent a significant capital cost. Carbon addition would also likely be required to perform both biological N and P removal. The result would be an unacceptably long payback based on chemical savings. Implementing EBPR is not recommended at this time.

4. CHEMICAL PHOSPHORUS REMOVAL METHODS

4.1 Struvite Recovery

Struvite is a crystal that forms when magnesium is introduced to phosphorus. Struvite recovery is a method of phosphorus removal in which magnesium (typically magnesium chloride or magnesium oxide) is added to the wastewater stream in order to react with phosphorus and create struvite crystals. These crystals can then be filtered out of the reactor and used or sold as fertilizer. Two companies are currently manufacturing processes that optimize this natural precipitation to remove phosphorus from the liquid stream. These companies are Ostara and NuReSys.

Ostara manufactures a struvite recovery system using fluidized bed crystallization reactor that is added onto either a main or side stream flow. The reactor adds magnesium to the stream with controlled pH in order to precipitate out the phosphorus. The struvite crystals then sink to the bottom of the reactor to be removed. If applicable, Ostara offers equipment that can release phosphorus in the stream before it reaches an anerobic digester. Ostara's system also produces distribution ready fertilizer with guaranteed buyers.

NuReSys offers a similar product to Ostara but emphasizes the combination of a stripper and a crystallizer, in which the stripper will regulate the pH of the system while the crystallizer precipitates out the phosphorus with magnesium chloride. NuReSys's system can be applied on the centrate after the stream has been dewatered, on the digestate before the dewatering occurs, or applied on a combination of both.

After speaking with Ostara and NuReSys representatives, the phosphorus concentration present in Monmouth influent and recycle streams is too low to be practical for phosphorus reduction via struvite precipitation. The influent phosphorus concentration is required to be around 100 mg/L for struvite recovery to be an appropriate recommendation. It typically provides an effluent of around 20 mg/L Ortho-P. Given that Ortho-P concentrations in Monmouth's system do not exceed 40 mg/L, struvite recovery is an unlikely option to fit the needs of Monmouth. It would have high capital costs to implement, ongoing magnesium chemical costs, and could only reduce the influent phosphorus at North Plant to a portion of the reduction the plant is already achieving.

4.2 Conventional Metal-Salt Precipitation

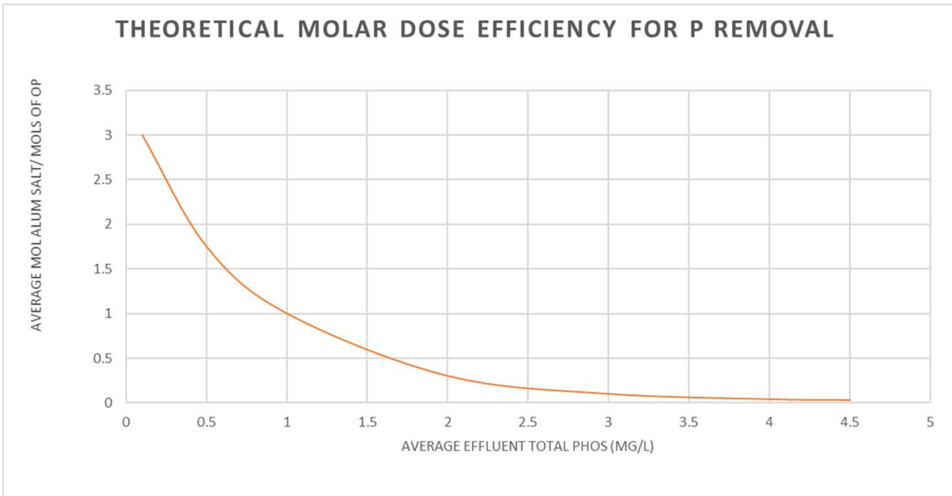
Phosphorus is currently removed from the two facilities using chemical precipitation. At the North Plant, this occurs in a proprietary process called GEMs. The GEMs process combines chemical addition with advanced air-floatation solids removal. At the Consolidated Plant, the chemical is injected in the second ring of the oxidation ditch just after the mixers. The operators used aluminum sulfate at both the North Plant and the Consolidated Plant. However, aluminum sulfate (alum) was replaced by ferric sulfate earlier this year due to rising chemical costs for sodium aluminate. Aluminum sulfate was replaced with ferric sulfate at the North Plant in March 2022 and at the Consolidated Plant in May 2022.

There are several parameters that may affect phosphorus removal including pH, TSS, dosing location, alkalinity, mixing and chemical oxidation demand (COD). The operators can most easily control the dosing and mixing. Therefore, these two parameters were investigated to improve phosphorus removal through evaluation of dosing and mixing.

4.2.1 Existing Chemical Treatment

To understand the effectiveness of current chemical treatment for phosphorus removal, chemical dosage and effluent phosphorus concentration data was analyzed from January 2021 to May 2022. This data was compared to the standard plot from Metcalf & Eddy, which provides guidance on the theoretical molar dose efficiency for phosphorus removal, shown in Figure 2.

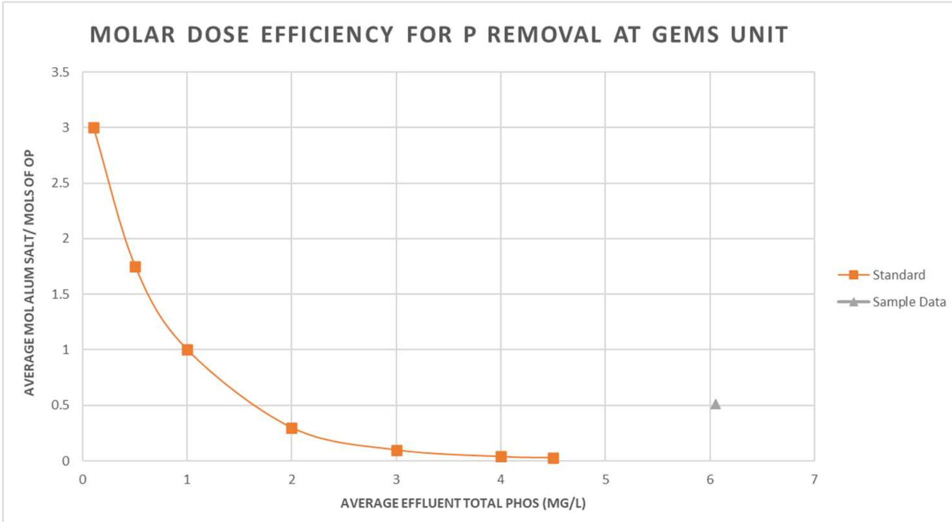
Figure 2: Theoretical Molar Dose Efficiency for P Removal



The horizontal axis shows the average effluent total phosphorus concentration, and the vertical axis is the chemical dosage. The dosage is calculated based on applied chemical per influent phosphorus concentrations. This curve was used as a benchmark to gauge the effectiveness of the current chemical dosing at Monmouth.

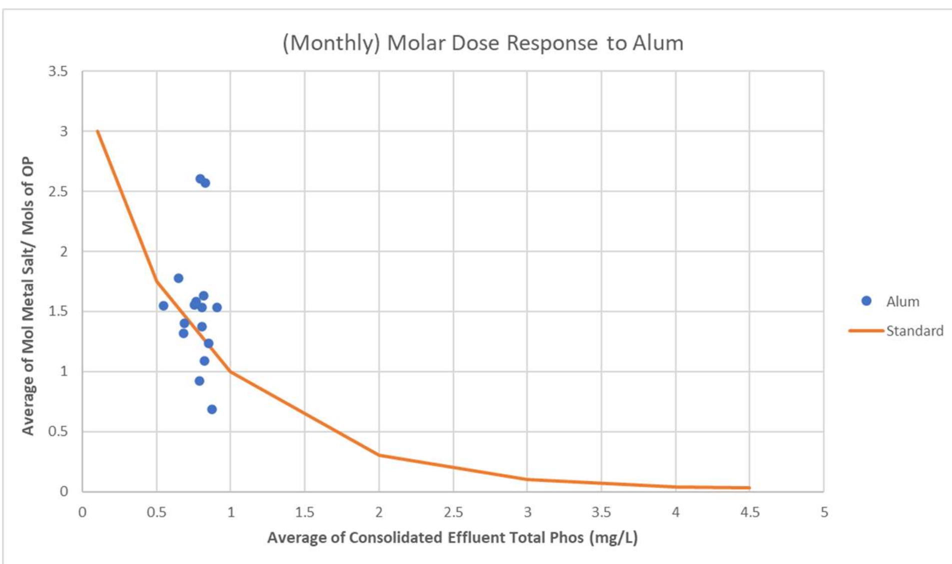
At the North Plant, the influent phosphorus data is not recorded, thus the operators collected sample data over a two week period at the influent of GEMs unit. This helped in understanding the efficiency of phosphorus removal. Figure 3 below indicates that the GEMs unit may not be efficient in phosphorus removal. Though the goal of chemical treatment at the North Plant is to reduce some phosphorus, the dosing required to do so seems high when compared to the theoretical curve. It is beyond the scope of this study to evaluate the GEMs process in detail. However, it can be suggested that further evaluation may be worthwhile.

Figure 3: Molar Dose Efficiency for P Removal at GEMS Unit



Historical data was available to evaluate chemical dosing and phosphorus removal efficiency at the Consolidated Plant. As mentioned above, the operators replaced aluminum sulfate with ferric sulfate on May 12, 2022. The dosage efficiency was compared for both chemicals to the theoretical efficiency. The efficiency of alum was plotted on an average monthly basis, using data for all of 2021 in Figure 4.

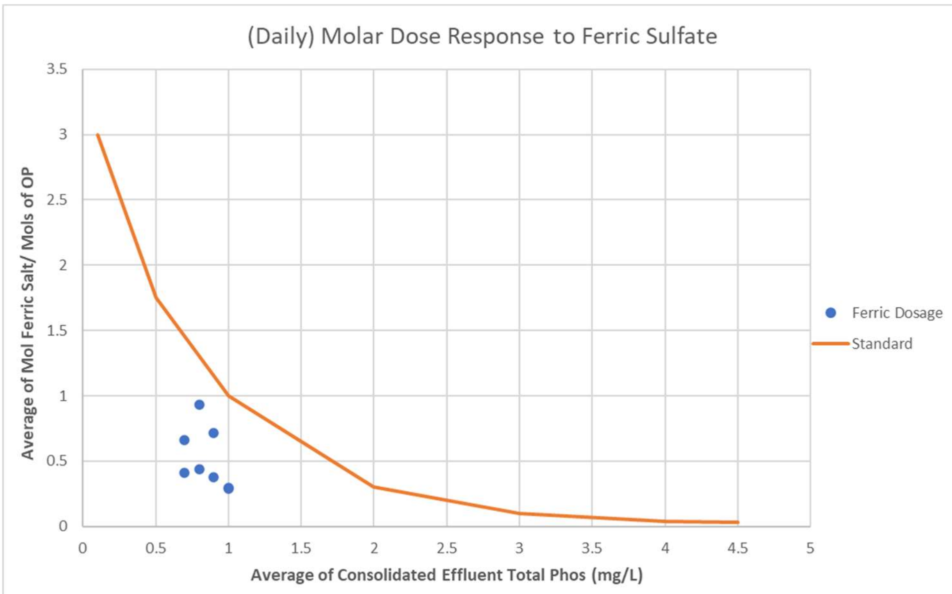
Figure 4: Molar Dose Response to Alum at Consolidated Plant (monthly)



For alum dosing the operators have optimized the dosing process to achieve effluent total phosphorus concentrations between 0.5 and 1 mg/L to reliably meet the current 1.0 mg/L TP permit limit. These concentrations are achieved by doses that generally match what the standard curve would predict. There are two dosing points that are higher than average without a corresponding drop in effluent TP concentration. This may suggest that there are other limiting factors such as inadequate mixing to improve reduction through chemical addition, though there is insufficient data to draw any firm conclusions.

Since the operators started using ferric sulfate recently, there is limited data available. Therefore, this plot shows daily data. From the figure below for ferric sulfate, the effluent total phosphorus concentrations between 0.5 and 1 mg/L are achieved with lower doses. This chemical appears to be more efficient on a molar basis at removing TP, with doses generally less than what would be predicted by the curve.

Figure 5: Molar Dose Response to Ferric Sulfate at Consolidated Plant



4.2.2 North Plant Chemical Optimization

As mentioned above, due to limited availability of data on North Plant influent phosphorus concentrations, it was not possible to conclusively determine dosing efficiency. Currently, Monmouth is using a lower dose of ferric sulfate and receiving comparable results to the higher dose of aluminum sulfate. It is a recommendation to review the GEMs operation by continuing to sample the influent phosphorus concentrations and effluent phosphorus concentration against the dosing of ferric sulfate. The unit is complicated to operate and energy intensive. The GEMs unit is also approaching obsolescence, and it may be beneficial to evaluate other approaches for phosphorus reduction by chemical treatment such as a different tertiary treatment technology and/or adding chemical ahead of the secondary clarifiers.

4.2.3 Consolidated Plant Chemical Optimization

At the Consolidated Plant, from the figure above, it appears that the ferric sulfate is able to reduce phosphorus concentrations to meet the current permit limit of 1 mg/L at lower doses. However, to reduce the concentrations further below 0.5 mg/L, some optimization may be required.

Currently, the chemical is dosed in the second ring of the oxidation ditch immediately downstream of one set of aerators. Mixing at this location is likely to be less than optimal. Moving this dosing location upstream of the aerators could provide better mixing of chemical in the oxidation ditch. Another option is to move the dosing location to the oxidation ditch overflow box to provide natural turbulence closer to the clarifiers. If the turbulence is not sufficient, adding a chemical mixer could help. It is recommended to pilot test these options to better understand the phosphorus reduction efficiency.

4.3 Enhanced Solids Removal

Enhanced solids removal is the removal of effluent solids particles, either by using some method of filtration or by improving clarification. Enhanced solids removal is necessary to reduce phosphorus below a 0.1 mg/L phosphorus limit, and may also be required to reliably meet an effluent limit of 0.5 mg/L. This is due to the amount of phosphorus that gets accumulated in the solids, which then becomes difficult to remove with chemical treatment methods alone.

Enhanced solids removal in other systems has seen success, in optimal settings, bringing phosphorus concentrations to as low as 0.02 mg/L when testing filtered effluent flow according to Metcalf and Eddy, 4th Edition. Therefore, the addition of either filtration or upgrades to clarifiers have the possibility to reduce phosphorus concentrations below 0.1 mg/L. Both methods, filtration and clarifier upgrades, were considered for the Consolidated Plant.

4.3.1 Clarifier Upgrades

The secondary clarifiers at the Consolidated Plant were evaluated for upgrades to improve performance. They are center feed Tow-Brow mechanisms. They have energy dissipating inlets and Stamford baffles. These clarifier mechanisms are in good working order and, with these features, are already optimized for good solids removal performance. The only upgrade Monmouth is considering for the clarifiers is the addition of launder covers to reduce the formation of algae over the peripheral weir. These are intended to be installed with a UV disinfection project. No additional mechanism upgrades are recommended.

4.3.2 Filter

Depending on the TSS concentration of a system, suspended solids can account for a significant amount of phosphorus in an effluent stream. A concentration of 10 mg/L of TSS can result in 0.4 to 0.6 mg/L of phosphorus. The average Consolidated Plant effluent TSS concentration (shown in Table 1) is 11 mg/L. To hit low phosphorus limits, filtration may be required.

Multiple vendors manufacture disc media filter systems. Two vendors, WesTech and Aqua-Aerobic Systems, were contacted to provide equipment quotes. Both systems use cloth media disc filtration technology that is capable of reducing phosphorus in water to 0.1 mg/L or less. These filters do not replace chemical addition. In fact, if the phosphorus limit is lowered, then an increase in chemical will be needed whether or not filters are required. A pilot study and optimization will clarify if a filter is required to meet 0.5 mg/L. A limit of 0.1 mg/L will not be achievable without a filter.

5. FEASIBLE ALTERNATIVES AND COSTS

5.1 Alternative 1 – Reduce Effluent Phosphorus Below 0.5 mg/L (with chemical addition only)

The first alternative for phosphorus discharge reduction in Monmouth is taking the necessary steps to reduce phosphorus below 0.5 mg/L via increased chemical dosing. The first step is to perform a pilot study to optimize the chemical dosing and inform the increased dose quantity.

It is possible that increasing the chemical dosage per mg of phosphorus influent can put Monmouth below 0.5 mg/L phosphorus. However, because the effectiveness of chemical phosphorus removal decreases as the amount of influent phosphorus per liter decreases, the cost of reducing phosphorus discharge below 0.5 mg/L via additional chemical alone is high. Dosing data from the past 2 years indicates very few points of data in which the chemical addition has reduced phosphorus below 0.5 mg/L. Therefore, anticipating dosage for future chemical use is based on two factors: (1) assuming current efficiency is maintained and (2) assuming chemical dose (metal salt to influent ortho phosphorus) is increased at the theoretical efficiency rate of increase. Following the theoretical dose curve, the dose would be approximately doubled, causing the average cost of ferric sulfate per year to be about $1 million per year. Monmouth spent $0.4 million dollars for aluminum sulfate in 2021.

Optimization of chemical dosing via capital upgrades may help reduce chemical costs, and more importantly, may be necessary to consistently meet an effluent limit of 0.5 with chemical addition only. Currently, the ferric solution is introduced into the center ring of the oxidation ditch of the Consolidated Plant, which potentially results in poor mixing and less effective chemical dosing than possible. A pilot study to test the results of moving the dose would likely cost about $50,000 for data collection, engineering analysis, and site work for piping and a temporary mixing pump. If the pilot study shows a long term savings by greater chemical efficiency, then a permanent solution for moving the dosing location and optimizing the chemical dose application could be approximately $200,000 capital cost. This would include a rapid chemical mixer wired back to MCC, SCADA instrumentation and controls, and permanent chemical piping installation. Additionally pilot testing would clarify if a filter is required for reliably meeting a 0.5 mg/L phosphorus effluent. For purposes of this study, the data regarding phosphorus effluent response to dose is insufficient to conclude that increasing chemical dose without a filter is a feasible option, but it is included to compare annual costs.

5.2 Alternative 2 – Reduce Effluent Phosphorus Below 0.5 mg/L (with a tertiary filter)

If a permit limit of 0.5 mg/L TP effluent is applied to the Consolidated Plant, then a filter may be required. For Alternative 2, to reduce Phosphorus Effluent below 0.5 mg/L, it is assumed that a pilot study for chemical optimization is performed, and is successful to optimally apply the chemical at the plant. Additional costs beyond the pilot study include the design and installation of a tertiary filter, operation and maintenance, and any additional chemical costs.

The cost of a filter is dependent on the level of redundancy required. For Alternative 2, the filter may be designed such that during dry weather, maintenance can be performed on half the filter disks while the other half are functioning. If full redundancy at peak flow would be required, this would double the amount of mechanism to be installed. If the permit allows for flexibility, such as meeting an average of 0.5 mg/L monthly effluent or determining the loading from a 0.5 mg/L daily limit and applying it annually, the size of the filter mechanism can be streamlined, decreasing capital, operations, and maintenance cost.

Additional site costs include piping, a lift station for the required head, a building to protect the equipment, a crane for maintenance, electrical upgrades and distribution, SCADA and controls. Most of these costs should be similar for any prescribed permit limit, however there are some increases with increased equipment, as shown in the costs table. Furthermore, it was assumed that Consolidated Plant chemical usage may will be the same as Alternative 1 to achieve the 0.5 mg/L effluent limit.

5.3 Alternative 3 – Reduce Effluent Phosphorus Below 0.1 mg/L

For Alternative 3, to reduce Phosphorus Effluent below 0.1 mg/L, it is assumed that a pilot study for chemical optimization is performed, and is successful to optimally apply the chemical at the plant.

According to the EPA Nutrient Control Design Manual from 2010 (EPA/600/R-10/100, pg 3-4), the ratio of metal salt to influent ortho phosphorus to reliably achieve effluent total P less than 0.1 mg/L is 6. This increases chemical use by a factor of 12, resulting in extremely high chemical costs. Furthermore, an assumed increase chemical at this rate would require additional chemical handling and sludge handling that neither WWTF currently has the capability for. The costs to design, construct, and operate additional chemical and solids handling facilities have not been accounted for. If a nutrient limit of 0.1 mg/L is applied to the Consolidated Plant, it may be worthwhile to revisit the capital cost upgrades to implement full nutrient removal.

In comparison to Alternative 2, it is assumed that additional filter capacity is required to provide full redundancy at peak flow. The site work: excavation, piping, concrete, etc. is doubled. The building costs are almost doubled for a twice as large structure. The instrumentation, controls, and electrical are assumed to be the same, however, additional equipment has the potential to require significant electrical upgrades.

5.4 Summary of Feasible Alternatives

To reduce effluent phosphorus below the 0.5 mg/L level, it is likely that Monmouth will need to increase and optimize their chemical dosing. However, Monmouth may not need a filter to get below 0.5 mg/L, especially if the limit is average over time instead of a daily max. A pilot study for chemical dose optimization would provide more data to determine if this is feasible. To reduce effluent phosphorus below the 0.1 mg/L level, Monmouth will need to incorporate all three techniques: increased dosing, optimization, and a filter.

Cost is the primary deciding factor for feasibility of phosphorus discharge reduction techniques. Seasonal variations do not significantly impact performance of chemical phosphorus removal, so the main influence on chemical cost is the level and stringency of the phosphorus limit, be it a daily, monthly, or yearly limit. The ability to be flexible in applying a phosphorus limit also impacts the costs of the filter units and the chemical dosing.

5.5 Conceptual Costs

The following costs were estimated only for the scenarios in which the technique results in a feasible solution. Both costs assume a pilot study is successful and chemical optimization is performed. Both costs therefore assume theoretical efficiency of chemical dose and installation of a filter. Alternative 1 assumes a filter about half the size of Alternative 2. These conceptual level costs are for comparison purposes only.

General conditions covers contractors' general conditions including bonds and insurance. Overhead and profit are incorporated into the individual line items.

Alternative 3 requires double the equipment and building space as Alternative 2. This raises the capital base cost, which is compounded by uncertainty represented by the contingency. Additionally, the more stringent limit will require more precise engineering design. The annual capital cost is estimated for a 20 year loan at a 1.5% interest rate. As the interest rate increases, the annual cost increases. Operations and Maintenance costs include replacement of the filters and various components. They are also estimated based on anticipated hours worked by the plant operators to maintain the additional lift station equipment, filter equipment, and lab work to refine operations. The chemical costs are represented as additional chemical to current operations.

Table 2: Cost Comparison for Alternatives

Item No.	Cost Item	Alternative 2: Meet 0.5 mg/L with chemical only	Alternative 2: Meet 0.5 mg/L	Alternative 3: Meet 0.1 mg/L
1.0	**Installation Costs**			
1.1	Pilot Study and chemical optimization	$250,000	$250,000	$250,000
1.2	General Conditions		$400,000	$500,000
1.3	Excavation, concrete, piping		$500,000	$1,000,000
1.4	Equipment		$1,000,000	$2,000,000
1.5	Building		$400,000	$700,000
1.6	I&C		$150,000	$150,000
1.7	Electrical		$300,000	$300,000
1.8	Lift Station		$750,000	$750,000
2.0	**CAPITAL BASE COST**	**$250,000**	**$3,750,000**	**$5,650,000**
2.1	Contingency (30%)	$75,000	$1,125,000	$1,695,000
2.2	Engineering & Construction Observation (25%)	$62,500	$937,500	$1,412,500
3.0	**TOTAL CAPITAL COST**	**$388,000**	**$5,813,000**	**$8,758,000**
3.1	Annual capital cost debt repayment with 20 year loan	$22,599	$338,582	$510,116
3.2	Operation and Maintenance per year	$20,000	$50,000	$85,000
3.3	Additional Chemical Costs per year	$1,282,000	$1,282,000	$5,363,000
4.0	**Anticipated Per Year Costs (2022 dollars)**	**$1,325,000**	**$1,671,000**	**$5,958,000**

6. CONCLUSION

An extensive review of potential available technologies was performed to identify the best solution to reduce Monmouth's phosphorus discharge. Typical municipal plants are able to utilize EBPR to reduce chemical costs, but due to Monmouth's high industrial pre-treatment load, the nitrate concentrations are too high to make this a feasible solution. The only feasible solution determined was to optimize the chemical dose in combination with designing and installing a filter to reach a limit of 0.5 mg/L. A pilot study would determine if simply adding more chemical would improve the phosphorus discharge enough and be reliable. A filter provides the most reliable path forward, however, it is also a large capital upgrade not to be taken lightly. The regulatory limit and how it is applied will impact the sizing and design of a filter. Achieving a phosphorus limit of 0.1 mg/L will increase chemical usage and solids production. Chemical handling and solids handling would need to be designed, constructed, and operated. The annual chemical costs are extremely high making this option unattractive economically.

APPENDIX A: PHOSPHORUS OPTIMIZATION REPORT

WOODARD &CURRAN

TECHNICAL MEMORANDUM

TO: IEPA, Bureau of Water, Permit Division

CC: Jack Troidl, Jen Anders

PREPARED BY: Pooja Chari, Samantha Weidenbenner, Erik Osborn

REVIEWED BY: Maureen Neville, Andy Jackson, Bill Hart

DATE: January 31, 2022

RE: Phosphorus Discharge Optimization Plan

LICENSED PROFESSIONAL ENGINEER
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OF ILLINOIS

1. INTRODUCTION

In September 2021, Illinois Environmental Protection Agency (IEPA) issued the final NPDES Permit (No. IL0036218) for the Monmouth Consolidated Wastewater Treatment Facility to discharge to the Waters of the State. The permit was issued with a special condition to develop a Phosphorus Discharge Optimization Plan. This Plan is the first step of several phosphorus related special conditions including a feasibility study for capital improvements and a Nutrient Assessment Reduction Plan (NARP) due subsequently. Review of the wastewater treatment systems in Monmouth shows that they are not configured for enhanced biological phosphorus removal (EBPR). Furthermore, due to the high levels of nitrate in the influent from the North Plant, optimization to achieve EBPR is unlikely to succeed. To meet current permit limits, phosphorus removal is being achieved through chemical means. Economic feasibility of future capital improvements will also take into account the impact to current chemical systems.

2. BACKGROUND

The City of Monmouth (City) owns and operates two wastewater treatment facilities (WWTF); North Plant WWTF and the Consolidated Plant. The North Plant is a pretreatment plant that serves only the Smithfield Foods processing facility (Smithfield), a hog slaughterhouse harvesting roughly 12,000 hogs/day and operating six days/week. The treated North Plant effluent is conveyed to the Consolidated Plant where it is combined with municipal flow pumped from the City.

2.1 Existing North Plant Pre-Treatment Operations and Performance

Treatment at the North Plant consists of an anerobic lagoon, a pair of aerated lagoons which are normally run in series, secondary clarifiers, and a GEM process (by Clean Water Technology) for phosphorus removal. The North Plant does not have a permitted discharge, but discharges to the Consolidated Plant, which consolidates municipal flow from the City of approximately 9,000 people. See Attachment A for process flow diagram.

North Plant flow is generated from Smithfield hog processing and is therefore reflective of their six day work week. The most recent North Plant flow analysis was performed in 2017 and indicated six-day flows of 1.40 MGD per day Monday thru Saturday with 0.69 MGD on Sunday. The maximum day is 1.65 MGD. The current Consolidated Plant NPDES permit includes phosphorus data collection and monitoring as well as a 1.0 mg/L monthly average effluent limit. The North Plant includes chemical phosphorus removal (GEM process) to allow the Consolidated Plant to meet this limit. The current Consolidated Plant NPDES permit also includes seasonal effluent limits for Ammonia Nitrogen (as N). The most stringent is from June through August with a monthly average concentration limit of 0.9 mg/L. Total Nitrogen (as N) is required to be monitored and reported.

The main operational goals of the North Plant are to reduce BOD, ammonia, and phosphorus loads to the Consolidated Plant. An anaerobic lagoon removes approximately 80% of the influent BOD load. A pair of aerated activated-sludge lagoons oxidize remaining BOD and ammonia. The operator throttles air in the first grid of the west aerated lagoon to recover alkalinity so more complete nitrification can be achieved. This presumably also reduces the nitrate in the effluent, though effluent nitrate is still very high: on the order of 80 to 100 mg/L. Recent upgrades include new blowers and DO probes for the aerated basins which allow for more precise delivery of air. The GEM process removes phosphorus by chemical and physical processes. Alum and sodium aluminate are added to precipitate ortho phosphorus, then polymer is added to help flocculate the precipitate and other colloidal material. The floc is removed as sludge using a combination of vortex concentration and dissolved air floatation. The GEM process reduces effluent ortho phosphorus from approximately 30 mg/L to 1.5 mg/L.

2.2 Existing Consolidated Plant Treatment Operations and Performance

The Consolidated Plant was completed in Summer 2010 and the treatment process consists of bar screens and grit channels, an oxidation ditch, secondary clarification and cascade aeration. A project to add UV Disinfection is anticipated to bid in 2022 contingent on funding. Sludge is stored in aerobic digesters, though these are typically unaerated to reduce energy cost. Treated effluent is discharged to an unnamed tributary of Markham Creek through permitted outfall 001. The unnamed tributary of Markham Creek flows into Markham Creek, which flows into the Cedar Creek, which flows into Henderson Creek, which flows into the Mississippi River.

Data from 2021 indicates the average daily flow at the Consolidated Plant is 4.82 MGD. The highest peak daily flow in the last five years' time was 9.24 MGD. The Consolidated Plant’s permitted design average daily flow is 4.62 MGD, and the permitted design peak daily flow is 10.23 MGD.

The oxidation ditch is operated to oxidize BOD and ammonia. There are three rings in the oxidation ditch at the Consolidated Plant. Typically, the flow is introduced into the oxidation ditch through the outer ring. However, during high flow, the oxidation ditch is step fed as the BOD is low. Each ring is operated at different DO levels as shown in Figure 1. The outer ring is operated at DO of 0.5 mg/L, middle ring is operated at 1 mg/L and inner ring at 2 mg/L. Aerator speed is adjusted automatically to maintain DO at 2.0 mg/L in the inner ring. The oxidation ditch is also operated based on maintaining MLSS concentration. During summer, the MLSS is maintained around 3200 mg/L and during winter, MLSS is maintained around 3800 mg/L. Table 1 shows the operating parameters in the Consolidated Plant. The oxidation ditch also includes a chemical phosphorus removal system. Alum is injected to the oxidation ditch in the middle ring. The operators have worked hard to optimize the plant to meet nitrogen and phosphorous limits to the best of its ability as currently designed.

Table 1: Consolidated Plant Operating Parameters

Parameter	Average	5^{th} Percentile	95^{th} Percentile
MLSS (mg/L)	3401	2620	4050
SRT	Operator Experience: 15 days (winter) and 13 days (summer)		
Clarifier 1 blanket depth (feet)	3.84	1.50	7.00
Clarifier 2 blanket depth (feet)	3.52	1.50	5.58
WAS flow (MGD)	0.08	0.00	0.12
RAS flow (% of influent flow)	83	41	133

From the oxidation ditch, the flow goes to the secondary clarifiers where the solids are separated out. The secondary clarifier effluent flows through cascade aerators to the outfall. Return activated sludge (RAS) is returned to the influent box. The new UV disinfection system will be installed between the secondary clarifiers and cascade aeration. Higher clarifier blanket depths were experienced in 2021 during episodes of RAS pump failure. This equipment has been replaced.

Figure 1: Oxidation Ditch Operating DO Concentrations

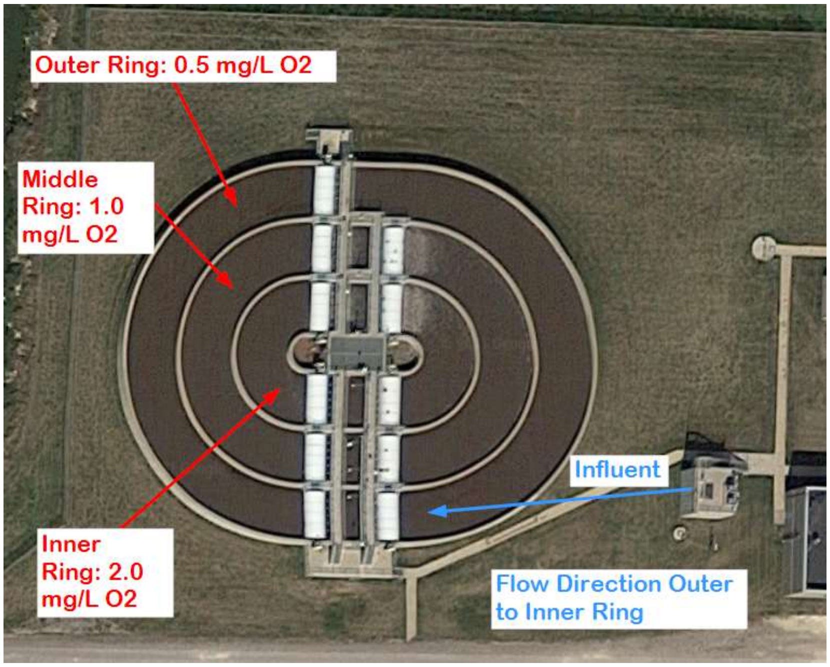


Table 2 shows the parameters for influent and effluent at the Consolidated Plant. The phosphorus concentration is higher from North Plant compared to the municipal influent. The Consolidated Plant, with chemical addition, is able to reduce effluent phosphorus to meet the permit limit of 1.0.

A 20:1 carbon to phosphorus (C:P) ratio is typically considered the minimum for enhanced biological phosphorus removal. Carbon to phosphorus ratio for the Consolidated Plant influent was calculated by flow weighting the BOD and phosphorus concentrations for each day in 2021. For example,

$$\left(\frac{(North\ Plant\ Flow}{Total\ Flow} * North\ \ Plant\ BOD\ Concentration\right) + \left(\frac{Munincipal\ Influent\ Flow}{Total\ Flow} * Municipal\ Influent\ BOD\ Concentration\ \right) = Consolidated\ Plant\ BOD\ Concentration$$

While the municipal influent alone has a favorable C:P ratio of 25:1, due to the North Plant effluent, the ratio of the combined influent is skewed to 12:1. If accounting for only the carbonaceous component of BOD, approximately 85% of BOD, the ratio is only 10:1. This low ratio poses a restriction on some of the removal methods discussed in later sections.

Table 2 reveals low BOD loading as well. Low influent loading has been typical for decades due to inflow and infiltration and combined sewer systems. The City has pursued a strategy of capturing and treating the first flush of rainfall combined with distributed storage to shave the peak and prevent combined sewer overflows. The strategy commenced in the 1990s, and significant infrastructure has been installed to capture and treat the combined flow to the extent practicable.

A review of phosphorus concentrations during dry weather periods in 2021 revealed typical concentrations between 3 and 5 mg/L. Metcalfe and Eddy, 5th ed., Table 3-18 Typical Composition for Untreated Domestic Wastewater lists low strength phosphorus concentration as 3.7 mg/L and medium strength as 5.6 mg/L. Therefore, there does not appear to be any unusually high phosphorus sources within the collection system.

Table 2: Influent and Effluent Concentrations [mg/L]

Parameter	Average			5th Percentile			95th Percentile		
	Muni* Influent	NP Effluent	CP Effluent	Muni Influent	NP Effluent	CP Effluent	Muni Influent	NP Effluent	CP Effluent
Total P	3.08	9.86	0.77	1.20	2.7	0.4	5.20	24.4	1.15
BOD	77.0	18.4	NS	19.5	5.0	NS	166.5	56.45	NS
CBOD	NS	NS	2.36	NS	NS	1.0	NS	NS	4.45
TSS	145.0	145.9	11.0	45.0	50.4	6.0	292.5	317.6	16.8
NH_3-N	7.69	13.1	0.24	1.67	0.57	0.0	15.35	41.3	0.87
NO_3-N	NS	80-100[1]	21	NS	NS	3.6	NS	NS	39

* Muni = Municipal, NP = North Plant, CP = Consolidated Plant, NS = Not Sampled

[1] Operator Estimated value from historical sampling

3. PHOSPHORUS REMOVAL METHODS

3.1 WWTP Influent Reduction Measures

Influent reduction measures can span from education campaigns to ordinance revisions. Initial data review focused on determining whether the major WWTF user, Smithfield Foods, was also the major phosphorus contributor. Other potentially significant point and non-point sources of phosphorus were also considered.

3.1.1 Headworks Phosphorus Loadings

Since the largest sewage treatment user in the City is Smithfield Foods, and their influent stream is segregated from other municipal users, phosphorus data was evaluated to determine the portion of phosphorus contribution from Smithfield Foods. Table 3 below indicates that 58% of the phosphorus load is from the North Plant. The phosphorus load from municipal flow is about 42%. The concentration and flow data were analyzed for the year 2021. However due to COVID-19, 2021 may not be representative of a normal year. Possible impacts to flows and loads include virtual learning at Monmouth College and lower hotel usage.

Table 3: Total Phosphorus Loading

Source	Average Concentration (mg/L)	Average Daily Flow (MGD)	Average Load (lbs/day)	Percent Load Contribution (%)
North Plant Effluent	9.86	1.30	112.21	58%
Municipal Influent	3.08	3.52	80.86	42%
Consolidated Plant Influent	4.78	4.82	193.07	100%
*Typical Influent**	*5.6*	*4.82*	*225.11*	-

*Values from Metcalfe and Eddy, 5th ed., Table 3-18 Typical Composition for Untreated Domestic Wastewater

3.1.2 Opportunities for Other Point Source Reduction

The City identified other potential phosphorus dischargers as the Order of St. Francis (OSF) Hospital and Clinics, Monmouth College, Midwest Pet Food, and a truck wash. Although the City has low to medium strength influent phosphorus concentration from the municipal collection system, as compared to Metcalfe and Eddy typical values, the City considered these as potential phosphorus sources. They are potential sources of phosphorus due to the nature of their discharge, and/or high water use where even a medium strength phosphorus concentration could result in significant loads. The City will sample in discharge manholes to isolate the phosphorus concentration in the discharge for the OSF Hospital, Midwest Pet Food, and the truck wash. This will determine if the phosphorus concentration is within a reasonable range.

The USEPA suggests that soap, fertilizer, and pet waste are important contributing factors to nutrients in waterways. (https://www.epa.gov/nutrientpollution/sources-and-solutions-and-around-home) Large quantities of soap can be assumed to be used at some large facilities such as the local OSF Hospital and Clinics. The State of Illinois has banned sales of soap with greater than 0.5% phosphorus (415 ILCS 92 Regulation of Phosphorus in Detergents Act), therefore public education is not anticipated to have a significant impact on residential phosphorus discharge from soap. Hospitals are exempt from the low phosphorus soap requirement and therefore phosphorus reductions from the OSF Hospital are not anticipated to be easy to enact. To reduce effluent due to phosphorus in soap, targeted outreach to retailers of soap to be sure they are complying with the law and hotels due to larger laundries may be a possible low-cost action.

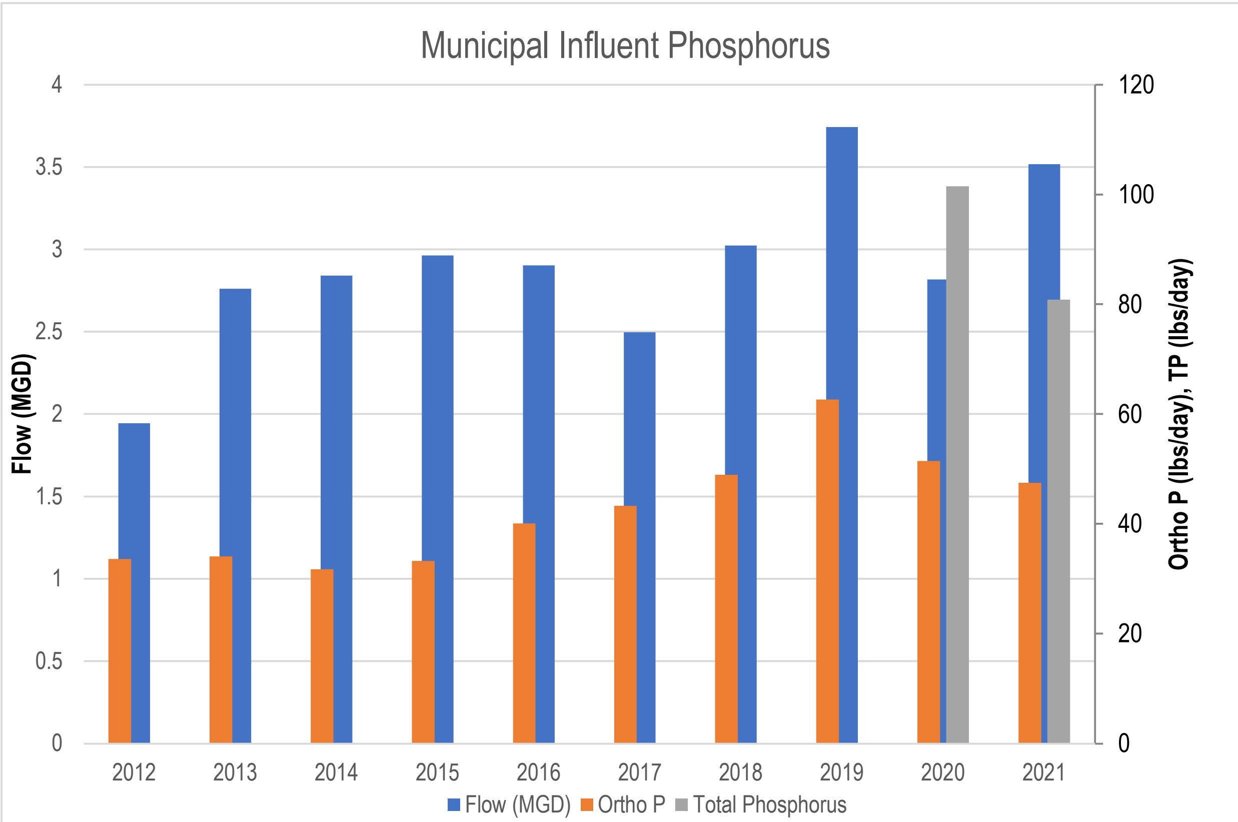
Monmouth College uses water in many sources all over campus which makes it difficult to isolate their contribution to phosphorus discharge. They do have a large science department that could be a contributor. However, it was constructed in the last couple of years, and the operators have not noticed a rise in average load over the last decade.

Midwest Pet Food uses significant water, but their process includes baking the food which evaporates much of the water. Their sewage discharge is very low compared to their water use and operators have not been able to distinguish between days when they are operating and when they are not based on flow or phosphorus contributions to the plant. Sampling will be performed to confirm that their phosphorus load is low.

Finally, a local truck wash was constructed in the last five years to wash down the trailers which provide hogs to Smithfield. Truck washdown water may contain soil and/or manure which could be contributing to phosphorus load. They operate a gravity separator for their wash down water. The operators have monitored phosphorus in the past looking at days the truck wash was operational versus not and have not seen any data indicating that this is a significant source of phosphorus. Sampling will be performed to confirm that the gravity separator continues to be operated properly, and their phosphorus discharge is reasonable.

The average municipal phosphorus loading was charted over the past decade to determine if phosphorus loadings have increased. Orthophosphorus load increased from 2014 to 2019. It decreased over the past two years. It is not clear if this is related to the COVID-19 pandemic or indicative of a decreasing trend. It is recommended to continue charting this data to spot any future long term increases in loading. Figure 2 shows the average influent municipal flow for each year in blue on the left axis. The right axis tracks the orthophosphorus (orange) and total phosphorus (gray) which started being sampled in August 2020.

Figure 2: Municipal Influent Phosphorus Load Over Time



3.1.3 Local Limits

An agreement with Smithfield limits the BOD and TSS or results in a surcharge fee for high BOD and TSS discharge. Phosphorus is not included in this agreement; however, Smithfield pays for the chemical phosphorus treatment at North Plant. Smithfield has a DAF to meet their limits although operation is not always consistent. No other local limits are implemented.

3.1.4 Opportunities for Non-Point Source Reduction

The City of Monmouth has combined sewers which consists of approximately 45% of the service area, however, significant portions of separated storm sewers are conveyed to combined sewer manholes for eventual treatment at the treatment plant. Therefore, landscaping applications could be important even in areas of separated sewers. Monmouth College was considered a potential source of fertilizer runoff, but it is located in a separate sewer system that does not re-combine with the combined system.

A review of rainfall, influent municipal flow, phosphorus concentration and load did not show a strong correlation between rainfall and increased phosphorus concentration or load. These charts are included in Attachment B. August and September 2021 were drier compared to other portions of the year. Phosphorus concentrations during the weeks without rainfall within this dry time of year average between 3 and 5 mg/L total phosphorus. This indicates that wet weather is not diluting the concentration to be lower than it is during dry weather. Visually, the change in loading due to wet weather is inconclusive. The early summer wet weather has a higher phosphorus loading than the spring wet weather. It is possible this is due to fertilizer runoff during early summer. Based on this level of analysis, the City may find some benefit in posting education about fertilizer on their website or as other opportunities arise, but a more extensive education campaign is unlikely to significantly reduce influent phosphorus.

3.2 WWTP Effluent Reduction Measures

Woodard and Curran analyzed the data and reviewed operations to evaluate if phosphorus optimization through operational changes is possible. While the permit is only for the Consolidated Plant, both the North Plant and Consolidated Plant must be reviewed together. Almost 60% of the phosphorus load is from the North Plant. Optimizing phosphorus removal at the North Plant reduces the phosphorous load that must be removed by the Consolidated Plant.

Before reviewing each suggested optimization technique, the big picture should be considered. Biological phosphorus removal is typically achieved with an anaerobic zone upstream of the aerated activated sludge. In order for phosphorus uptake to occur, the phosphorus must be present in the water with sufficient carbon and no available oxygen present either as dissolved oxygen or nitrate. Nitrification is occurring at the North Plant, but not complete denitrification. The North plant also removes a significant amount of BOD. Therefore, the influent to the Consolidated Plant has a high nitrate concentration, to a relatively low carbon concentration. Both of these factors would prevent biological phosphorus removal at the Consolidated Plant even if an anaerobic zone was constructed upstream of the oxidation ditch. This background is critical to understanding why most of the optimization measures evaluated will not reduce phosphorus as stand-alone measures.

Because it is critical to remove more nitrate in order to biologically remove phosphorus, nitrification and denitrification techniques have been evaluated below. Optimization and future capital improvements are focused on nitrogen reduction to improve conditions for future biological phosphorus reduction. It also shows the optimization that has already been performed by the plant staff to reduce nutrient discharge to the extent practicable with existing infrastructure.

3.2.1 Solids Retention Time

The operators have already adjusted solids retention time (SRT) at the North Plant and Consolidated Plant with the goal of complete nitrification. The SRT at the Consolidated Plant is 12 days in summer and 15 days in winter. The North plant is run with a target MLSS of 3,500 to 4,000. Sampling data for both plants (Table 2) shows that the majority of ammonia has been converted to nitrate. Therefore, further increasing the SRT does not appear to be beneficial for nutrient discharge reduction. Based on the data presented in Table 1, the Consolidated Plant has high nitrate concentration which prohibits biological phosphorus removal. While some WWTFs have achieved enhanced biological phosphorus removal (EBPR) by reducing SRT to the minimum required for nitrification, these conditions make reducing SRT to increase EBPR not applicable to this treatment system.

3.2.2 Aeration Rates

At the North Plant, operators already turn off air in the first aeration zone of the west basin to promote denitrification. In 2021, the diffusers and blowers were replaced providing the opportunity for increased air output in particular zones of the aeration basins. Further pilot testing and desktop evaluation at the North Plant can be performed to determine the full denitrification potential.

Reducing DO can promote simultaneous nitrification denitrification. The operators have already spent time optimizing the oxidation ditch zones to achieve this to the extent practicable. The municipal flow and North Plant effluent are combined before conveyance into the oxidation ditch. This consolidated flow can be conveyed to the outer ring or split between the outer and middle rings. If ammonia increases, due to a process upset or out of order equipment at the North Plant, all flow is conveyed to the outer ring in order to complete the nitrification process. Typically, when the ammonia is low, the influent flow is split between the outer and middle rings. This allows for some denitrification in the outer ring. During high flow, when the BOD is diluted from the presence of stormwater, the flow is also split in order to maintain carbon levels in the middle and inner rings.

3.2.3 Baffles Addition

Theoretically, baffles could be added in the aerated lagoons at the North Plant. The baffles could be a type of curtain wall in the lagoons. Baffles can increase the ability of the plant to isolate a section of the aerated lagoon to promote anoxic conditions. The addition of baffles can be assessed when the full denitrification potential has been determined from the previous discussion.

At the Consolidated Plant, the oxidation ditch is already divided into three passes, but the ditch could be further subdivided using fiberglass baffles. The benefit of this proposition is currently low. Management of influent nitrate and carbon levels would need to be addressed before baffles could provide benefit.

3.2.4 Aeration Settings

In plug-flow basins, air can be turned off on the inlet side to create anoxic or anaerobic zones to enhance biological nitrogen and phosphorous removal. The operators are currently adjusting the aerators in the aerated lagoons in the North Plant. They have created an anoxic zone in the upstream portion of the west basin by closing the valve for the discharge air piping for the southern third of that basin. There is a limit to this technique since having a longer anoxic zone affects the sludge settling in the secondary clarifiers and eventually impacts the ability of the plant to nitrify. Per discussion in 3.2.2, plant staff will work with engineers to continue to optimize nitrification and denitrification.

Anoxic zones in the oxidation ditch already provide a denitrification benefit. However, further lowering the dissolved oxygen by changing aeration settings to create an anaerobic zone is not feasible at the Consolidated Plant, because the influent nitrates are too high in concentration (see Table 1). The nitrate concentration from the North Plant effluent would have to be reduced to be able to perform biological phosphorus removal using this technique.

3.2.5 Impact of recycle streams by improving aeration within holding tanks

The North Plant does not have any recycle streams from solids handling. The WAS is wasted to a lagoon where it settles and is stored until the local hauler collects it for land application. Thus, there is no impact.

The daily decant from the sludge storage basins in the Consolidated Plant goes to the storage lagoons. Excess flow from the North Plant secondary clarifiers is also sent to these storage lagoons. Storage lagoon water is then used during periods of low North Plant flow to maintain a constant flow rate to the GEMs phosphorus chemical removal process at North Plant. Any phosphorous in the sludge storage tank decant is thus recycled back to the GEMs process.

During the winter months, the operators run one blower to keep the water in the sludge storage tanks from freezing. In the summer, aeration is switched off. The decant process allows for long enough SRT to get stabilized sludge for land application without aeration. It is likely that anaerobic stabilization in the storage basins releases some phosphorous. Further analysis may present an opportunity for optimization of this recycle stream with capital improvements.

3.2.6 Reconfigure Flows

There are many ways that flows could be reconfigured that would be currently possible or require capital upgrades. For phosphorus removal, an anerobic zone would need to be added at the start of the basin. This would require capital upgrades, not flow reconfigurations. However, as discussed previously, high nitrate concentration is inhibiting biological phosphorus removal. Reconfiguring flows at either plant could result in improved nitrification denitrification.

One method to reconfigure flows is to do a step feed at the North Plant. The west basin, currently the first in series treatment, has an anoxic zone at the head of the basin. Pilot testing could reveal if creating an anoxic zone at the head of the east basin and introducing some flow from the anaerobic lagoon, would result in further denitrification due to the presence of nitrates from the west basin and carbon from the anaerobic lagoon flow.

Without step feed, the only current method to introduce nitrate to the head of the aerobic lagoons is through the return activated sludge (RAS) flow. Currently RAS flow is maintained around 100%. If the rate of RAS is increased, more nitrate could in theory be denitrified, however nitrate levels would still be too high for bio-P removal at the Consolidated Plant.

Another method would be to add mixed liquor recycle to bring in more nitrate at the head of the North Plant without increasing the RAS flow. This would help with reducing the nitrate levels in the North Plant effluent. The flow could be run through each aerated basin in parallel instead of in series to avoid hydraulic issues. A mixed liquor pump for each basin would return the downstream mixed liquor to the head of the basin. Process modeling would be required to determine if there is sufficient basin capacity. Also, even if the mixed liquor recycle rate was increased to 400%, about 20% or 20 mg/L of nitrate would still be conveyed to the Consolidated Plant. In order to reduce this even further, a post-anoxic zone with supplemental carbon would be required. These options would all involve capital improvements and would need to be further studied for technical and economic feasibility.

Adding recycle streams would require capital upgrades. These options enhance nitrogen removal and can be a part of the strategy for nitrogen and phosphorus removal. However, these are not an optimization, but a capital improvement to reconfigure flows and add an anaerobic zone.

3.2.7 Increase Volatile Fatty Acids

For plants that are implementing biological phosphorous removal and are limited by VFA concentrations in the influent, there are several possibilities for generating additional VFA within the plant. These include generating VFA in the primary clarifiers (if available), in the anaerobic zone, or in a sidestream process such as RAS or sludge processing. If it is possible to reduce the nitrate concentrations low enough to biologically remove phosphorus, then VFAs production could be considered as a way to achieve a more favorable carbon to phosphorous ratio.

3.2.8 Separately treat Phosphorus from Municipal Influent

Throughout this evaluation, the presence of high nitrate concentration in the Consolidated Plant from the North Plant effluent has been one of the primary limiting factors for biological phosphorus removal. It is beyond the scope of this study to evaluate capital improvements, however, the City is aware that capital improvements will be evaluated to continue addressing the special conditions in the NPDES permit. Therefore, it is worth noting that capital improvements to consider anaerobic zones and recycle flows for only the municipal influent to the Consolidated Plant could result in enhanced biological phosphorus reduction at the Consolidated Plant. Because 40% of the phosphorus load is from the municipal influent, a reduction there could be effective. This is one possible capital improvement that may be considered in the future feasibility study.

4. EVALUATION OF PHOSPHORUS ALTERNATIVES

Based on a review of the influent sources of phosphorus, the City will pursue a few low-cost items including sampling and conversations with local business owners. No local limits are being proposed at this time. Smithfield Foods does have an agreement in place with the City that limits their discharge as well as requiring Smithfield to bear the cost of additional treatment when the discharge is exceeded. Municipal influent concentrations are moderate suggesting that there is no unusual source of phosphorus in the collection system.

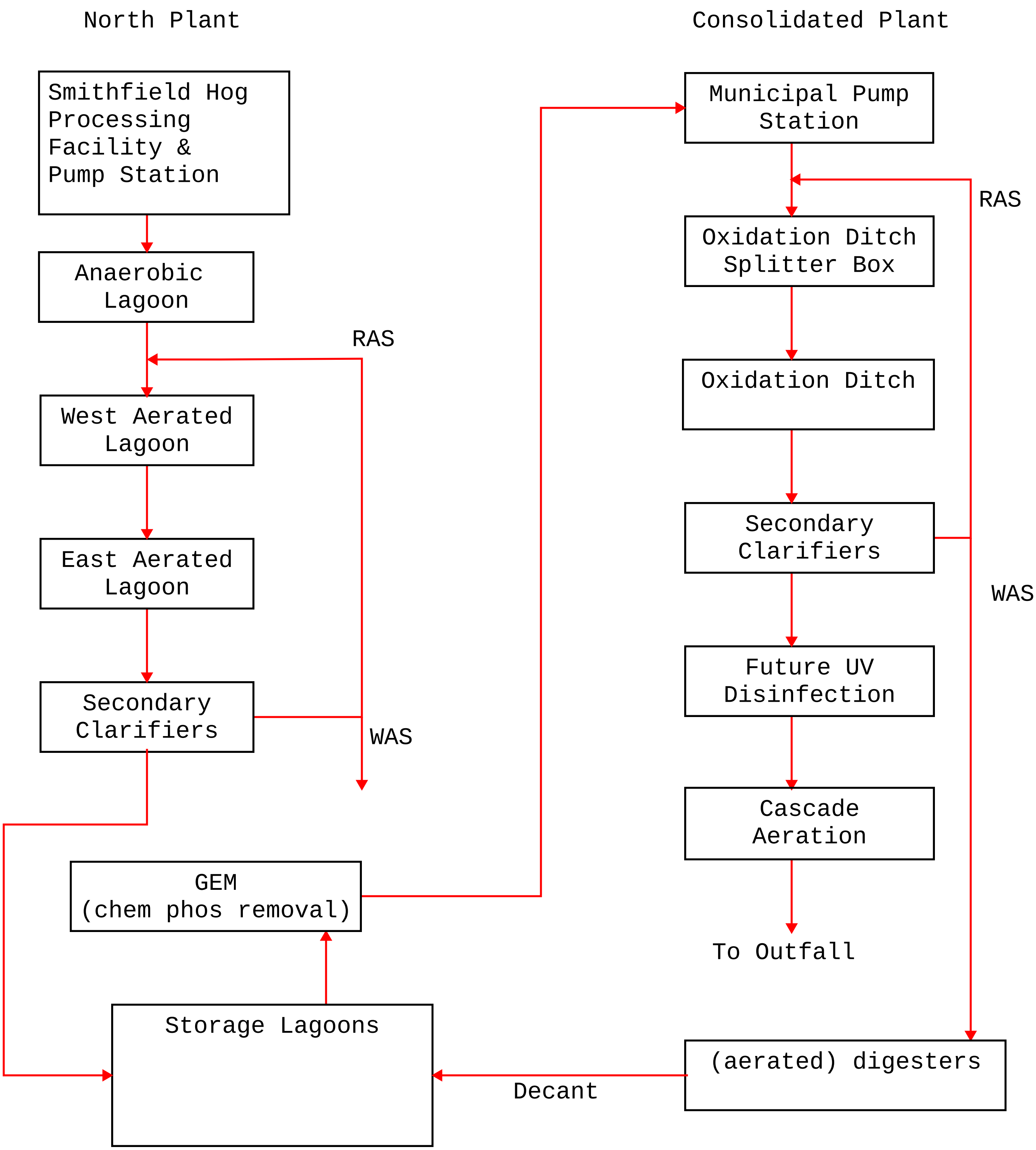
The City of Monmouth is able to meet a 1 mg/L phosphorus limit with chemical addition at the North Plant and Consolidated Plant. Further reducing the discharged phosphorus through optimization is not possible since the plant as configured has been optimized through many efforts on the part of the operators. Limiting factors include the high nitrate effluent from the North Plant, low carbon to phosphorus ratio, and limited zoning capability with an oxidation ditch. However, this discharge optimization plan has revealed the challenges that would need to be overcome in order to design capital improvements for further phosphorus reduction.

5. RECOMMENDATIONS

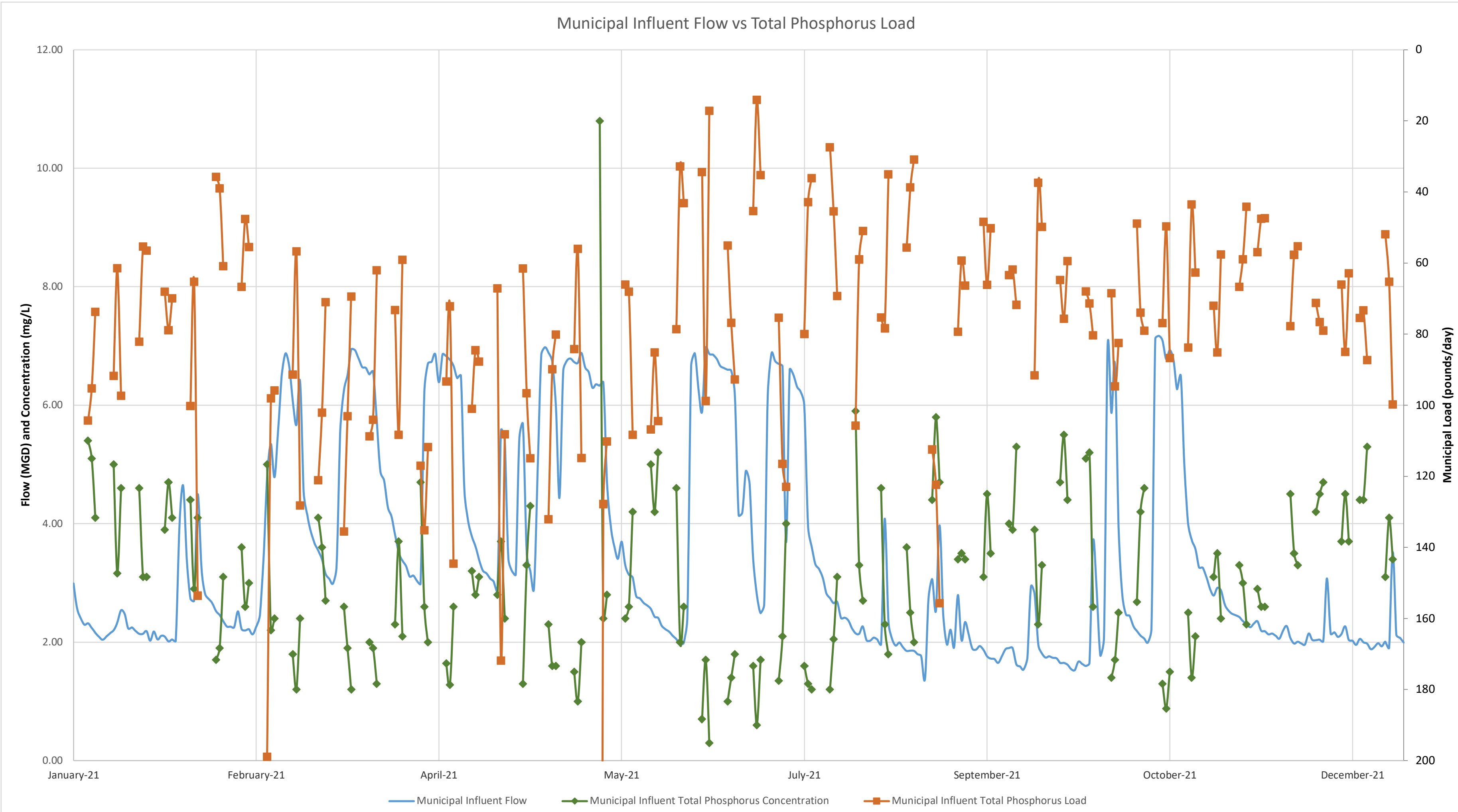
Influent reduction measures are limited. It is recommended that the City reach out to retailers of soap to be sure they are complying with the state law and reach out to hotels to see if their soap use also complies with state law. It is also recommended that the City sample the discharge from the OSF Hospital and Clinics, Midwest Pet Food, and the truck wash to determine if they are significant sources of phosphorus.

Plant optimization recommendations are limited based on plant configurations and influent characteristics. Effluent reduction measures are predominantly based on optimizing nitrification and denitrification at North Plant. Once the recent upgrades are fully realized, further pilot testing and desktop evaluation at the North Plant can be performed to determine the full denitrification potential. This analysis will lead to the next step, which is to evaluate the technical and economic feasibility of capital improvements.

ATTACHMENT A



ATTACHMENT B

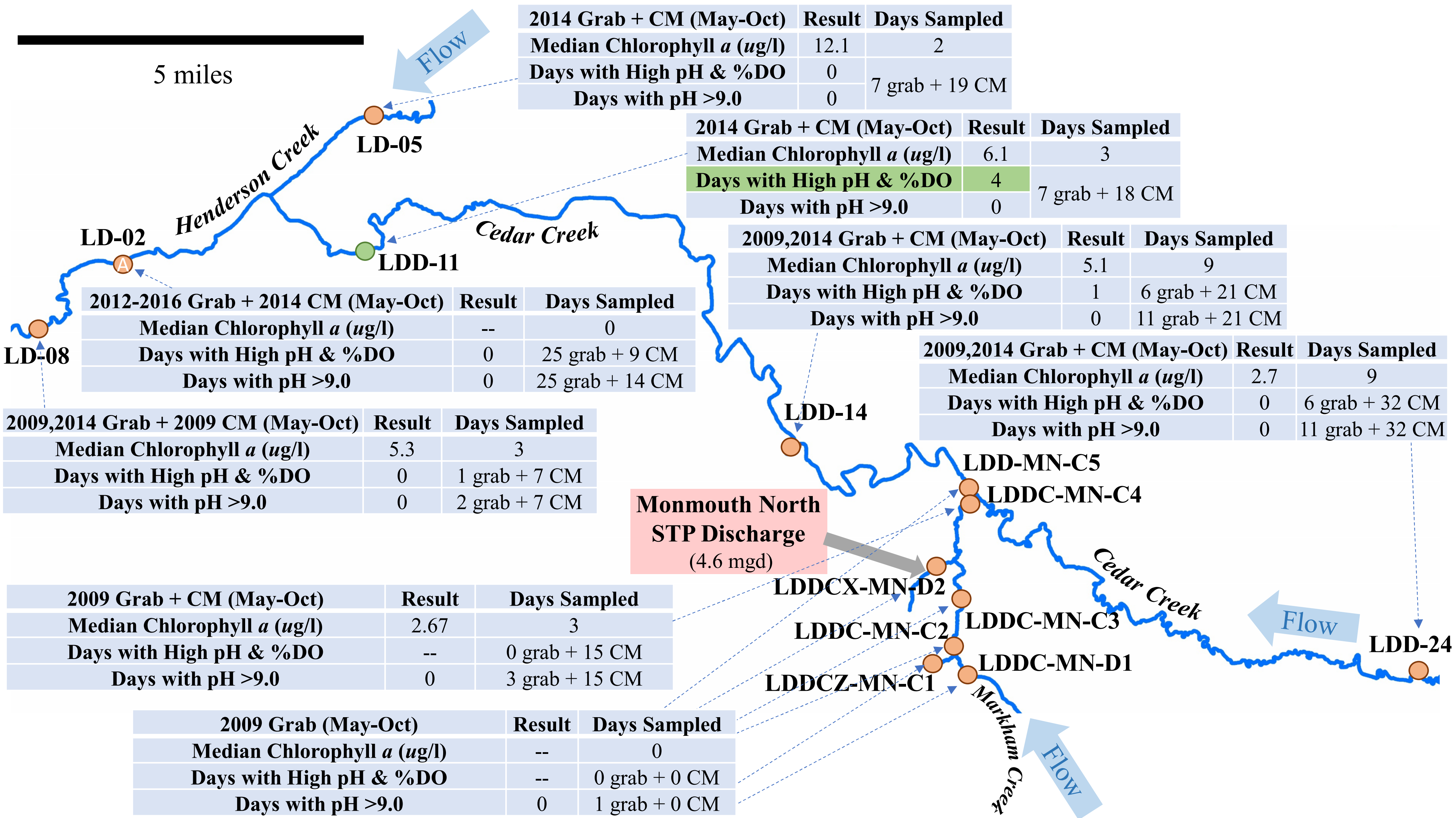


Municipal Influent Flow vs Total Phosphorus Load
Flow (MGD) and Concentration (mg/L)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Municipal Load (pounds/day)
0
20
40
60
80
100
120
140
160
180
200
January-21
February-21
April-21
May-21
July-21
September-21
October-21
December-21
Municipal Influent Flow
Municipal Influent Total Phosphorus Concentration
Municipal Influent Total Phosphorus Load

Woodard & Curran

woodardcurran.com

APPENDIX C: FOIA INFORMATION SUMMARY



2014 Grab + CM (May-Oct)	Result	Days Sampled
Median Chlorophyll *a* (ug/l)	12.1	2
Days with High pH & %DO	0	7 grab + 19 CM
Days with pH >9.0	0	

2014 Grab + CM (May-Oct)	Result	Days Sampled
Median Chlorophyll *a* (ug/l)	6.1	3
Days with High pH & %DO	4	7 grab + 18 CM
Days with pH >9.0	0	

2009,2014 Grab + CM (May-Oct)	Result	Days Sampled
Median Chlorophyll *a* (ug/l)	5.1	9
Days with High pH & %DO	1	6 grab + 21 CM
Days with pH >9.0	0	11 grab + 21 CM

2009,2014 Grab + CM (May-Oct)	Result	Days Sampled
Median Chlorophyll *a* (ug/l)	2.7	9
Days with High pH & %DO	0	6 grab + 32 CM
Days with pH >9.0	0	11 grab + 32 CM

2012-2016 Grab + 2014 CM (May-Oct)	Result	Days Sampled
Median Chlorophyll *a* (ug/l)	--	0
Days with High pH & %DO	0	25 grab + 9 CM
Days with pH >9.0	0	25 grab + 14 CM

2009,2014 Grab + 2009 CM (May-Oct)	Result	Days Sampled
Median Chlorophyll *a* (ug/l)	5.3	3
Days with High pH & %DO	0	1 grab + 7 CM
Days with pH >9.0	0	2 grab + 7 CM

2009 Grab + CM (May-Oct)	Result	Days Sampled
Median Chlorophyll *a* (ug/l)	2.67	3
Days with High pH & %DO	--	0 grab + 15 CM
Days with pH >9.0	0	3 grab + 15 CM

2009 Grab (May-Oct)	Result	Days Sampled
Median Chlorophyll *a* (ug/l)	--	0
Days with High pH & %DO	--	0 grab + 0 CM
Days with pH >9.0	0	1 grab + 0 CM

StationCode	Start_DateTime	Parameter	PeriodDuration_WholeHRS	Period_Minimum	Period_Maximum	Period_Average
LDD-11	07/22/14	Dissolved-oxygen saturation	191	84.2	124.8	97.62
LDD-11	07/22/14	pH	191	7.99	8.47	8.23
LDD-11	09/18/14	Dissolved-oxygen saturation	287	88.4	126.4	100.73
LDD-11	09/18/14	pH	287	8.09	8.43	8.27

StationCode	Start_DateTime	Parameter	Max_Day1	Max_Day2	Max_Day3	Max_Day4
LDD-11	07/22/14	Dissolved-oxygen saturation	118.8	122.9	118.8	101.8
LDD-11	07/22/14	pH	8.39	8.34	8.34	8.27
LDD-11	09/18/14	Dissolved-oxygen saturation	100.6	100.7	101.5	101.9
LDD-11	09/18/14	pH	8.18	8.2	8.2	8.23

StationCode	Start_DateTime	Parameter	Max_Day5	Max_Day6	Max_Day7	Max_Day8
LDD-11	07/22/14	Dissolved-oxygen saturation	103.9	113.1	116.4	
LDD-11	07/22/14	pH	8.16	8.22	8.32	
LDD-11	09/18/14	Dissolved-oxygen saturation	103.9	105.2	107.9	112
LDD-11	09/18/14	pH	8.24	8.28	8.32	8.35

StationCode	Start_DateTime	Parameter	Max_Day9	Max_Day10	Max_Day11
LDD-11	07/22/14	Dissolved-oxygen saturation			
LDD-11	07/22/14	pH			
LDD-11	09/18/14	Dissolved-oxygen saturation	114.9	117.1	122.7
LDD-11	09/18/14	pH	8.4	8.42	8.43

APPENDIX D: NARP SAMPLING PLAN

1520 S. Fifth Street
Suite 273
St. Charles, Missouri 63303
www.woodardcurran.com

T 800.426.4262

SAMPLING PLAN - MONMOUTH, IL NARP 0234615.00

OUTLINE:

1.) GOALS OF SAMPLING

a. The goal of sampling Cedar Creek, Markham Creek, and the unnamed tributary to Markham Creek is to identify the relative condition of the creeks at a snapshot in time. This information will be used in the Nutrient Assessment and Reduction Plan (NARP) Memo to be submitted to the City of Monmouth, IL. The NARP memo focuses on how to reduce phosphorus discharge. For this memo, more background information about the discharge from Consolidate Sewer Treatment Plant (Consolidated WWTF) is needed. The sampling will show how the creeks may be affected by the Consolidated WWTF's discharge, the nearby golf course, surrounding agriculture, or other factors in the area. The following constituents will be measured: ammonia, organic nitrogen, nitrate, nitrite, phosphates, orthophosphate, total phosphorus, total nitrogen, alkalinity, pH, conductivity, and dissolved oxygen.

2.) LOCATIONS

The following locations are planned to be sampled:

A: Cedar Creek (Downstream (DS) of confluent with Markham Creek)

B: Cedar Creek (Upstream (US) of confluent with Markham Creek)

C: Markham Creek (US of confluent with Cedar Creek)

D: Markham Creek (US of confluent with Cedar Creek)

F: Unnamed tributary of Markham Creek (US of confluence with STP WWTF Outfall)

E: STP WWTF Outfall (Unnamed tributary of Markham Creek)

G: 85 St. and 210th Ave (Markham Creek, near Gibson Woods Golf Course)

These locations are not definite, but approximations for where samples will be collected. The sampling team's health and safety will take priority, and samples will be collected where it is feasible. Exact locations will be recorded in the field at time of sampling.

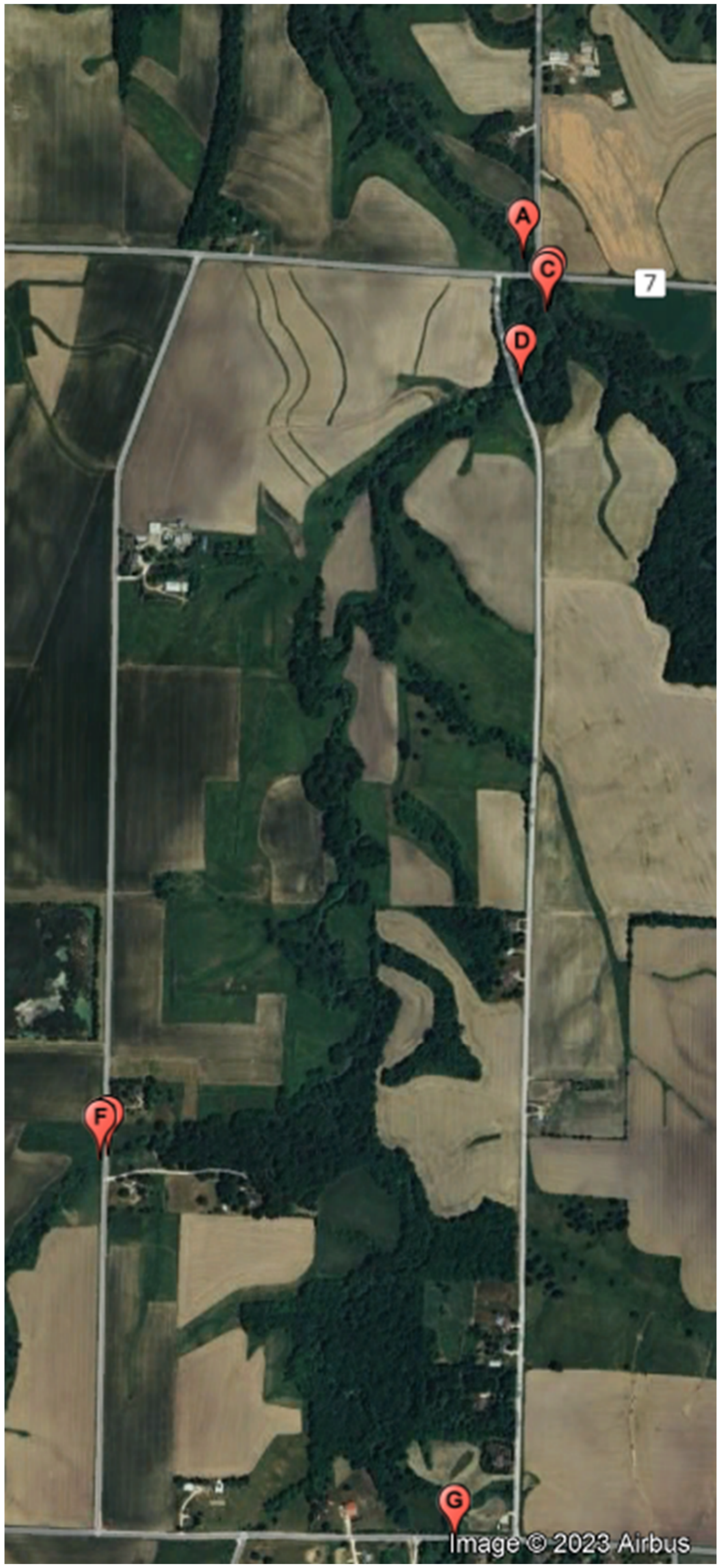


FIGURE 1 – SAMPLING LOCATIONS

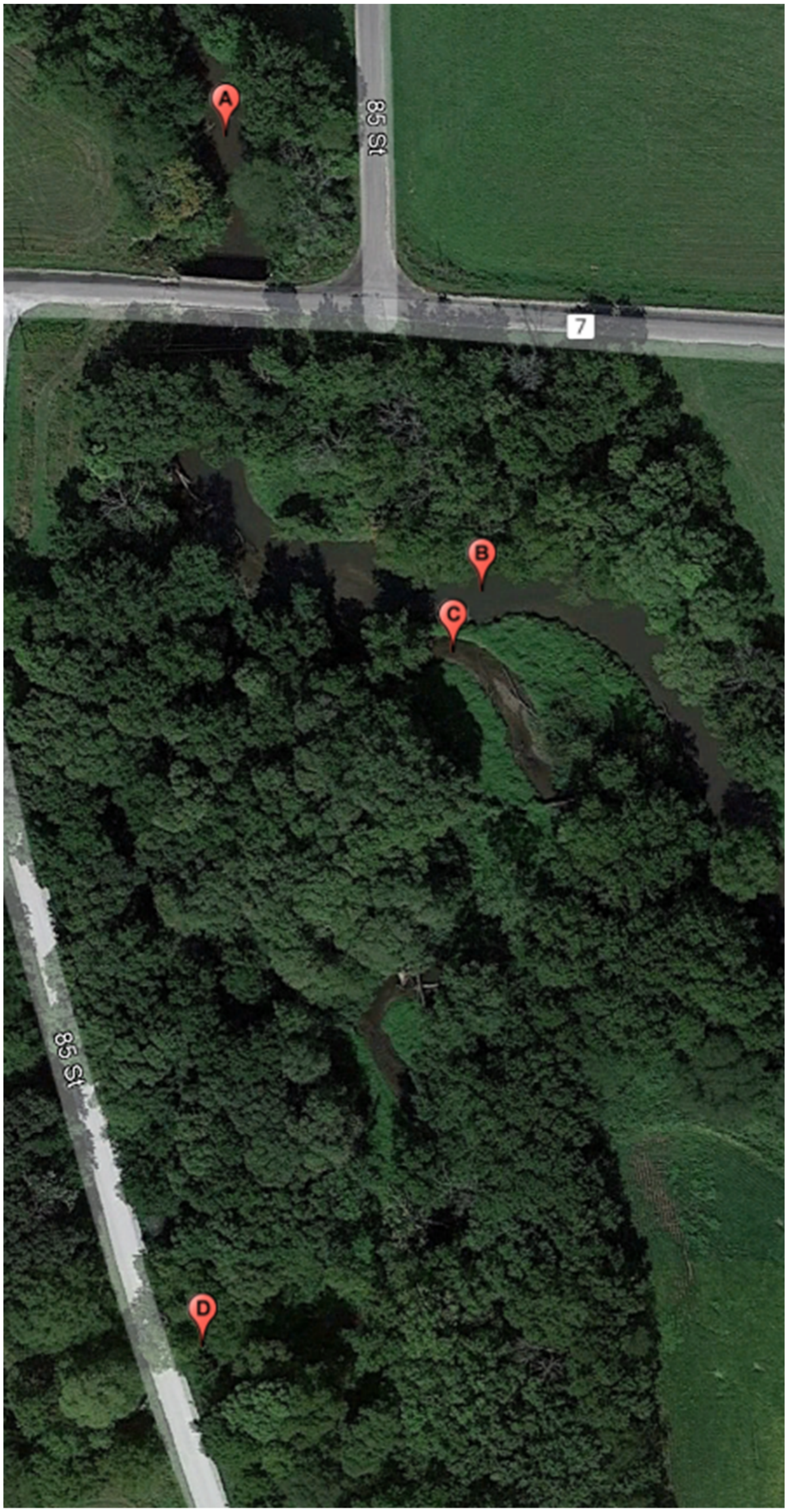


FIGURE 2 - SAMPLING LOCATIONS A – D

FIGURE 3 - SAMPLING LOCATIONS E – G

3.) DATES AND TIMES

a. Samples will be collected on 3 different days at the 7 locations each day depending on the conditions.

TABLE 1 - SAMPLING LOCATIONS AND APPROXIMATE SAMPLING TIMES

Locations	July 20, 2023	August 3, 2023	August 17, 2023
A. Cedar Creek (DS of confluence with Markham Stream)	7 AM	7 AM	7 AM
B. Cedar Creek (US of Confluence with Markham)	8 AM	8 AM	8 AM
C. Markham Stream (US of confluence with Cedar Creek)	9 AM	9 AM	9 AM
D. Markham Creek (US of confluence with Cedar Creek)	10 AM	10 AM	10 AM
F. Unnamed tributary of Markham Creek (US of confluence with STP WWTF Outfall)	11:30 AM	11:30 AM	11:30 AM
E. STP WWTF Outfall	12:30 PM	12:30 PM	12:30 PM
G. 85 St. and 210^{th} Ave (near golf course)	2 PM	2 PM	2 PM

*Times listed are estimates. Actual times will be recorded during the sampling event.

4.) MATERIALS

TEKLAB, INC. (the lab) will provide a cooler and sample bottles.

Rental equipment from Pine Environmental Services, LLC (PINE) will include a flow meter, multi-meter, wading rod, dipper, ladles, and extra batteries from the rental service. The multi-meter will test DO, pH, conductivity, and temperature.

The sampling team will supply ice, a tape measure, markers, pen, Zip-Lock gallon sized bags, stakes to mark the stream, paper towels, scissors, notebooks, mallet, map of the area, waders, hi-visibility vest, long pants, protective-toe boots, long sleeved shirt, nitrile gloves, rope, laptop hat/bandana, insect repellant, poisonous plant wipes/cleaner, first aid kit, plastic tarp, spray bottle, phosphate free soap, branch cutter, trash bags, measuring rod and optionally sunscreen and a change of clothes.

5.) ROUTE OF SAMPLING

First, a bottle from Monmouth STP will be picked up to sample an extra orthophosphate. Sampling will be conducted downstream to upstream so as not to disturb the sampling area. For locations A, B, and C, the sampling team will park near the intersection of 225th Ave. and 85th St. Sampling will start at location A and end at C for this area. The car will be parked close to location C to minimize the distance carrying the cooler. After collecting at this location, the sampling team will drive to Location D along 85th St. and collect samples there. The sampling team will then drive up 85th St. to Locations E and F and park along 85th St. to collect samples. At E, an extra orthophosphate sample will be collected using the bottle from the WWTF. The sampling team will drop off the orthophosphate sample at Consolidated WWTF before heading to Location G. For Location G, the sampling team will park near the intersection of 85th St. and 210th Ave. to sample. After all samples and data have been collected, the cooler will be dropped off at the lab at 5445 Horseshoe Lake Rd, Collinsville, IL 62234.

6.) METHOD OF SAMPLING

a. PROCEDURE

1. Collect water samples.
2. Place water samples in the cooler.
3. Use multi-meter where samples were collected.
4. Set up stakes and rope where samples were taken to define the cross section that will be used to calculate streamflow.
5. Take velocity measurements at designated intervals along the cross section.

b. NOTES

i. Include the following in field notes:

1. Potential sources of contamination
2. Location of sites
3. Specific location on where sample was drawn
4. Site access instructions
5. Photographs
6. Measurements
7. Weather
8. Temperature
9. Environmental hazards

10. Times

11. Information on how samples were collected

c. COLLECTING SAMPLES

The following steps elaborate on the process for collecting a sample:

1.) Before sampling, label all sample bottles and record where each sample will be collected

2.) Ensure cooler has ice and can be kept at 6° Celsius

3.) Select a cross section across the total width of the stream, where it is relatively uniform, free of boulders, and aquatic growth

4.) Wear new nitrile gloves

5.) Assign one personnel as CH (clean hands) and the other as DH (dirty hands)

6.) CH will take the samples and DH will record data and handle equipment

7.) CH will field rinse the swivel dipper ladle/put a new plastic ladle in it as needed

8.) CH will stand downstream of the sampling location

9.) DH will record sampling time

10.) CH will submerge the swivel dipper vertically into the body of water

11.) CH will fill dipper with water

12.) CH will then pour material into the sampler bottle

13.) CH with the help of DH will dry off bottle and put in a Ziplock bag

14.) Put the Ziplock bag in the cooler with ice

15.) Repeat steps 7 through 14 until all bottles have been filled at that location

16.) Rinse off dipper and put the head of it in a Ziplock bag

IF WATER IS TOO SHALLOW FOR SWIVEL DIPPER, USE SAMPLE BOTTLE AND NOTE THE CONTAMINATION

17.) Clean PPE and all materials

18.) Repeat steps 3-17 for each location

19.) Review information before shipping

d. MULTI-METER READINGS

The following steps elaborate on how the multi-meter will be used:

1.) After sampling, field rinse the multi-meter probe

2.) Place the multi-meter probe in the same location that sampling was conducted.

3.) Record the information on the multi-meter screen

4.) Take a picture of the screen if feasible

e. STREAMFLOW MEASUREMENTS

The following steps elaborate on how the streamflow will be recorded:

1.) At the location samples were taken, calculate the streamflow of the cross section

2.) Choose a point as our bank reference point that we will fix the tape measure at

3.) Place a stake at the reference point and tie a rope to it

4.) Stretch the tape across the channel keeping the tape perpendicular to the streamflow.

5.) Once we reach the opposite bank, record the width of the stream surface.

6.) Place a stake on the opposite bank as another reference point and cut and tie a rope to it

7.) Record depths at appropriate intervals (need 20 to 30 verticals we can change the spacing if needed) (where depth and velocity are changing rapidly, record closer) (must ensure that no more than 5 or 10 percent of the total discharge occurs within a single subsection)

8.) Face upstream, note which bank started at

9.) If the water depth is greater than 2.5 feet, measure the velocity at 2 points between 0.2 and 0.8 of the depth below the water surface, and then utilize the average

10.) If the water depth is less than 2.5 feet, measure the velocity at one point 0.6 of the depth below the water surface

11.) Keep the wading rod vertical and the flow sensor perpendicular to the tape rather than perpendicular to the flow while measuring velocity with an electronic flowmeter

12.) Measure velocity at every vertical

13.) Record

14.) Leave stakes in place until our last sampling date

In our notes we will include the current weather and previous weather (including temperature) using the National Weather Service.

7.) WEATHER

a. SAMPLING TEMPERATURES

We will be sampling during dry conditions. If the National Weather Service predicts more than an inch and a half of rain within 48 hours and more than a half inch of rain within the past 24 hours of the sampling event, we will need to reschedule the sampling event.

b. CANCELATIONS

If weather conditions do not permit with our testing plan, we must notify Teklab, Pine Environmental, and all personnel involved 24 hours before equipment pickup/drop off. Equipment pickups are the evenings of July 19th, August 2nd, and August 16th at 5 PM Central.

8.) CONTACTS – Personal Information Removed for Public Document.

Teklab:

Pine Environmental:

Woodard and Curran Employees:

Onsite contacts-

Offsite contacts-

Monmouth O&M-

St Charles Office-

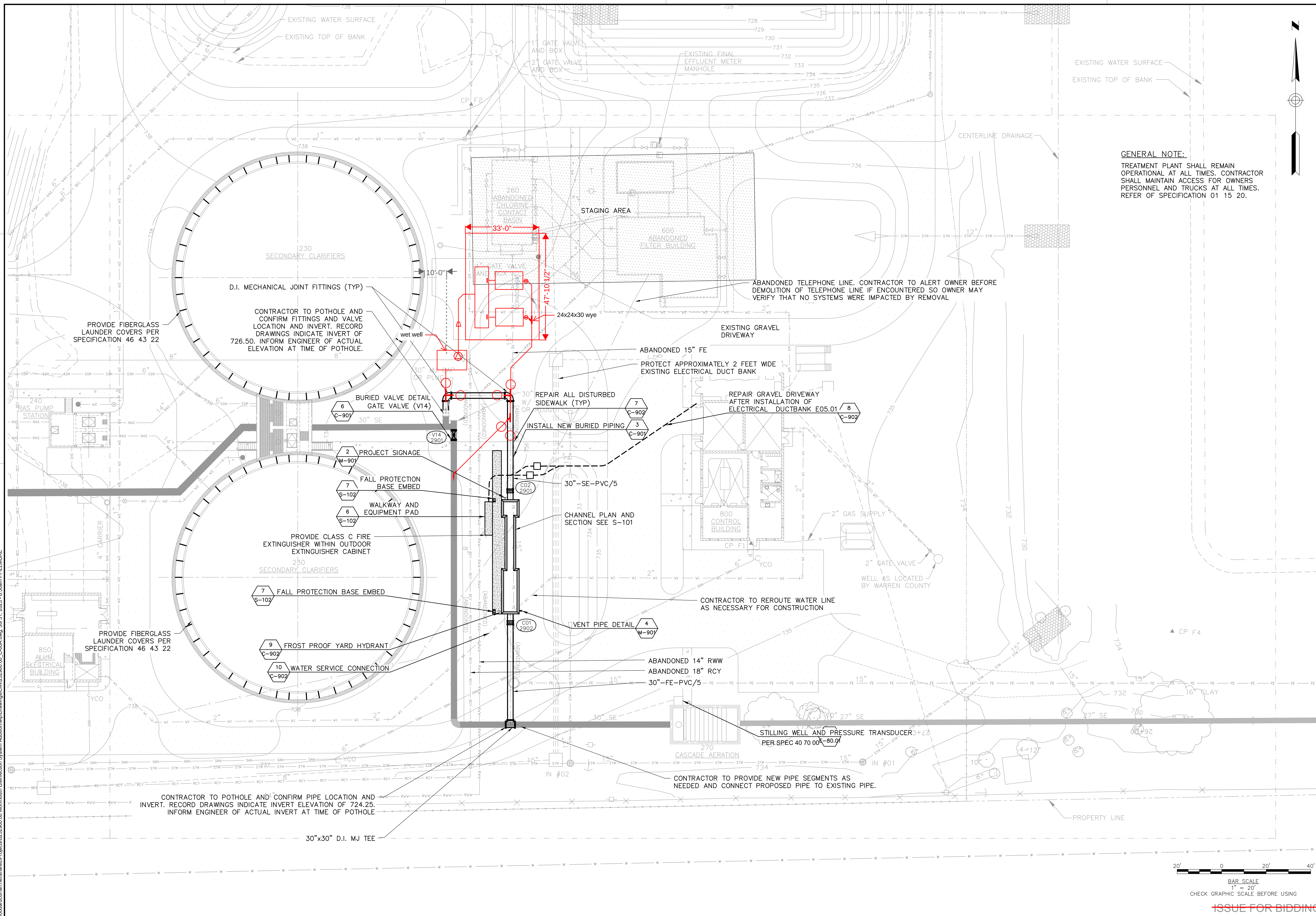
9.) LAB INSTRUCTIONS: TEKLAB

Approximately a week before sampling, Teklab will drop off the bottles.

10.) EQUIPMENT INSTRUCTIONS: PINE ENVIRONMENTAL

Pine Environmental will drop the equipment off the day before scheduled testing. They will drop it off at the St. Charles office. When we are done, we will email or call the office to have them pick it up.

APPENDIX E: CONCEPTUAL FILTRATION SYSTEM LAYOUT



22x34 SHEET 1:1

WOODARD & CURRAN
1520 S. Fifth Street, Suite 273
St. Charles, Missouri 63303
800.426.4262 | www.woodardcurran.com
COMMITMENT & INTEGRITY DRIVE RESULTS

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REV	DESCRIPTION	DATE
0	ISSUE FOR CONSTRUCTION	04/08/22

DESIGNED BY: SW | DRAWN BY: PF | CHECKED BY: EO

Conceptual Filtration System Layout

CITY OF MONMOUTH
MONMOUTH, ILLINOIS

DISINFECTION SYSTEM ADDITION

JOB NO: 232960.00
DATE: JUNE 2022
SCALE: AS NOTED
SHEET: 4 OF 23

C-002

APPENDIX F: CAPITAL COST SUMMARY

Client: Monmouth, IL
Project: Monmouth, IL - NARP
Component: Capital Costs of Phosphorus Removal

Woodard & Curran
1520 S. Fifth Street, Suite 273
St. Charles, MO 63303
Telephone (800) 426-4262

Completed By MK
Checked By BKM
Project No. 234615.00
Date 11/2/2023

Engineer's Opinion of Probable Project Cost
Estimate Type: *Conceptual*
Accuracy Range: *-15% to +50%*
Itemized Cost Summary

Item	Description	Unit	Quantity	Unit Price	Labor	Total Price	Notes
1	Pilot Study and Chemical Optimization	LS	1	$ 250,000	$ -	$ 250,000	
2	General Conditions & Mobilization/Demobilization	LS	1	$ 655,600	$ -	$ 656,000	10% of Construction subtotal
3	Cloth Media Disc Filter	LS	2	$ 850,000	$ 30,000	$ 1,760,000	WesTech Proposal
4	Building Foundation	CY	120	$ 1,200	$ -	$ 144,000	
5	Chemical Cleaning System	LS	2	$ 35,000	$ 5,000	$ 80,000	WesTech Proposal
6	Filtration Building	SF	1,400	$ 500	$ -	$ 700,000	
7	Concrete Housing for Filters	CY	16	$ 1,200	$ -	$ 19,000	
8	6-inch PVC Piping (Backwash Waste Connection)	LF	1	$ 250	$ -	$ 1,000	
9	24-inch PVC Piping (Feed/Filtrate Connections)	LF	48	$ 625	$ -	$ 30,000	
10	30-Inch PVC Piping	LF	97	$ 625	$ -	$ 61,000	
11	45° Bend (24-Inch)	EA	6	$ 10,000	$ -	$ 60,000	
12	45° Bend (30-Inch)	EA	3	$ 12,000	$ -	$ 36,000	
13	30x30x30-Inch Tee	EA	2	$ 18,000	$ -	$ 36,000	
14	24x24x30-Inch Wye	EA	1	$ 18,000	$ -	$ 18,000	
15	30-Inch Wye	EA	1	$ 25,000	$ -	$ 25,000	
16	24-Inch to 30-Inch Reducer	EA	1	$ 10,000	$ -	$ 10,000	
17	24-Inch Gate Valve	EA	2	$ 20,000	$ -	$ 40,000	
18	30-inch Gate Valve	EA	6	$ 30,000	$ -	$ 180,000	
19	Stop Gate (24'x36')	EA	2	$ 5,000	$ -	$ 10,000	
20	Splitter Box	CY	21	$ 1,200	$ -	$ 26,000	
21	Wet Well Structure (Concrete)	CY	21	$ 1,200	$ -	$ 26,000	
22	Submersible Pump	EA	2	$ 37,500	$ 9,000	$ 93,000	
23	Davit Crane	LS	1	$ 8,000	$ -	$ 8,000	
24	Select Granular Backfill	CY	180	$ 60	$ -	$ 11,000	
25	Site Work	LS	1	$ 15,660	$ -	$ 16,000	
26	Excavation & Backfill	CY	430	$ 100	$ -	$ 43,000	
27	Electrical and Instrumentation	LS	1	$ 441,171	$ 75,000	$ 517,000	
28	Survey	LS	1	$ 3,000	$ -	$ 3,000	
29	Shoring & Dewatering	LS	1	$ 100,000	$ -	$ 100,000	
30	Erosion and Sediment Control	LS	1	$ 2,500	$ -	$ 3,000	
					Raw Construction Subtotal	**$ 4,962,000**	
					Contractor's Overhead and Profit	$ 745,000	15% of Raw Construction
					Escalation	$ 1,230,000	5% Annually
					Subtotal	*$ 6,937,000*	
					Construction Contingency	$ 2,082,000	30% of Raw Construction, O&P, and Escallation
					CONSTRUCTION COST SUBTOTAL	**$ 9,019,000**	2027 Dollars
					Non-Construction Project Costs	$ -	
					Engineering, Permitting, Construction Assistance & Periodic Inspection	$ 1,534,000	
					Control System Integration	$ 100,000	
					Other Owner Costs	$ -	
					Capital Cost Subtotal	*$ 10,653,000*	
					TOTAL PROJECT COST	**$ 10,700,000**	2027 Dollars

*Line items with blank labor costs already include labor in Unit Price

APPENDIX G: WESTECH FILTRATION PROPOSAL

Monmouth

Illinois

Representative

Brian Amsler
Ray Lindsey Company
Saint Louis, Missouri
(816) 388-7440
bamsler@raylindsey.com

Contact

Don Tyson
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WESTECH®

Proposal Number: 2260346
Tuesday, October 24, 2023

ISO 9001 SYSTEM CERTIFICATION SGS

Table of Contents

Technical Proposal

Item A – SuperDisc™ Filtration System, Model TD 2420-16

Design Overview		
Description	**Unit**	**Dimension/Capacity**
Application	-	Tertiary Wastewater
WesTech System Model	-	TD 2420-16, Tank-Mounted
Average Flow Rate	MGD	4.46
Peak Design Flow Rate	MGD	10.23
Redundancy and Unit Quantity	-	2 × 50%, (2) total units
Approximate Dimensions	Per Unit	16'-1 1/2" L x 8'-11 7/8" W x 9'-2" H
Weight		
Shipping	lbs. Per Unit	9,634
Operating	lbs. Per Unit	36,662
Connection Sizes	in	24" feed/filtrate connections 6" backwash waste connection 1" chemical cleaning connection

WesTech is a leader in innovative filtration system technology, including packaged systems, retrofit engineering solutions, and intelligent controls. WesTech disc filter systems are fully assembled and factory tested prior to shipment. We have provided more than 250-disc filtration systems globally with system sizes in excess of 200 MGD.

In addition to disc filtration equipment, WesTech offers extensive pre- and post-treatment options for an integrated, complete process with consolidated support. As a company, WesTech has 530 employees, 190 degreed engineers, and more than 15,000 process equipment installations throughout the world. This significant experience translates to reliable, time-tested equipment.

Design Information

Water Quality

Effluent quality is estimated based on the following influent quality information. System design is based on available filter influent within the limits found below.

Feed Water Quality*

Description	Unit	Value
Source	-	Secondary Effluent
Upstream Biological Process	-	Activated Sludge
pH		6.5 – 8.5
Temperature	°C	5 – 20*
Total Suspended Solids, Average	mg/L	≤10
Total Suspended Solids, Peak	mg/L	≤30
Phosphorus		
Total, as P	mg/L	<2.44
Particulate, as P	mg/L	>0.5
Soluble Non-Reactive, as P	mg/L	<0.02
Total Alkalinity, as $CaCO_3$	mg/L	≥60

*Consideration of material compatibility, particularly in regard to parameters not provided or represented, like chlorides, is to be validated by others. It is expected that the influent water will not contain any substances that would inhibit or damage the process / equipment including solvents, lubricants, preservatives, and oil.

Treated Water Quality*

Description	Unit	Value
Total Suspended Solids	mg/L	≤10 average, without chemical addition ≤5 average, with chemical addition

*The influent to the filtration system must contain particles of sufficient size and strength to allow retention on the specified 10-micron media surface in order for the performance criteria to be met. Upstream process adjustments are the responsibility of and must be made by the Owner / Contractor to provide sufficient particle size and strength for filterability.

*Treated water quality may be dependent on appropriate type and concentration of chemical, as applicable, with dosing relevant to project water quality and constituent speciation. Determination and optimization of reaction chemistry is by others. WesTech can support bench- and pilot-scale testing, if desired.

Process Design

Design Summary		
Parameter	**One Unit Off**	**All Units Operating**
Number of Units in Operation	1	2
WesTech System Model	SuperDisc™ TD2420-16, Tank Mounted	
Media Properties		
Nominal Pore Size	10 µm	
Installed Discs / Disc Capacity per Unit	16 / 20	
Filter Disc Diameter	2.4 m	
Total Effective / Submerged Surface Area	740.5 ft²	1,481.0 ft²
Hydraulic Loading		
Average	2.1 gpm/ft²	2.1 gpm/ft²
Maximum (Peak Condition)	4.8 gpm/ft²	4.8 gpm/ft²
Maximum Total Head Loss	16 - 18 in	
Estimated Backwash Operation	Intermittent, Estimated 30% of Time	
Estimated Backwash Duration	30 sec	
Operating Flow Rates		
Average Gross Flow Rate	1,549 gpm	3,097 gpm
Maximum (Peak) Feed Flow Rate	3,552 gpm	7,104 gpm
Backwash Flow Rate	134 gpm	134 gpm
Backwash Pressure	109 psi	109 psi
Approx. Total Treated Flow Per Day (Peak)	5.1 MGD	10.2 MGD
Approx. Total Waste Volume per Day	28,965 gpd	57,931 gpd
Estimated System Recovery (Peak)	99.4 %	99.4 %
Estimated Chemical Clean Frequency	Annually	

Process Description

The feed water flows via gravity into the SuperDisc filter. The water passes in an inside-out flow path through the filter media. Using a small micron pore size, suspended solids and particulate are retained on the inside of the discs. Filtered water is directed into the internal level tank. During the filtration process, headloss across a disc is increased through build-up of suspended solids and particulate, which translates to increased headloss and a rise in inlet channel water level. A backwash cycle is initiated once the liquid level reaches a high-level probe in the inlet channel.

During a backwash, the drum rotates and a high-pressure oscillating spray is applied to the discs. A centrifugal pump is used to draw filtrate from the level tank as the backwash supply. Level probes on the unit serve as backwash pump protection. The drum is rotated using a drive assembly consisting of a carbon synchronous belt, stainless steel sprocket, and a small motor. The backwash continues until the liquid level decreases to below the low-level sensor for an adjustable time delay (typically 20 seconds).

If the suspended solids loading and/or hydraulic loading exceeds machine capacity, an emergency overflow condition occurs in which influent water overflows the bypass weirs located at the inlet box. When this bypass event occurs, water flows over the bypass weir, around the level tank, and out the effluent nozzle or into the concrete channel to avoid cross contamination. With a static rotor, the filter cassettes can tolerate a differential pressure of up to 16 inches for up to 48 hours.

Scope of Supply

Scope of Supply – SuperDisc™ System			
Item	**Quantity**	**Description**	**Brand/Material**
Disc Filter Units	2 × 50%	Shop-assembled, integral effluent tank for stand-alone design	-
Filter Discs and Frames*	16/unit 32/system	10 µm pore size	Polyester Filter FRP Frame
Level Tank	1/unit	Integral, filtered water collection	304SS
Reject Trough	1/unit	Backwash waste collection	304SS
Rotor Drum	1/unit	Discs connected with gaskets	304SS
Drum Shaft	1/unit	Rotation during backwash	304SS
Backwash Header	1/unit	High pressure oscillating spray	304SS
Chemical Cleaning Header	1/unit	Chemical solution supply	Sch 80 PVC
Backwash Assembly			
Pump	1/unit	25 HP, 480 V, 3 ph	Grundfos
Header	1/unit	0.16 HP, 480 V, 60 Hz	SEW
Nozzles	288/unit	Ceramic	Spraying Systems
Isolation Valve	1/unit	Butterfly, CI, Wafer Style	BPS
Pressure Valve	1/unit	Ball Valve, 316 SS, Threaded	Nibco
Strainer	1/unit	Polyester coated steel housing; 316SS filter element	Amiad
Filter Drive Assembly	1/unit	Carbon synchronous belt and 304 ss sprocket; 2.0 HP, 480 V, 3 pH	SEW
Access Hatches	1/unit	Clam-shell Automatic cover w/actuator	FRP
Instrumentation			
Liquid Level Probe	5/unit	Standard conductance probe	304SS
Electrical Controls	2 Master	NEMA 4X, 480 V, 3 ph, PLC, HMI	Allen-Bradley

*Access walkways, handrail, and stairs (if required) are not included. All interconnecting piping, supports, insulation and heat protection of piping and equipment, wiring and conduit is by others except as listed above.

SuperDisc™ Tank Design Packaged Disc Filtration System

Additional Services

On-Site Technical Assistance and Training

WesTech has included on-site technical assistance during construction, pre-commissioning, and start-up to ensure the equipment is installed and commissioned per WesTech and sub-supplier requirements. All service visits will be completed by certified field technicians that are qualified and have experience working with WesTech equipment.

Any additional trips that the customer may request can be purchased at the standard WesTech daily rates plus travel and living expenses.

On-Site Technical Service

Service	Number of Trips	Number of Days
Installation Inspection and Start-Up	1	3
Operator Training and Assistance	1	3
Total Included Service	2	6

To supplement the above noted technical assistance, WesTech will provide the additional services.

- Technical support during WesTech office hours with a direct phone number to reach a qualified and involved project representative during the equipment warranty period.
- Access to a 24-hour on-call emergency support line.

Process Design and Engineering

WesTech will provide the following process engineering and support for the system.

- Equipment general arrangement drawings.
- Equipment installation instructions.
- Operations and maintenance manuals.

Optional Items

Item A-1 – Optional Adder for Chemical Cleaning System

A chemical cleaning system can be used to restore filter permeability. The mobile chemical cleaning system is connected to the integral chemical spray bar in the filter and the PLC panel. The cleaning process is then initiated from the panel and the user is prompted to open the appropriate valves. The chemical is applied to the outside of the filter media. Residual chemical is captured in the level tank and is discharged with the effluent at diluted levels.

Scope of Supply – Chemical Cleaning System

Item	Quantity	Description	Brand (or equal)
Cart / Frame	1	-	-
Storage Tank	1	26 gal, HDPE	-
Recirculation Pump	1	1.5 HP	Iwaki
Float Switch	1	-	Chicago Sensor
Pressure Gauge	1	2 ½” dial	Winters

Clarifications and Exceptions

General Clarifications

Terms & Conditions: This proposal, including all terms and conditions contained herein, shall become part of any resulting contract or purchase order. Changes to any terms and conditions, including but not limited to submittal and shipment days, payment terms, and escalation clause shall be negotiated at order placement, otherwise the proposal terms and conditions contained herein shall apply.

Paint: If your equipment has paint included in the price, please take note to the following. Primer paints are designed to provide only a minimal protection from the time of application (usually for a period not to exceed 30 days). Therefore, it is imperative that the finish coat be applied within 30 days of shipment on all shop primed surfaces. Without the protection of the final coatings, primer degradation may occur after this period, which in turn may require renewed surface preparation and coating. If it is impractical or impossible to coat primed surfaces within the suggested time frame, WesTech strongly recommends the supply of bare metal, with surface preparation and coating performed in the field. All field surface preparation, field paint, touch-up, and repair to shop painted surfaces are not by WesTech.

Escalation: If between the proposal date and actual procurement and through no fault of the Seller, the relevant cost of labor, material, freight, tariffs, and other Seller costs combined relating to the contract, increase by greater than 2.5% of the overall contract price, then the contract price shall be subject to escalation and increased. Such increase shall be verified by documentation and the amount of contract price escalation shall be calculated as either the actual increased cost to the Seller or, if agreed by the Parties, the equivalent increase of a relevant industry recognized third-party index, and in both cases without any additional profit or margin being added.

USA Tariffs and Current Trade Laws: All prices are based on current USA and North America tariffs and trade laws/agreements at time of bid. Any changes in costs due to USA Tariffs and trade laws/agreements will be passed through to the purchaser at cost.

The Infrastructure Investment and Jobs Act of 2021 (IIJA) includes potentially significant changes to historical “Buy American” or “American Iron and Steel” (AIS) requirements for federally funded projects, including water-related infrastructure projects as administered by the Environmental Protection Agency (EPA). The IIJA was signed into law on Nov 15, 2021. However the EPA has yet to issue additional information and guidance clarifying the application and interpretation of these changes. Although WesTech makes every effort to source the steel for our equipment and products domestically, not everything is reasonably or commercially available to meet all project specific constraints. Consequently, any proposal or offer for sale by WesTech, including any resulting equipment order, does not guarantee compliance with the Buy American provisions of the Infrastructure Investment and Jobs Act of 2021 at this time.

Schedule: Due to supply chain disruptions and volatility, delivery schedule is a best estimate only and may be improved or hampered based on date of contract execution, scope selection, and materials availability. Items related to electrical and programming components are at specific risk of extended delivery timeframes. Any documented delays associated with electrical scope of supply are not subject to any penalties, charges, or damages assessed to the seller.

Commercial Proposal

Proposal Name: Monmouth
Proposal Number: 2260346
Tuesday, October 24, 2023

1. Bidder's Contact Information

Company Name	WesTech Engineering, LLC
Primary Contact Name	Don Tyson
Phone	(801) 265-1000
Email	dtyson@westech-inc.com
Address: Number/Street	3665 S West Temple
Address: City, State, Zip	Salt Lake City, UT 84115

2. Budget Pricing

Currency: USD

	Scope of Supply	
A	SuperDisc™ Filtration System, Model TD 2420-16	$850,000
	Optional Items	
A-1	Optional Adder for Chemical Cleaning System	$35,000
	Taxes (sales, use, VAT, IVA, IGV, duties, import fees, etc.)	Not Included

Prices are valid for a period not to exceed 30 days from date of proposal.

Additional Field Service	
Daily Rate (Applicable Only to Field Service Not Included in Scope)	$1,350

Pricing does not include field service unless noted in scope of supply, but is available at the daily rate plus expenses. The greater of a two week notice or visa procurement time is required prior to departure date. Our field service policy can be provided upon request for more details.

3. Payment Terms

Purchase Order Acceptance and Contract Execution	10%
Submittals Provided by WesTech	15%
Release for Fabrication	35%
Notification of Ready to Ship	40%

All payments are net 30 days. Partial shipments are allowed. An approved Letter of Credit is required if Incoterms CIF, CFR, DAP, CIP, or CPT are applicable. Payment is required in full for all other Incoterms prior to international shipment. Other terms per WesTech proforma invoice. Please note that the advising bank must be named as: Wells Fargo Bank, International Department, 9000 Flair Drive, 3rd Floor, El Monte, California 91731, USA.

4. Schedule

Submittals, after Purchase Order Acceptance and Contract Execution	6 to 8 weeks
Ready to Ship, after Receipt of Final Submittal Approval	24 to 26 weeks
Estimated Weeks to Ready to Ship	**30 to 34 weeks***

*Customer submittal approval is typically required to proceed with equipment fabrication and is not accounted for in the schedule above. Project schedule will be extended to account for time associated with receipt of customer submittal approval.

5. Freight

Domestic: FOB Shipping Point - Full Freight Allowed to Jobsite (FSP-FFA)

From	Final Destination	Number of Trucks or Containers
WesTech Shops	Monmouth, IL	Approximately 2

One-Year Warranty

WesTech is meeting a global need for clean water through technology treatment solutions. We are proud that the equipment and systems we design, build, maintain, and operate are making the world a better place and creating a more sustainable environment for future generations.

Equipment manufactured or sold by WesTech Engineering, LLC, once paid for in full, is backed by the following warranty:

> Subject to the terms below, WesTech warrants all new equipment manufactured or sold by WesTech Engineering, LLC to be unencumbered and free from defects in material and workmanship, and WesTech will replace or repair, F.O.B. its factories or other location it chooses, any part or parts returned to WesTech which WesTech's examination and analysis determine have failed within the warranty period because of defects in material and workmanship. The warranty period is either, one calendar year immediately following start-up, or eighteen (18) months from when WesTech sent its ready-to-ship notification to the purchaser, whichever expires sooner. All repair or replacement parts qualifying under this warranty shall be free of charge. Purchaser will provide timely written notice to WesTech of any defects it believes should be repaired or replaced under this warranty. WesTech will reject as untimely any warranty defect claim that purchaser submits more than thirty (30) days after the possible warranty defect first occurred. Unless specifically stated otherwise, this warranty does not cover normal wear or consumables. This warranty is not transferable.
>
> This warranty shall be void and shall not apply where the equipment or any part thereof
>
> a) has been dismantled, modified, repaired or connected to other equipment, outside of a WesTech factory, or without WesTech's written approval, or
> b) has not been installed in complete adherence to all WesTech's or parts manufacturer's requirements, recommendations, and procedures, or
> c) has been subject to misuse, abuse, neglect, or accident, or has not at all times been operated and maintained in strict compliance with all of WesTech's requirements and recommendations therefor, including, but not limited to, the relevant WesTech Operations & Maintenance Manual and any other of WesTech's specified guidelines & procedures, or
> d) has been subject to force majeure events; use of chemicals not approved in writing by WesTech; electrical surges; overloading; significant power, water or feed supply fluctuations; or non-compliance with agreed feedwater or chemical volumes, specifications or procedures.

In any case where a part or component of equipment under this warranty is or may be faulty and the component or part is also covered under the warranty of a third party then the purchaser shall provide reasonable assistance to first pursue a claim under the third party warranty before making a claim under this warranty from WesTech. WesTech Engineering, LLC gives no warranty with respect to parts, accessories, or components purchased other than through WesTech. The warranties which apply to such items are those offered by the respective manufacturers.

This warranty is expressly given by WesTech and accepted by purchaser in lieu of all other warranties whether written, oral, express, implied, statutory or otherwise, including without limitation, warranties of merchantability and fitness for particular purpose. WesTech neither accepts nor authorizes any other person to assume for it any other liability with respect to its equipment. WesTech shall not be liable for normal wear and tear, corrosion, or any contingent, incidental, or consequential damage or expense due to partial or complete inoperability of its equipment for any reason whatsoever. The purchaser's exclusive and only remedy for breach of this warranty shall be the repair and or replacement of the defective part or parts within a reasonable time of WesTech's accepting the validity of a warranty claim made by the purchaser.

Terms & Conditions

Terms and Conditions appearing in any order based on this proposal which are inconsistent herewith shall not be binding on WesTech Engineering, LLC The sale and purchase of equipment described herein shall be governed exclusively by the foregoing proposal and the following provisions:

1. SPECIFICATIONS: WesTech Engineering, LLC is furnishing its standard equipment as outlined in the proposal and as will be covered by final approved drawings. The equipment may not be in strict compliance with the Engineer's/Owner's plans, specifications, or addenda as there may be deviations. The equipment will, however, meet the general intention of the mechanical specifications of these documents.

2. ITEMS INCLUDED: This proposal includes only the equipment specified herein and does not include erection, installation, accessories, nor associated materials such as controls, piping, etc., unless specifically listed.

3. PARTIES TO CONTRACT: WesTech Engineering, LLC is not a party to or bound by the terms of any contract between WesTech Engineering, LLC's customer and any other party. WesTech Engineering, LLC's undertakings are limited to those defined in the contract between WesTech Engineering, LLC and its direct customers.

4. PRICE AND DELIVERY: All selling prices quoted are subject to change without notice after 30 days from the date of this proposal unless specified otherwise. Unless otherwise stated, all prices are F.O.B. WesTech Engineering, LLC or its supplier's shipping points. All claims for damage, delay or shortage arising from such equipment shall be made by Purchaser directly against the carrier. When shipments are quoted F.O.B. job site or other designation, Purchaser shall inspect the equipment shipped, notifying WesTech Engineering, LLC of any damage or shortage within forty-eight hours of receipt, and failure to so notify WesTech Engineering, LLC shall constitute acceptance by Purchaser, relieving WesTech Engineering, LLC of any liability for shipping damages or shortages.

5. PAYMENTS: All invoices are net 30 days. Delinquencies are subject to a 1.5 percent service charge per month or the maximum permitted by law, whichever is less on all past due accounts. Pro rata payments are due as shipments are made. If shipments are delayed by the Purchaser, invoices shall be sent on the date when WesTech Engineering, LLC is prepared to make shipment and payment shall become due under standard invoicing terms. If the work to be performed hereunder is delayed by the Purchaser, payments shall be based on the purchase price and percentage of completion. Products held for the Purchaser shall be at the risk and expense of the Purchaser. Unless specifically stated otherwise, prices quoted are for equipment only. These terms are independent of and not contingent upon the time and manner in which the Purchaser receives payment from the owner.

6. PAYMENT TERMS: Credit is subject to acceptance by WesTech Engineering, LLC's Credit Department. If the financial condition of the Purchaser at any time is such as to give WesTech Engineering, LLC, in its judgment, doubt concerning the Purchaser's ability to pay, WesTech Engineering, LLC may require full or partial payment in advance or may suspend any further deliveries or continuance of the work to be performed by the WesTech Engineering, LLC until such payment has been received.

7. ESCALATION: If between the proposal date and actual procurement and through no fault of the Seller, the relevant cost of labor, material, freight, tariffs, and other Seller costs combined relating to the contract, increase by greater than 2.5% of the overall contract price, then the contract price shall be subject to escalation and increased. Such increase shall be verified by documentation and the amount of contract price escalation shall be calculated as either the actual increased cost to the Seller or, if agreed by the Parties, the equivalent increase of a relevant industry recognized third-party index, and in both cases without any additional profit or margin being added.

8. APPROVAL: If approval of equipment submittals by Purchaser or others is required, a condition precedent to WesTech Engineering, LLC supplying any equipment shall be such complete approval.

9. INSTALLATION SUPERVISION: Prices quoted for equipment do not include installation supervision. WesTech Engineering, LLC recommends and will, upon request, make available, at WesTech Engineering, LLC's then current rate, an experienced installation supervisor to act as the Purchaser's employee and agent to supervise installation of the equipment. Purchaser shall at its sole expense furnish all necessary labor equipment, and materials needed for installation.

Responsibility for proper operation of equipment, if not installed by WesTech Engineering, LLC or installed in accordance with WesTech Engineering, LLC's instructions, and inspected and accepted in writing by WesTech Engineering, LLC, rests entirely with Purchaser; and any work performed by WesTech Engineering, LLC personnel in making adjustment or changes must be paid for at WesTech Engineering, LLC's then current per diem rates plus living and traveling expenses.

WesTech Engineering, LLC will supply the safety devices described in this proposal or shown in WesTech Engineering, LLC's drawings furnished as part of this order but excepting these, WesTech Engineering, LLC shall not be required to supply or install any safety devices whether required by law or otherwise. The Purchaser hereby agrees to indemnify and hold harmless WesTech Engineering, LLC from any claims or losses arising due to alleged or actual insufficiency or inadequacy of the safety devices offered or supplied hereunder, whether specified by WesTech Engineering, LLC or Purchaser, and from any damage resulting from the use of the equipment supplied hereunder.

10. ACCEPTANCE OF PRODUCTS: Products will be deemed accepted without any claim by Purchaser unless written notice of non-acceptance is received by WesTech Engineering, LLC within 30 days of delivery if shipped F.O.B. point of shipment, or 48 hours of delivery if shipped F.O.B. point of destination. Such written notice shall not be considered received by WesTech Engineering, LLC unless it is accompanied by all freight bills for said shipment, with Purchaser's notations as to damages, shortages and conditions of equipment, containers, and seals. Non-accepted products are subject to the return policy stated below.

11. TAXES: Any federal, state, or local sales, use or other taxes applicable to this transaction, unless specifically included in the price, shall be for Purchaser's account.

12. TITLE: The equipment specified herein, and any replacements or substitutes therefore shall, regardless of the manner in which affixed to or used in connection with realty, remain the sole and personal property of WesTech Engineering, LLC until the full purchase price has been paid. Purchaser agrees to do all things necessary to protect and maintain WesTech Engineering, LLC's title and interest in and to such equipment; and upon Purchaser's default, WesTech Engineering, LLC may retain as liquidated damages any and all partial payments made and shall be free to enter the premises where such equipment is located and remove the same as its property without prejudice to any further claims on account of damages or loss which WesTech Engineering, LLC may suffer from any cause.

13. INSURANCE: From date of shipment until the invoice is paid in full, Purchaser agrees to provide and maintain at its expense, but for WesTech Engineering, LLC's benefit, adequate insurance including, but not limited to, builders risk insurance on the equipment against any loss of any nature whatsoever.

14. SHIPMENTS: Any shipment of delivery dates recited represent WesTech Engineering, LLC's best estimate but no liability, direct or indirect, is assumed by WesTech Engineering, LLC for failure to ship or deliver on such dates.

WesTech Engineering, LLC shall have the right to make partial shipments; and invoices covering the same shall be due and payable by Purchaser in accordance with the payment terms thereof. If Purchaser defaults in any payment when due hereunder, WesTech Engineering, LLC may, without incurring any liability therefore to Purchaser or Purchaser's customers, declare all payments immediately due and payable with maximum legal interest thereon from due date of said payment, and at its option, stop all further work and shipments until all past due payments have been made, and/or require that any further deliveries be paid for prior to shipment.

If Purchaser requests postponements of shipments, the purchase price shall be due and payable upon notice from WesTech Engineering, LLC that the equipment is ready for shipment; and thereafter any storage or other charge WesTech Engineering, LLC incurs on account of the equipment shall be for the Purchaser's account.

If delivery is specified at a point other than WesTech Engineering, LLC or its supplier's shipping points, and delivery is postponed or prevented by strike, accident, embargo, or other cause beyond WesTech Engineering, LLC's reasonable control and occurring at a location other than WesTech Engineering, LLC or its supplier's shipping points, WesTech Engineering, LLC assumes no liability in delivery delay. If Purchaser refuses such delivery, WesTech Engineering, LLC may store the equipment at Purchaser's expense. For all purposes of this agreement such tender of delivery or storage shall constitute delivery.

15. WARRANTY: WesTech Engineering LLC warrants equipment it supplies only in accordance with the attached WesTech Warranty. This warranty is expressly given by WesTech and accepted by purchaser in lieu of all other warranties whether written, oral, express, implied, statutory or otherwise, including without limitation, warranties of merchantability and fitness for particular purpose. WesTech neither accepts nor authorizes any other person to assume for it any other liability with respect to its equipment. WesTech shall not be liable for normal wear and tear, corrosion, or any contingent, incidental, or consequential damage or expense due to partial or complete inoperability of its equipment for any reason whatsoever. The purchaser's exclusive and only remedy for breach of this warranty shall be the repair and or replacement of the defective part or parts within a reasonable time of WesTech's accepting the validity of a warranty claim made by the purchaser.

16. PATENTS: WesTech Engineering, LLC agrees that it will, at its own expense, defend all suits or proceedings instituted against Purchaser and pay any award of damages assessed against it in such suits or proceedings, so far as the same are based on any claim that the said equipment or any part thereof constitutes an infringement of any apparatus patent of the United States issued at the date of this Agreement, provided WesTech Engineering, LLC is given prompt notice in writing of the institution or threatened institution of any suit or proceeding and is given full control of the defense, settlement, or compromise of any such action; and Purchaser agrees to give WesTech Engineering, LLC needed information, assistance, and authority to enable WesTech Engineering, LLC so to do. In the event said equipment is held or conceded to infringe such a patent, WesTech Engineering, LLC shall have the right at its sole option and expense to a) modify the equipment to be non-infringing, b) obtain for Purchaser the license to continue using said equipment, or c) accept return of the equipment and refund to the Purchaser the purchase price thereof less a reasonable charge for the use thereof. WesTech Engineering, LLC will reimburse Purchaser for actual out-of-pocket expenses, exclusive of legal fees, incurred in preparing such information and rendering such assistance at WesTech Engineering, LLC's request. The foregoing states the entire liability of WesTech Engineering, LLC, with respect to patent infringement; and except as otherwise agreed to in writing, WesTech Engineering, LLC assumes no responsibility for process patent infringement.

17. SURFACE PREPARATION AND PAINTING: If furnished, shop primer paint is intended to serve only as minimal protective finish. WesTech Engineering, LLC will not be responsible for the condition of primed or finish painted surfaces after equipment leaves its shops. Purchasers are invited to inspect paint in shops for proper preparation and application prior to shipment. WesTech Engineering, LLC assumes no responsibility for field surface preparation or touch-up of shipping damage to paint. Painting of fasteners and other touch-up to painted surfaces will be by Purchaser's painting contractor after mechanism installation.

Motors, gear motors, and other components not manufactured by WesTech Engineering, LLC will be painted with that manufacturer's standard paint system. It is WesTech Engineering, LLC's intention to ship major steel components as soon as fabricated, often before drive, motors, and other manufactured components. Unless Purchaser can ensure that shop primed steel shall be field painted within thirty (30) days after arrival at the job site, WesTech Engineering, LLC encourages the Purchaser to order these components without primer.

WesTech Engineering, LLC's prices are based on paints and surface preparations as outlined in the main body of this proposal. In the event that an alternate paint system is selected, WesTech Engineering, LLC requests that Purchaser's order advise of the paint selection. WesTech Engineering, LLC will then either adjust the price as may be necessary to comply or ship the material unpainted if compliance is not possible due to application problems or environmental controls.

18. CANCELLATION, SUSPENSION, OR DELAY: After acceptance by WesTech Engineering, LLC, this proposal, or Purchaser's order based on this proposal, shall be a firm agreement and is not subject to cancellation, suspension, or delay except upon payment by Purchaser of appropriate charges which shall include all costs incurred by WesTech Engineering, LLC to date of cancellation, suspension, or delay plus a reasonable profit. Additionally, all charges related to storage and/or resumption of work, at WesTech Engineering, LLC's plant or elsewhere, shall be for Purchaser's sole account; and all risks incidental to storage shall be assumed by Purchaser.

19. FORCE MAJEURE: Neither party hereto shall be liable to the other for default or delay in delivery caused by extreme weather or other act of God, strike or other labor shortage or disturbance, fire, accident, war or civil disturbance, act of government, pandemic, delay of carriers, failure of normal sources of supply, complete or partial shutdown of plant by reason of inability to attain sufficient raw materials or power, and/or other similar contingency beyond the reasonable control of the respective parties. The time for delivery specified herein shall be extended during the continuance of such conditions, or any other cause beyond such party's reasonable control. Escalation resulting from a Force Majeure event shall be equitably adjusted per the escalation policy stated above.

20. RETURN OF PRODUCTS: No products may be returned to WesTech Engineering, LLC without WesTech Engineering, LLC's prior written permission. Said permission may be withheld by WesTech Engineering, LLC at its sole discretion.

21. BACKCHARGES: WesTech Engineering LLC will not approve or accept backcharges for labor, materials, or other costs incurred by Purchaser or others in modification, adjustment, service, or repair of WesTech Engineering LLC furnished materials unless such back charge has been authorized in advance in writing by a WesTech Engineering LLC purchase order, or work requisition signed by WesTech Engineering LLC.

22. INDEMNIFICATION: Purchaser agrees to indemnify WesTech Engineering, LLC from all costs incurred, including but not limited to court costs and reasonable attorney fees, from enforcing any provisions of this contract, including but not limited to breach of contract or costs incurred in collecting monies owed on this contract.

23. ENTIRE AGREEMENT: This proposal expresses the entire agreement between the parties hereto superseding any prior understandings and is not subject to modification except by a writing signed by an authorized officer of each party.

24. MOTORS AND MOTOR DRIVES: In order to avoid shipment delays of WesTech Engineering, LLC equipment, the motor drives may be sent directly to the job site for installation by the equipment installer. Minor fit-up may be required.

25. EXTENDED STORAGE: Extended storage instructions will be part of information provided to shipment. If equipment installation and start-up is delayed more than 30 days, the provisions of the storage instructions must be followed to keep WARRANTY in force.

26. LIABILITY: Professional liability insurance, including but not limited to, errors and omissions insurance, is not included. In any event, liability for errors and omissions shall be limited to the lesser of $100,000 USD or the value of the particular piece of equipment (not the value of the entire order) supplied by WesTech Engineering LLC against which a claim is sought.

27. ARBITRATION NEGOTIATION: Any controversy or claim arising out of or relating to the performance of any contract resulting from this proposal or contract issued, or the breach thereof, shall be settled by arbitration in accordance with the Construction Industry Arbitration Rules of the American Arbitration Association, and judgment upon the award rendered by the arbitrator(s) may be entered to any court having jurisdiction.

ACCEPTED BY PURCHASER

Customer Name: ______________________________

Customer Address: ______________________________

____

____

Contact Name: ______________________________

Contact Phone: ______________________________

Contact Email: ______________________________

Signature: ______________________________

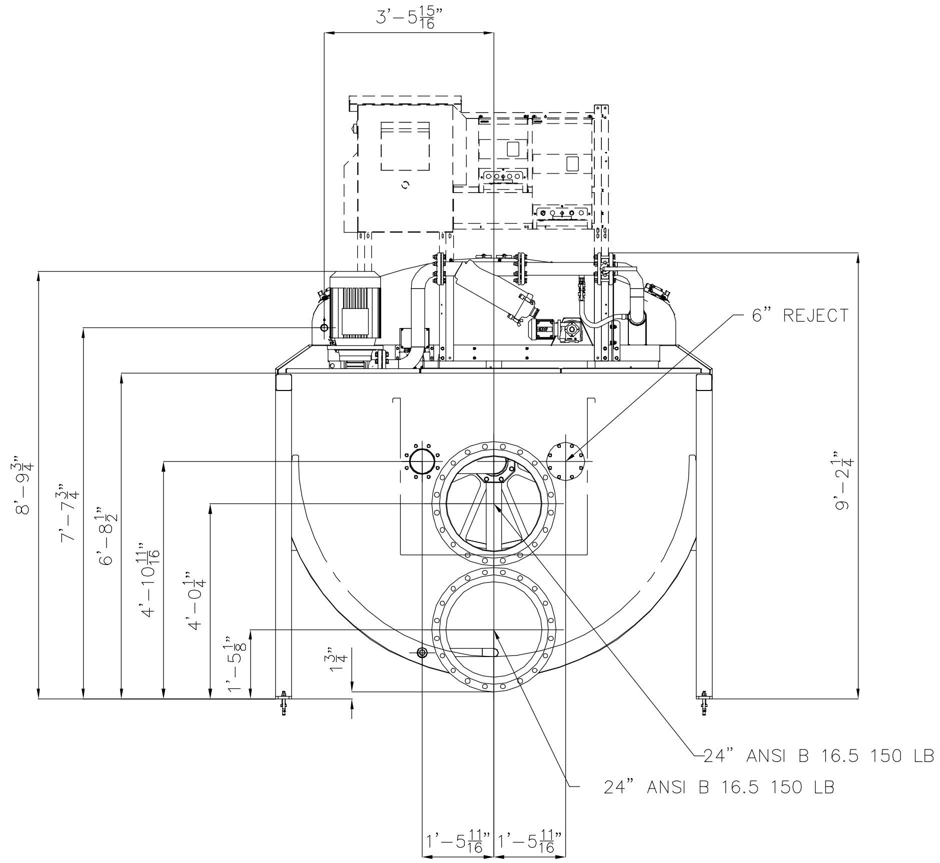
Printed Name: ______________________________

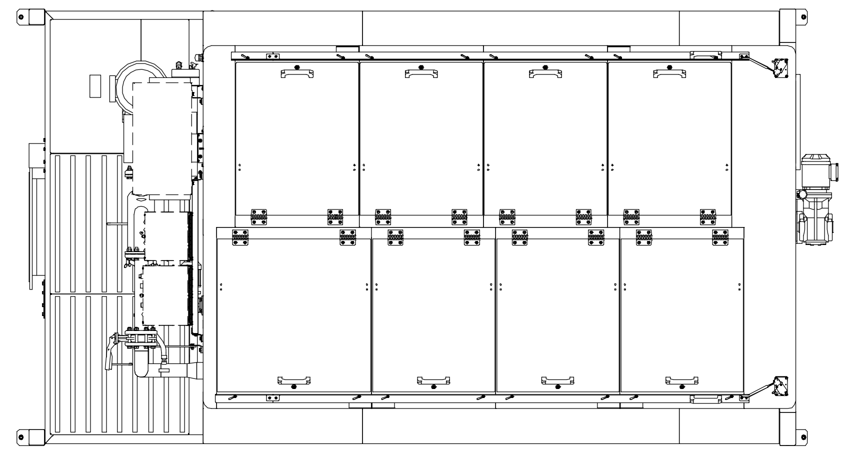
Title: ______________________________

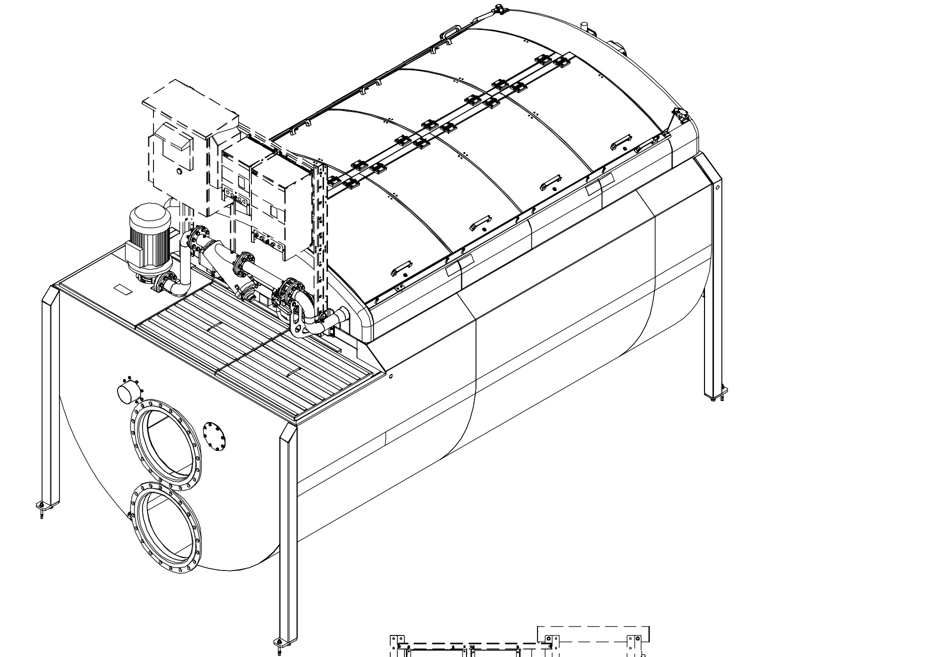
Date: ______________________________

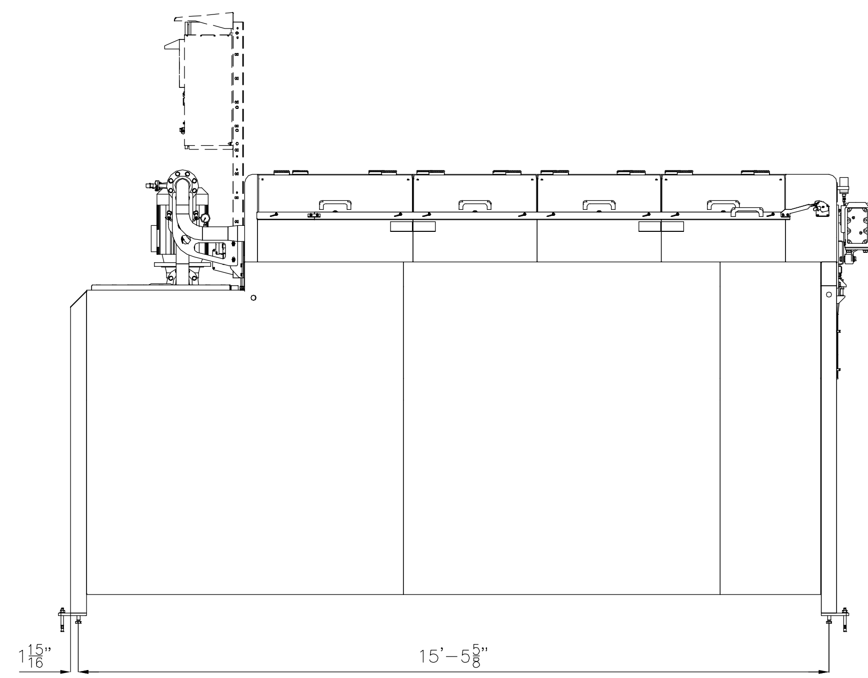
Supplemental Information

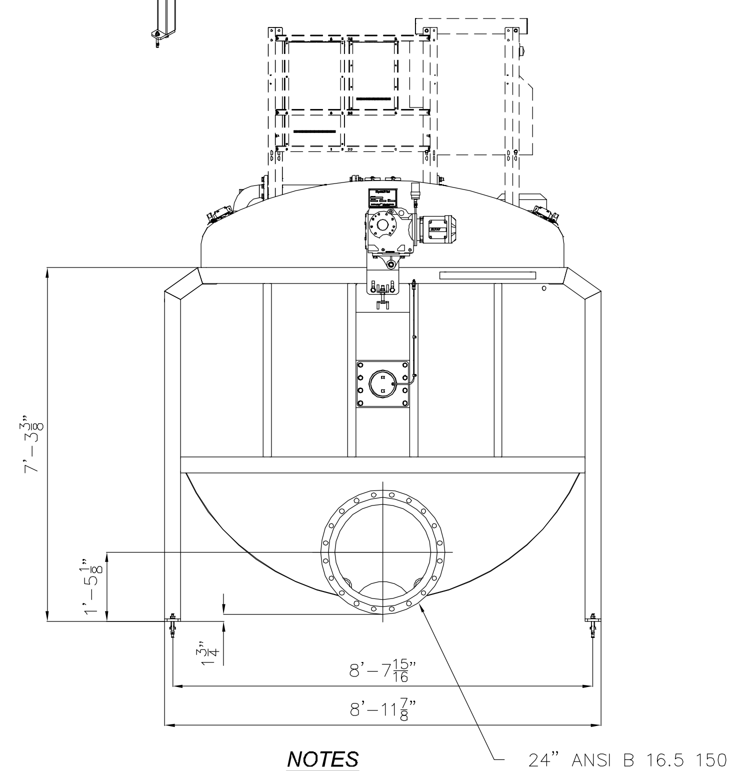
General Arrangement Drawing
SuperDisc™ Brochure

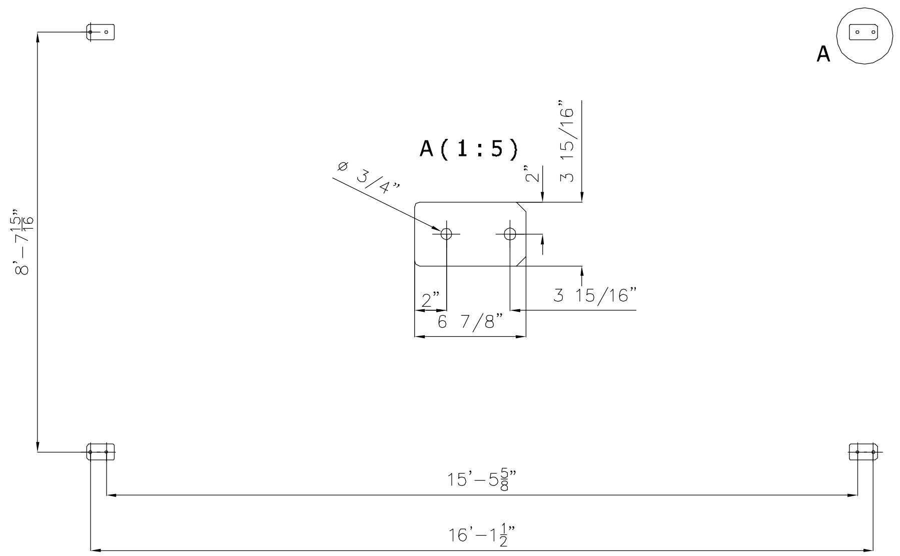












NOTES

1.

PROJECT

CUSTOMER

ENGINEER

CONTRACTOR

PO/CONTRACT NUMBER

WESTECH

TITLE **SUPERDISC DIMENSIONAL DRAWING**
TDC2420

DESIGNER	CHECKER	APPROVER	DATE
V000			2013-12-17

DOCUMENT NUMBER	SHEET	REV
	1 OF 1	-

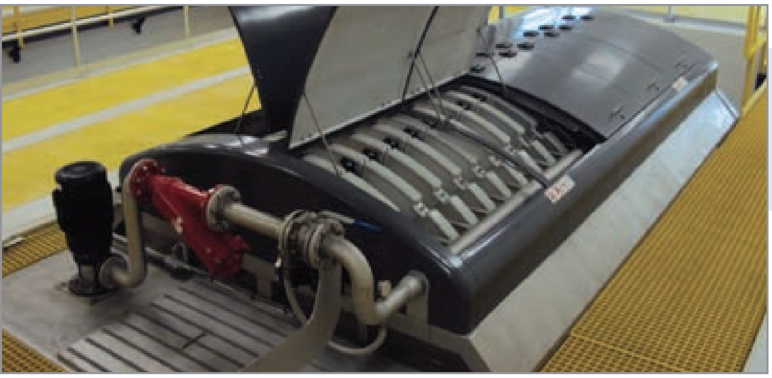
REV	REVISION DESCRIPTION	ECN	DESIGNER	APPROVER	DATE	REFERENCE DOCUMENTS

SuperDisc™

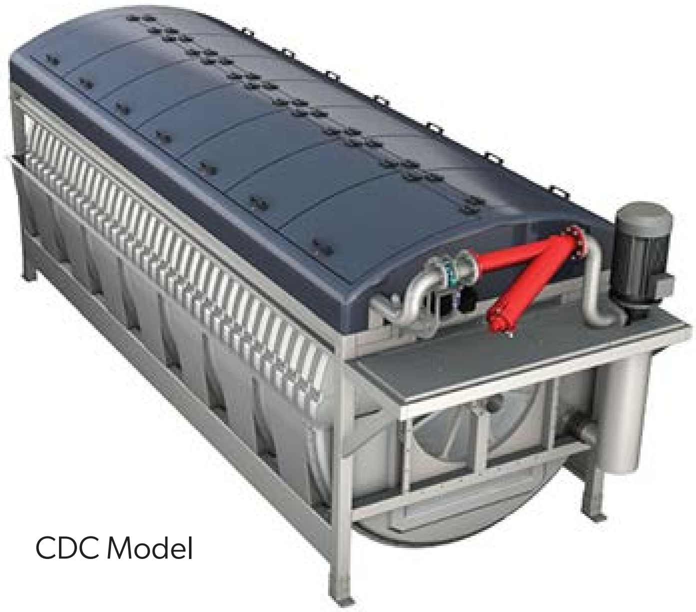
ISO 9001 WesTech CERTIFIED Quality System

WesTech®

SuperDisc™



From raw water screening to wastewater polishing, the SuperDisc™ filter delivers superior filtration performance for water, wastewater, and water reuse applications.



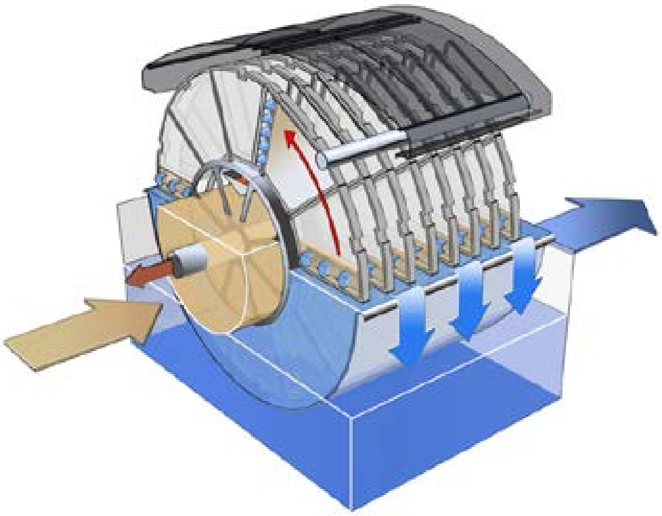
CDC Model

Intelligent Design

Consisting of multiple rotating filter discs, the SuperDisc™ filter features a well-proven system that uses fine-woven filter media. This sophisticated design produces a highly effective filtration process that can achieve high filtration efficiencies.

How it Works

Water to be filtered is guided into the rotor drum and flows by gravity into the filter discs through openings in the drum, and passes through the filter media on the sides of the discs. Suspended solids are separated and accumulated on the inside of the filter disc panels.



When the water level inside the filter rotor increases to a pre-set point, the filter rotor starts rotating and the backwash of the filter media starts. The high pressure backwash spray removes the accumulated suspended solids into the reject flume inside the filter. The suspended solids are then discharged via the reject pipe. The discs are submerged to approximately 65% and the water level of the filtrate is maintained by an integral outlet weir.

Two Versions, One Method

The SuperDisc™ filter is available as a freestanding unit with filter discs contained in a stainless steel tank and a version for installation in a concrete tank. The two versions have the same design regarding drive system, backwash system, outlet weir, disc cassettes, etc. The effective filter area can be up to 1,620.5 ft^2 per filter.

TDC Model

Superior Performance

Combining intelligent engineering with sophisticated technology, the SuperDisc™ filter offers a distinct advantage when it comes to filtration applications. Our unique design enables professionals in the water treatment industry to get maximum performance and reliability day-in and day-out.

The filter cassettes are easily replaceable with only a minimal amount of downtime.

The oscillating spray bar backwash system and the integrated level tank are some of the specific design details that make the SuperDisc™ a reliable and low-maintenance filtration unit with more operational control.

The rotation of the filter discs is driven by a long-life synchronous cog belt, which is carbon fiber-reinforced, corrosion resistant, and lubrication and maintenance free.

- 10 - 60 µm Screen Size (larger openings are available)
- Durable Lightweight FRP Frames
- Recyclable EVO Filter Cassettes

SuperDisc Benefits

- **Compact design, small footprint**
- **Quick replacement; fewer parts per disc**
- **The largest amount of filter area with up to 35 discs in one unit**
- **Level tank with long weir minimizes headloss and avoids need for outlet weirs in the civil construction**
- **Nozzles do not clog because backwash water is pulled directly from the filtered water level tank**
- **Fully automated operation**
- **Operates efficiently with 12-18 inches of headloss**

Filtration Applications

- **Effluent polishing of wastewater**
- **Phosphorus removal**
- **Raw water filtration**
- **Water reuse - Title 22 approved**
- **Process water filtration**
- **Cooling water filtration**

Streamline Your Operation

WesTech provides start-to-finish system configurations with its line of proprietary products. These proven configurations can meet stringent requirements while increasing water recovery--ideal for municipalities and industrial facilities requiring complete water and wastewater package solutions.

Tel: 801.265.1000
westech-inc.com
info@westech-inc.com
Salt Lake City, Utah, USA

APPENDIX H: OPERATIONS & MAINTENANCE COST SUMMARY

Woodard & Curran
1520 S. Fifth Street
St. Charles, MO 63303
Telephone (800)-426-4262

Client: Monmouth, IL
Project: Monmouth, IL - NARP
Component: Annual Costs for Pollution Control

Completed By MK
Checked By SLW
Date 12/1/2023
Project No. 234615.00

Engineer's Opinion of Probable Project Cost
Estimate Type: ***Conceptual***
Accuracy Range ***-15% to +50%***
Itemized Cost Summary

Item	Description	Unit	Quantity	Unit Price	Total Price	Notes
1	Ferric Sulfate	Gal	175	$ 0.24	$ 1,000	Ferric sulfate solution increase needed to reach 0.5 mg/L
3	Monitoring	HR	140	$ 95	$ 14,000	Daily walk through checks
4	Waste Disposal Charges	Ton	113	$ 125	$ 15,000	Costs for hauling expected additional sludge from chemical addition
5	Replacement Parts	LS	1	$ 66,000	$ 66,000	Based on WesTech Filter Manual
6	Repair/Replacement/Routine Maintanence Man Hours	HR	214	$ 95	$ 21,000	Based on WesTech Filter Manual
7	Administration	LS	1	$ 7,000	$ 7,000	Work order management
8	SCADA	LS	1	$ 4,000	$ 4,000	Interface updates
				Subtotal	**$ 128,000**	
				Escalation	$ 7,000	5% Annually
				Other Owner Costs	$ -	
				TOTAL PROJECT COST	**$ 135,000**	2024 Dollars

APPENDIX J: FERRIC SULFATE DOSING CALCULATIONS

*Appendix I left out for clarity

Ferric Sulfate Dosing Calculations

Performed by: MMK
Checked by: SLW 12/1/2023
Appendix J

Client: Monmouth, IL
Project: Monmouth, IL NARP
Component: Calculation of theoretical additional ferric sulfate needed to meet 0.5 mg/L TP effluent

Molecular weight of ferric sulfate (FS) =	399.88	g/mol
Density of ferric sulfate solution =	1.58	kg/L
Iron Molar Mass =	55.85	g/mol
P Molar Mass =	30.97	g/mol
FS Molar Equiv. Mass =	199.94	g/mol

FS is 13.18% Iron by weight (from supplier)
1.75 mol Fe per 1 mole P (Metcalf & Eddy Figure)

$$\frac{1.75\text{ mol Fe}}{1\text{ mol P}} \times \frac{55.85\text{ g Fe}}{\text{mol Fe}} \times \frac{\text{mol P}}{30.97\text{ g P}} = 3.15587665\text{ g Fe/g P} \rightarrow$$

$$\rightarrow = 3.155876655\text{ kg Fe/ kg P}$$

Consolidated Plant Effluent Flow = 3.84 MGD (median from data)

$$\frac{3.84\text{ MG}}{\text{day}} \times \frac{10^6\text{ gal}}{\text{MG}} \times \frac{3.785\text{ L}}{\text{gal}} = 14534400\text{ L/day}$$

Consolidated Plant Inffluent OP = 4.03 mg/L P

$$\frac{4.03\text{ mg P}}{\text{L}} \times \frac{\text{kg}}{10^6\text{ mg}} \times \frac{3.156\text{ kg Fe}}{\text{kg P}} = 1.2718\text{E-05 kg Fe/L}$$

$$\frac{1.27\times10^{-5}\text{ kg}}{\text{L}} \times \frac{14534400\text{ L}}{\text{day}} = 184.851158\text{ kg Fe/day}$$

$$\frac{184.85\text{ kg Fe}}{\text{day}} \times \frac{\text{FS}}{13.18\%\text{ Fe}} = 1402.51258\text{ kg FS/day}$$

$$\frac{1402.51\text{ kg FS}}{\text{day}} \times \frac{\text{L}}{1.58\text{ kg}} \times \frac{\text{gal}}{3.785\text{ L}} = 234.522111\text{ gal FS/day}$$

234.5 gal FS/day - 60 gal/day (current use) = **174.52211 gal Ferric Sulfate/day (additional)**

APPENDIX K: SLUDGE PRODUCTION CALCULATIONS

Sludge Production Calculations

Performed by: MMK
Checked by: ECO 12/1/2023
Appendix K

Client: Monmouth, IL
Project: Monmouth, IL NARP
Component: Calculation of theoretical current and future sludge production when meeting 0.5 mg/L TP effluent

Current Sludge Production

4.03 mg/L P to .59 mg/L P = W% removal
W% = 85.36%

Current mM FS/mM P avg. = 0.510839901 (from data)

85.36%	4.03 mg P	mM P	=	0.1111 mM P/L (removed)
	L	30.97 mg P		

4.03 mg P	mM P	=	0.1301 mM P/L (influent)
L	30.97 mg P		

0.51 mM FS	0.13 mmP	=	0.0665 mM Fe/L (added)
mM P	L		

mM Fe	0.111 mM P	=	0.1111 mM Fe/L (used in FePO4 rxn, theoretically)
mM P	L		

$Fe_2(SO_4)_3 \cdot 9H_2O + 2PO_4 \rightarrow 2FePO_4 + 3SO_4 + 9H_20$
1 to 1 Fe to P ratio

0.0664 mM Fe/L (added) - 0.111 mM Fe/L (used in rxn, theor.) = -0.0446 mM Fe/L (leftover)
↑ indicates some other form of P removal happening since only 0.0664 mM Fe/L was actual added. No Fe(OH)3 rxn taking place

Sludge as 2FePO4

0.066 mM Fe	2 FePO4	150.815 mg FePC	=	10.0252 mg FePO4/L
L	Fe2(SO4)3	mM		

Consolidated Plant Effluent Flow = 4 MGD (median from data)

39.21 mg	8.34 lb/MG	3.84 MGD	=	321.06 lbs/day
L	mg/L			

Sludge Production Calculations

Performed by: MMK
Checked by: ECO 12/1/2023
Appendix K

Client: Monmouth, IL
Project: Monmouth, IL NARP
Component: Calculation of theoretical current and future sludge production when meeting 0.5 mg/L TP effluent

Future Sludge Production

4.03 mg/L P to .5 mg/L P = W% removal
W% = 87.593052 %

0.8759	4.03 mg P	mM P	=	0.114	mM P/L (removed)
	L	30.97 mg P			

4.03 mg P	mM P	=	0.1301	mM P/L (influent)
L	30.97 mg P			

1.75 mM Fe	0.13 mMP	=	0.2277	mM Fe/L (added)
mM P	L			

mM Fe	0.114 mM P	=	0.114	mM Fe/L (used in FePO4 rxn)
mM P	L			

Fe2(SO4)3.9H2O + 2PO4 → 2FePO4 + 3SO4 + 9H20 MW_FePO4 = 150.815
1 to 1 Fe to P ratio

0.228 mM Fe/L (added) - 0.114 mM Fe/L (used in rxn) = 0.1137 mM Fe/L (leftover/Fe used in Fe(OH)3 rxn)

Fe + 3OH <-> Fe(OH)3 MW_Fe(OH)3 = 106.85

Sludge as 2FePO4

0.1139 mM Fe	2 FePO4	0.815 mg FePO4	=	17.1895	mg FePO4/L
L	Fe2(SO4)3	mM			

Sludge as Fe(OH)3

0.1137 mM Fe	Fe(OH)3	6.85 mg Fe(OH)3	=	12.1534	mg Fe(OH)3/L
L	Fe	mM			

Sludge Production Calculations

Performed by: MMK
Checked by: ECO 12/1/2023
Appendix K

Client: Monmouth, IL
Project: Monmouth, IL NARP
Component: Calculation of theoretical current and future sludge production when meeting 0.5 mg/L TP effluent

Total sludge production

17.19+12.15 = 29.342934 mg/L

29.34 mg	8.34 lb/MG	3.84 MGD	=	939.73 lbs/day
L	mg/L			

Excess sludge = future - current sludge production = 939.7-321 = 618.67 lbs/day

31.97 lbs	365 day	ton	=	**112.9 ton/year (additional)**
day	yr	2000 lbs		

APPENDIX L: ECONOMIC EVALUATION WORKSHEETS & EXHIBITS

Worksheet 1

Debt Service and Residential Flow Calculation		
Annual Debt Service Costs	**Input**	**Footnotes**
Interest Rate	1.36%	1
Term of Loan (Years)	20	
Present Value (Loan Amount)	$ 10,700,000	
Annual Debt Service Payment	$614,662	
Residential Share		
Residential Wastewater Flow (MGD)	3.52	2
Total Wastewater Flow (MGD)	3.52	
Residential Share Factor	1	

Cost Per Household: Worksheet 1		
Current WWT Costs		
Annual O&M Expenses (excluding depreciation)	$ 3,616,681	3
Annual Debt Service (P&I)	$ 2,429,498	4
Subtotal of Current Costs	$ 6,046,179	
Projected WWT and CWA Costs (in Current $)		
Estimated Annual O&M Expenses (excluding depreciation)	$ 135,000	
Annual Debt Service (P&I)	$ 614,662	
Subtotal of Projected Costs	$ 749,662	
Total Current and Projected WWT and CWA Costs	$ 6,795,841	
Residential Share of Total WWT and CWA Costs	$ 6,795,841	
Total Number of Households in Service Area	3,345	
Cost per Household	$ 2,032	

Footnotes

1. IEPA SRF Loan interest rates through June 30, 2024, Small Community Rate.

2. The residential share factor is one due to all wastewater flow being attributable to residential customers. The City does provide wastewater services for Smithfield Foods but charges a flat fee for services and therefore not accounted for in wastewater flow reporting. Smithfield Foods also pays the City the cost of debt service payments for the cost of capital improvements completed to support the company. Additionally, even if the residential share was 0.6, the City would still be in the "High" scoring for the residential indicator.

3. The City has a combined water & sewer fund and as such it is not possible to fully separate all sewer expenses from the combined fund. This figure reflects the O&M expenses less depreciation reported in the City's 2022 Audited Financial Statements.

4. This reflects the 2023 Bonds Payable for Business-Type Activities reported in the City's 2022 Audited Financial Statements. All of the long-term debt for Business-Type activities is attributable to water/sewer improvements and are repaid by net revenues from the City's water and sewer system.

Worksheet 2

Residential Indicator: Worksheet 2		
Median Household Income (MHI)		**Input**
Census Year MHI	$	54,400
MHI Adjustment Factor		1
Adjusted MHI	$	54,400
Annual WWT and CWA Control Cost per Household	$	2,032
Residential Indicator		
Annual Wastewater and CWA Control Costs per Household as a percent of Adjusted MHI		3.73%
COMMUNITY RESIDENTIAL IMPACT SCORE		**High**

Worksheet 3

Bond Rating: Worksheet 3		
Most Recent General Obligation Bond Rating	**Input**	**Footnotes**
Date	8/19/2021	
Rating Agency	S&P	
Rating	A	1
Most Recent Revenue (Water/Sewer or Sewer) Bond		
Date	N/A	
Rating Agency	S&P	
Bond Insurance (Yes/No)	Yes	
Rating	A	2
Summary Bond Rating	A	
COMMUNITY BOND RATING SCORE	**Strong**	

Footnotes

1. Reflects the uninsured rating for the General Obligation Refunding Bonds, Series 2021A and Series 2021B official Bond Prospectus Dated August 19, 2021. Sourced from the Electronic Municipal Market Access.

2. The City does not have any Revenue Bond ratings. However, the same issuance above (footnote 1) is repaid by net revenues from the City's water and sewer system, as noted in the 2022 Audited Financial Report, Note 10.

Worksheet 4

Overall Net Debt as a Percent of Full Market Property Value: Worksheet 4			
Description		**Input**	**Footnotes**
Direct Net Debt (GO Bond Excluding Double-Barreled Bonds)	$	3,235,000	1
Debt of Overlapping Entities (Proportional Share of Multijurisdictional Debt)		0	
Overall Net Debt		3235000	
Full Market Value of Property	$	257,788,509	
Overall Net Debt as a Percent of Full Market Property Value		1.255%	
COMMUNITY NET DEBT AS % OF FULL MARKET PROPERTY VALUE SCORE		**Strong**	

Footnotes

1. According to the City's 2022 Audited Financial Statements, there is only one GO that is repaid by property taxes and not supported by water & sewer revenues (specific revenue source). This GO is repaid by water & sewer revenues and general property taxes and had debt outstanding 4/30/2022 of $3,235,000

Worksheet 5

Unemployment Rate: Worksheet 5		
Description	**Input**	**Footnotes**
Unemployment Rate - Permittee		
Data Source		
Unemployment Rate - County (use if permitee's rate is unavailable)	3.90%	1
Data Source		
Benchmark		
Average National Unemployment Rate	3.60%	
Data Source	IDES/BLS	
UNEMPLOYMENT RATE SCORE	**Mid-Range**	

Footnotes

1. This reflects the 2022 average annual unemployment rate for Warren County. City specific data is unavailable due to population size. It is worth noting that 2022 unemployment rate is significantly lower than the 2021 unemployment rate (4.8%). Data sourced from Illinois Department of Employment Security, Local Area Unemployment Statistics, with the same rate listed at BLS.gov.

Worksheet 6

Median Household Income: Worksheet 6			
Description		**Input**	**Footnotes**
Median Household Income - Permittee	$	54,400	
Source			1
Benchmark			
National MHI	$	69,717	
Source			
Relationship to Benchmark			
Permittee MHI Relationship to National MHI		-21.97%	
MEDIAN HOUSEHOLD INCOME SCORE		**Mid-Range**	

Footnotes

1. MHI data reflects the Census Bureau's American Community Survey 2021 5-year estimates detailed table B19013, median household income in the past 12 months (in 2021 inflation-adjusted dollars).

Worksheet 7

Property Tax Revenues as a Percent of Full Market Property Value: Worksheet 7		
Description		**Input**
Full Market Value of Real Property	$	257,788,509
Total Property Tax Revenues	$	1,049,065.00
Property Tax Revenue as a Percent of Full Market Value		0.41%
PROPERTY TAX REVENUE AS A PERCENT OF FULL MARKET PROPERTY VALUE SCORE		**Strong**

Worksheet 8

Property Tax Revenue Collection Rate: Worksheet 8		
Description		**Input**
Property Tax Revenue Collected	$	1,049,065
Property Taxes Levied	$	2,517,305
Property Tax Revenue Collection Rate		42%
PROPERTY TAX REVENUE COLLECTION RATE SCORE		**Weak**

Worksheet 9

Summary of Financial Capability Indicators Benchmarks: Worksheet 9			
Indicator	**Actual Value**	**Benchmark**	**Score**
Bond Rating	A	Strong	3
Overall Net Debt as a Percent of Full Market Property Value	1.25%	Strong	3
Unemployment Rate	3.90%	Mid-Range	2
Median Household Income	$54,400	Mid-Range	2
Property Tax Revenues as a Percent of Full Market Property Value	0.41%	Strong	3
Property Tax Revenue Collection Rate	41.67%	Weak	1
Permittee Indicators Score (Sum of Score divided by Number of Entries)			2.33
Financial Capability Indicators Rating			

Benchmarks

Financial Capability Indicators Rating	**Socioeconomic, Debt, and Financial Indicators**
Weak	Below 1.5
Mid-Range	1.5 to 2.5
Strong	Above 2.5

OVERALL FINANCIAL CAPABILITY INDICATORS RATING	**Mid-Range**

Exhibit 3

Lowest Quintile Poverty Indicator Score: Exhibit 1						
Indicator (Census Data Code)	**Strong (Score = 3)**	**Mid-Range (Score = 2)**	**Weak (Score = 1)**	**Weight**	**Actual Value**	**Matrix Score**
LQPI #1 Upper Limit of Lowest Quintile Income (B19080)	More than 25% above national LQI	Plus or minus 25% of national LQI	More than 25% below national LQI	50%	24,233	2
LQPI #2 Percentage of Population with Income Below 200% of Federal Poverty Level (S1701)	More than 25% below national value	Plus or minus 25% of national LQI	More than 25% above national value	10%	38%	1
LQPI #3 Percentage of Households Receiving Food Stamps/SNAP Benefits (S2201)	More than 25% below national value	Plus or minus 25% of national LQI	More than 25% above national value	10%	17.20%	1
LQPI #4 Percentage of Vacant Housing Units (B25002)	More than 25% below national value	Plus or minus 25% of national LQI	More than 25% above national value	10%	10.78%	2
LQPI #5 Trend in Household Growth (B25002)	>1%	0-1%	<0%	10%	-1.04%	1
LQPI #6 Percentage of Unemployed Population 16 and Over in Civilian Labor Force (DP03)	More than 25% below national value	Plus or minus 25% of national LQI	More than 25% above national value	10%	7.60%	1
Score for LQPI #1						**2**
Average Score for LQPI #2 to #6 (Sum of 2 through 6 divided by 5)						**1.2**
Lowest Quintile Poverty Indicator Score (sum of two lines above divided by 2)						**1.6**
Lowest Quintile Poverty Indicator Benchmarks						
Low Impact (Above 2.5)						
Medium Impact (1.5 to 2.5)						**Medium Impact**
High Impact (Below 1.5)						

Supporting Calculations

Indicator	**National Score**	**Community Score**	**Strong Level**	**Weak Level**	**Source**
LQPI #1	28,336	24,233	35,420	21,252	B19080: HOUSEHOLD INCOME QUINTILE ... - Census Bureau Table
LQPI #2	29%	38%	22%	37%	S1701: POVERTY STATUS IN THE PAST ... - Census Bureau Table
LQPI #3	11.40%	17.20%	8.55%	14.25%	S2201: FOOD STAMPS/SUPPLEMENTAL ... - Census Bureau Table
LQPI #4	11.20%	10.78%	8.40%	14.00%	B25002: OCCUPANCY STATUS - Census Bureau Table
LQPI #5		-1.04%			B25002: OCCUPANCY STATUS - Census Bureau Table
LQPI # 6	3.50%	7.60%	2.63%	4.38%	DP03: SELECTED ... - Census Bureau Table

LPQI #2 Calc	**National**	**Monmouth**
Population for whom poverty status determined	321,897,703	7,839
All individuals with income below 200% of poverty level	94,041,155	2,943
Percent Below Poverty Level	29%	38%

LPQI #4 Calc	**National**	**Monmouth**
Total Housing Units	139,647,020	3,749
Vacant	15,636,028	404
Percent Vacant Housing Unit	11.20%	10.78%

LPQI # 5 Calc	**Monmouth**
Current Census (2021) Occupied Housing Units	3,345
Prior Census (2016) Occupied Housing Units	3,524
5-Year Geometric Average Growth Rate	-1.04%

Exhibit 2

Financial Capability Matrix: Exhibit 2	
Reference	**Value**
Residential Indicator Score	3.73%
Residential Indicator Impact	High
Financial Capability Indicator Score	2.33
Financial Capability Indicator Impact	Mid-Range

Financial Capability Indicators Score	Residential Indicator Score		
	Low Impact (Below 1%)	**Mid-Range (1% to 2%)**	**High Impact (Above 2%)**
Strong (Above 2.5)	Low Impact	Low Impact	Medium Impact
Mid-Range (1.5 to 2.5)	Low Impact	Medium Impact	High Impact
Weak (Below 1.5)	Medium Impact	High Impact	High Impact

FINANCIAL CAPABILITY MATRIX IMPACT RESULT	**High**

Exhibit 3

Expanded Financial Capability Assessment Matrix: Exhibit 3

Reference	Value
FCA Score (RI and FCI)	High
Lowest Quintile Poverty Indicator Score	1.6
Lowest Quintile Poverty Indicator Benchmark	Medium Impact

FCA Score (RI and FCI)	Lowest Quintile Poverty Indicator Score		
	Low Impact	**Medium Impact**	**High Impact**
Low Impact	Low Impact	Low Impact	Medium Impact
Medium Impact	Low Impact	Medium Impact	High Impact
High Impact	Medium Impact	High Impact	High Impact

EXPANDED FINANCIAL CAPABILITY ASSESMENT MATRIX RESULT	**HIGH IMPACT**

Exhibit 4

Recommended Implementation Schedule Benchmarks for Alternative 1: Exhibit 4	
Expanded FCA Matrix Result	**Recommended Implementation Schedule Benchmarks**
Low Impact	Normal Engineering/Construction Schedule
Medium Impact	Total schedule generally up to 10 years
Medium Impact with Comprehensive Financial Alternatives Analysis	Total schedule generally up to 15 years
High Impact	Total schedule generally up to 15 years (or 20 years based on further negotiation with EPA and state NPDES authorities)
High Impact with Comprehensive Financial Alternatives Analysis	Total schedule generally up to 20 years (or 25 years based on further negotiation with EPA and state NPDES authorities)

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