Ferric Chloride Water Treatment Facility Permit Renewal Report

2020-2025 NPDES/SDS Permit No: MN0067377

Mailed to:
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PRIOR LAKE SPRING LAKE WATERSHED DISTRICT

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Background

Spring Lake is a recreational lake located in central Scott County, Minnesota. The lake is listed on the State Impaired Waters List as impaired for aquatic recreation due to excess nutrients. Monitoring for a study completed by the Prior Lake-Spring Lake Watershed District (PLSLWD) in the 1990's identified phosphorus as the nutrient most contributing to water quality impairment and algae blooms. That study also noted that a significant portion of the phosphorus entering Spring Lake was in the form of dissolved phosphorus (soluble reactive phosphorus, or SRP) thus making it readily available for algal uptake. Spring Lake flows directly into Upper Prior Lake, which is also listed as impaired due to excess nutrients.

In 1998, the PLSLWD constructed the ferric chloride ($FeCl_3$) treatment system to precipitate SRP out of stormwater from County Ditch 13, the main inflow to Spring Lake (Figure 2). The treatment system involves the injection of 35% liquid $FeCl_3$ solution into a stormwater pond, or desiltation basin. The iron within the $FeCl_3$ binds with the dissolved phosphorus in the water and creates colloidal particles (floc) which settle at the bottom of the basin. The treated water then flows downstream into Spring Lake. The system was constructed as part of a Minnesota Pollution Control Agency (MPCA) Clean Water Partnership Implementation Project.

The treatment system began operation under a permit from the Department of Natural Resources. In 2004, the treatment system permit was renewed as a National Pollutant Discharge Elimination System permit administered by the MPCA. In 2009, the District applied to the MPCA for a renewed permit and the permit was approved in 2012. The system did not operate in 2011 or 2012 because it no longer met the requirements of the permit. This is because the system injected $FeCl_3$ directly into the channel immediately downstream of the Ferric Chloride weir on the south side of Highway 13, where it would mix until reaching the desiltation pond. The District spent these years working toward a design that would meet the requirements of the new MPCA permit.

In July 2013, the treatment facility began operating again after it was retrofitted to meet new MPCA permit requirements. The new design transfers $FeCl_3$ underground for 900 feet through a double-walled pipe from the treatment building to a culvert north of Highway 13 that flows directly into the desiltation basin. The new design addresses the previous concerns of the MPCA by avoiding direct discharge into a water of the state and instead goes directly into a stormwater pond.

Figure 1. Bypass Weir

The retrofit project allows for more water to be treated as compared to the old system. With the old system, high flows could resuspend phosphorus-iron flocculants within the basin and flush the flocculent downstream and into Spring Lake. The new system is designed to overtop a bypass weir and flow around the desiltation basin before the flow reaches a point of resuspension in the pond (Figure 1). This allows for the maximum amount of phosphorus to be treated without resuspending the material in the desiltation basin.

Figure 2. Aerial Map of Ferric Chloride Treatment System

In 2023, the District initiated a whole system assessment project that aimed to identify, document, and replace aging and failed system components. Facility improvements are designed to improve safety, longevity, treatment efficiencies, and ease of access to the facility for ferric chloride deliveries. Improvements such as a new double walled chemical storage tank, hard piping, an upgraded feed pump, new radar sensors at the weir and tank, data logging electronics, and improved drive access are expected to be completed by Spring 2025. The system assessment includes updates to the operations and maintenance manual. The District is also reviewing maintenance needs of the desiltation pond and the Highway 13 Wetland, which is upstream of the facility, to ensure efficiency and improved water quality for the coming years.

Operations and Maintenance

Routine Maintenance

District staff led and coordinated routine site maintenance and conducted work to meet permit requirements. Site maintenance included clearing brush and mowing the driveway to the Ferric Chloride shed. Staff coordinated with either the City of Prior Lake Public Works or Vessco Inc. to maintain the dosing pump, hoses, and nozzle injection during fall winterization and spring startup. In the fall, the facility was winterized by purging the ferric line to prevent freezing and removing the injector nozzle to avoid over-winter damage. Prior to system start-up each spring, system components were inspected, old and worn parts were replaced, the injector nozzle was re-installed, the pump was restarted and calibrated, the dosing pump program was verified, and line pressures were checked.

Other routine maintenance by PLSLWD staff included cleaning the staff gauge, removing debris from both the Highway 13 Wetland and bypass weirs, installing snowmobile signs, downloading and calibrating water level sensors, routinely inspecting the facility, taking flow measurements, and collecting weekly water quality samples.

Common Carp Management

Common carp have been observed for years upstream of site SW-001 within the Highway 13 Wetland. Carp are known to stir up bottom sediments and decrease water quality. Between 2015 and 2018, the water became noticeably more turbid (visually and in the data). Staff had concerns that carp were impacting water quality results both upstream in the wetland and downstream in the desiltation pond. In 2018, WSB Consulting estimated 1,452±615 carp living in the wetland, equating to a biomass of 198±61 pounds per acre. A fish barrier installed at the downstream end of the Highway 13 Wetland was missing tines and was inoperable; a new fish barrier was installed in 2020 that included a new, safer and sturdier walking deck (Figure 3). From 2020 to 2022, staff and consultants continued assessing the carp population and removed carp when opportunities allowed. In addition to removals, water level management and natural conditions including drought and low levels of dissolved oxygen played a role in reducing the carp population within the Highway 13 Wetland. Bluegill stocking was initiated in 2020 to help mitigate carp reproduction, as both basins were identified as carp nurseries (Table 1). Bluegill have been shown to be an effective management tool as they predate on carp eggs. As of the end of 2023, it appears carp have been removed from the Highway 13 Wetland. As a result, submerged aquatic vegetation has made a strong rebound with nearly 100% coverage throughout the growing season.

Table 1. Bluegill stocking

FeCl Bluegill Stocking By Year	2020	2021	2022	2023	2024
Hwy 13 Wetland	2000	2000	2400	2400	0
Desilt Pond	100	700	1200	1200	1800

Other Operations and Maintenance

Operations and Maintenance items that were completed between 2020 and 2024, in addition to the above-mentioned routine items:

- A “pit tag station” was operated below the weir to monitor if carp are leaving the wetland and when migration upstream occurs.
- Wetland health macroinvertebrate sampling was conducted in 2021 within the Highway 13 Wetland.
- A carp trap/barrier was operated at the outlet of the desilt pond.
- An eye-wash station was installed and maintained inside the Ferric Chloride shed.

System Improvements

As of 2023, the ferric chloride tank was 25 years old and needed to be replaced. A considerable complication was that the shed was not designed for the tank to be removed, so the shed needed to be at least partially dismantled. A feasibility study to determine the options for tank replacement and to analyze the efficiency of the ferric chloride treatment facility, including options to increase efficiency, was completed in 2024. Staff and District Board Managers considered options for removing and replacing the tank and contracted EOR Inc., an engineering firm, to design and site manage system updates. Beginning in the fall of 2024, work began replacing aging components of the treatment system including tank, pump skid, piping, and adding a garage door.

The current driveway to the shed poses an issue for ferric chloride delivery. Improvements were proposed in the system assessment completed by EOR Inc, including design options that could reduce the damage done to the lawn of the access property and provide easier and safer access for the delivery driver. Modifications to the driveway are scheduled to be completed in spring of 2025.

Figure 3. New walking deck over weir and fish barrier completed in 2020

Ferric Usage

The chemical storage tank is housed inside an onsite shed and holds 4,400 gallons. At start of the permit issuance year, the tank stored 1753 gallons over winter. Operations typically start between mid-March and early April. Due to the low-lying property conditions, delivery is avoided in early spring due to soft road conditions. The system is typically winterized in late November or early December as streams freeze and flow decreases. With plans for a new tank to be installed in 2025, the old tank was run dry in fall of 2024 to allow contractors easier removal and replacement. Throughout the term of the permit, chemical delivery occurred 6 times with an average delivery of 2,655 gallons. Drought conditions combined with an adequate starting volume led to low chemical usage and no need for deliveries in 2022. Between 2020 and 2024 a total of 15,930 gallons of Ferric Chloride was delivered and 17,448 gallons were dosed. A summary of the annual Ferric Chloride starting and ending volumes, quantities delivered, and total gallons used are shown in Table 2.

Table 2. Ferric Storage, Deliveries, and Usage

Year	Starting Ferric (gal)	Delivered Ferric (gal)	Ending Ferric (gal)	Total Ferric Used (gal)
2020	1541	6200	2237	5533
2021	2213	3200	3452	1961
2022	3452	0	2365	1087
2023	2360	2640	1753	3247
2024	1753	3890	20	5620

Future Maintenance

Desilt Pond

The Desiltation Pond is one of the earliest PLSLWD projects, constructed in 1978, originally designed to decrease County Ditch 13 sediment deposition into Spring Lake. With excavation of the Highway 13 Wetland and construction of the $FeCl_3$ Treatment System, completed in 1998, the Desiltation Pond was enhanced to serve as the iron-bound phosphorus flocculation basin for the overall treatment system. Since then, the Desiltation Basin has been periodically excavated to restore flocculant storage capacity. The pond was last dredged in 2012, down to 902 feet in mean sea level. As storage volume is reduced, the detention time for settling and pollutant removal efficiency is reduced. Once the pond bottom nears 908’, the pond should be dredged again. In 2022 and 2023, staff mapped the bathymetry of the pond using a kayak with a sonar unit and processing software (Figure 4). The pond was found to be about 7-8 feet deep (bottom elevation of 903.5”) in the middle and as a result, is likely several years away from needing to be dredged.

History of pond dredging and survey information is summarized below:

1978: Desilt pond constructed with a bottom elevation of 902.5’, and an outlet elevation of 910.3’
1998: Desilt pond bottom surveyed at 907.8’
1999: Pond was dredged to an elevation of 902.5’
2005: Pond bottom surveyed at 904.5’
2010: Pond bottom surveyed at 906.5’
2012: Pond was dredged to 902.0’ (as-built survey available)
2016: Pond bottom mapped by Platypus and estimated to be 903.5’ using BioBase software
2019: Pond mapped twice with BioBase kayak setup. Pond bottom estimate to be 903.5’.
2022: Pond mapped with BioBase kayak setup. Pond bottom estimate to be 903.5’.
2023: Pond mapped with BioBase kayak setup. Pond bottom estimate to be 903.5’.

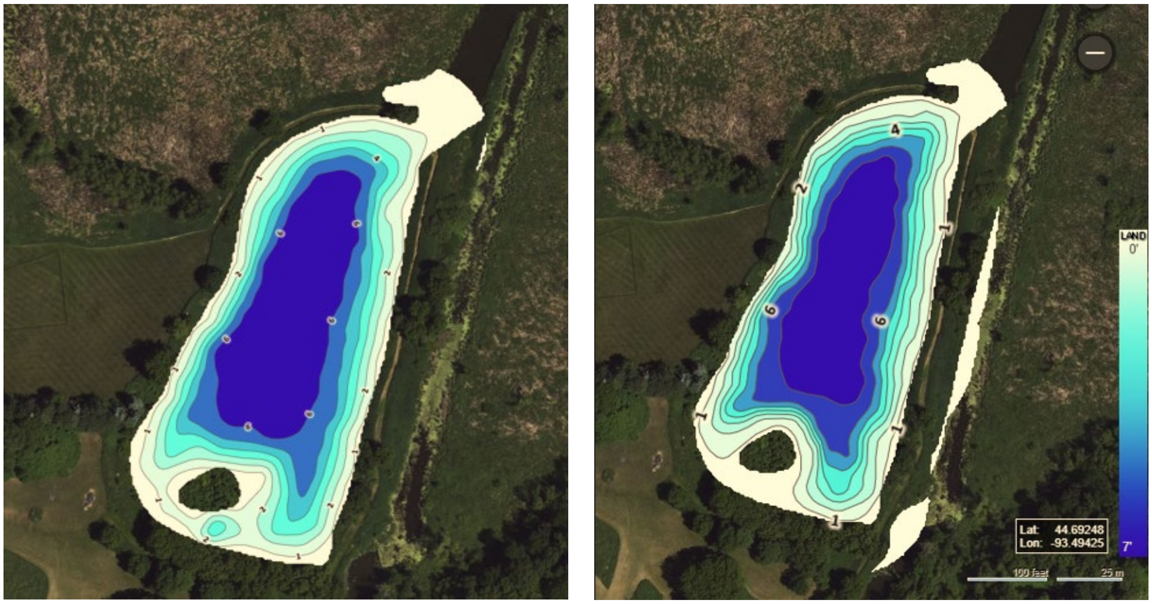

Figure 4. Bathymetry map of Desilt Pond in 2022 (left) and 2023 (right).

Highway 13 Wetland

Construction of the Highway 13 Wetland Enhancement Project was completed in February of 1997. Originally, the wetland was excavated to afford pretreatment for the Ferric Chloride system with two deeper pools with a maximum depth of 909.0 and an outlet elevation of 913.0. A 2010 bathymetry survey of the wetland indicated minimal sediment accumulation since 1997. In 2017, the wetland was again surveyed (Figure 5). Comparison of the 2010 and 2017 surveys indicated that 4,700 cubic yards of sediment had accumulated in the wetland over that time, largely attributed to 2014 flooding and subsequent sediment transport through County Ditch 13. A bathymetry survey completed in June 2024 showed an additional 4,800 cubic yards of sediment have accumulated in the wetland since 2017 (Figure 5). When combined with the sediment accumulation calculated in 2017, a total of 9,500 cubic yards of sediment has accumulated in the wetland. Maintenance excavation of the wetland system is recommended, as the original wetland pools are less than two feet deep and the accumulated sediments are susceptible to resuspension from wave action and high flows through the system. District staff are working to advance this project to maintain pretreatment for the system.

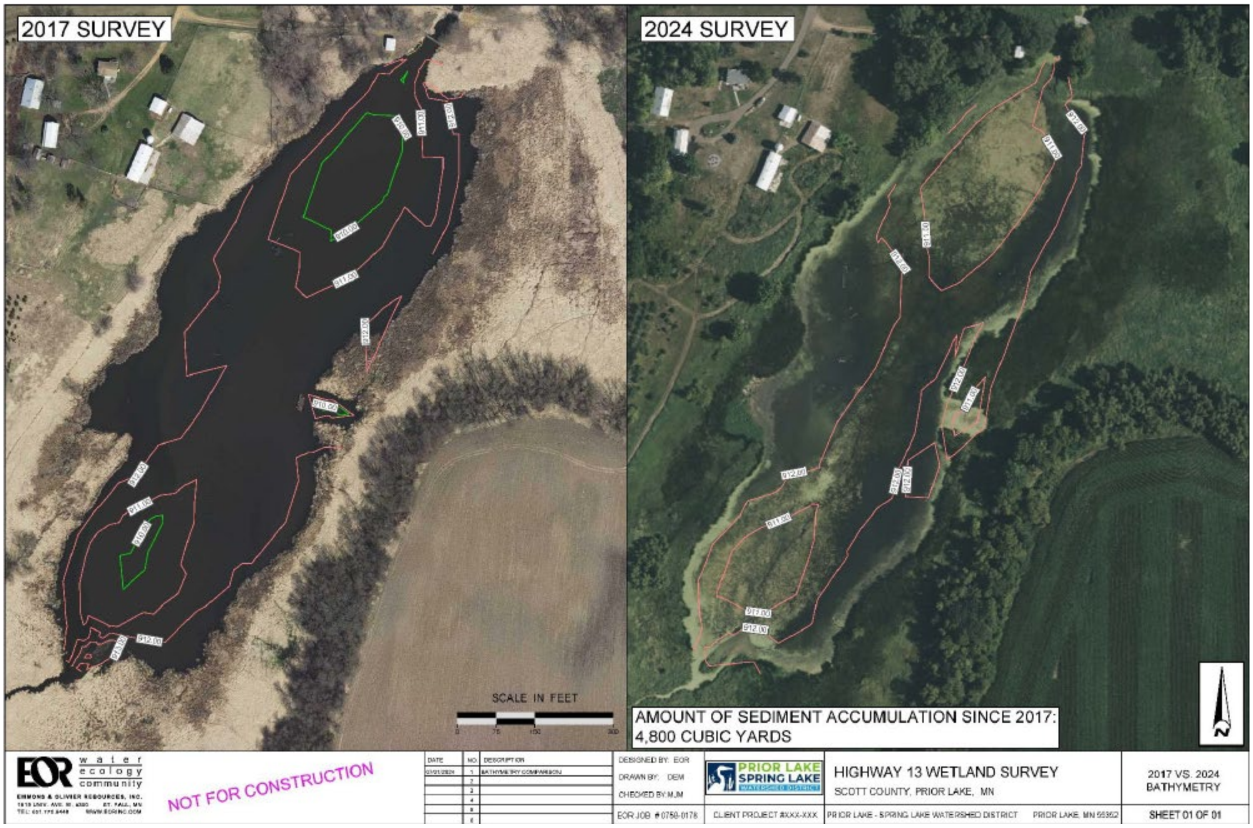

Figure 5. Highway 13 Wetland bathymetry comparison from 2017 to 2024.

Phosphorus Reduction

Table 3 shows phosphorus loading reductions from 2014 to 2024 using monthly averages reported in the NPDES permit required quarterly Discharge Monitoring Reports. Over the span of the permit, system operations reduced the average concentration of total phosphorus (TP) by 17% and the concentration of ortho phosphorus (OP) by an average of 57%.

Table 3. Summary of Phosphorus removals since 2014

Year	Lbs TP Removed	Lbs OP Removed	% TP Reduction	% SRP Reduction	MG of Water Treated	Notes
2014	550	752	43%	72%	959	Treated 4/1-10/31
2015	402	103	48%	51%	348	Treated 4/1-10/31
2016	578	323	36%	64%	1327	Treated 3/11-11/10
2017	534	240	35%	58%	938	Treated 3/5-11/30
2018	465	616	31%	58%	1614	Treated 4/1-11/20
2019	466	594	19%	43%	1981	Treated 4/1-11/12
2020	N/A	N/A	25%	58%	N/A	Treated 3/10-8/24, 9/30-11/4. Flow sensor broken.
2021	44	42	33%	49%	672	Treated 3/5-9/3, Intermittent flow
2022	13	15	2%	29%	293	Treated 3/18-6/30

2023	42	132	6%	66%	442	Treated 4/5-6/30
2024	972	851	20%	84%	1219	Treated 4/1-11/26, intermittent flow

The data from 2020 to 2024 shows a consistent decrease in both Total Phosphorus (TP) and Orthophosphate (OP) levels after treatment in Table 4 below. In 2020, the system achieved a 27% reduction in TP and a 45% reduction in OP. This trend continued in 2021, with reductions of 28% in TP and 48% in OP. The year 2022 saw a smaller decrease in TP at 2%, but OP reduction remained steady at 48%. By 2023, the system's efficiency improved, resulting in a 15% reduction in TP and an impressive 81% reduction in OP. In 2024, the system achieved its highest reductions, with TP decreasing by 30% and OP by 63%.

Table 4. – Phosphorus Concentrations and Percent Removals 2020 - 2024

	Before Treatment (SW001) Annual Mean		**After Treatment (SD002) Annual Mean**		**% Change after Treatment**	
Year	**Total Phosphorous (mg/l)**	**OP (mg/l)**	**Total Phosphorous (mg/l)**	**OP (mg/l)**	**Total Phosphorous (mg/l)**	**OP (mg/l)**
2020	2.19	0.650	1.60	0.356	27%	45%
2021	1.30	0.570	0.94	0.294	28%	48%
2022	0.49	0.171	0.48	0.089	2%	48%
2023	0.20	0.235	0.17	0.045	15%	81%
2024	2.50	2.274	1.75	0.852	30%	63%

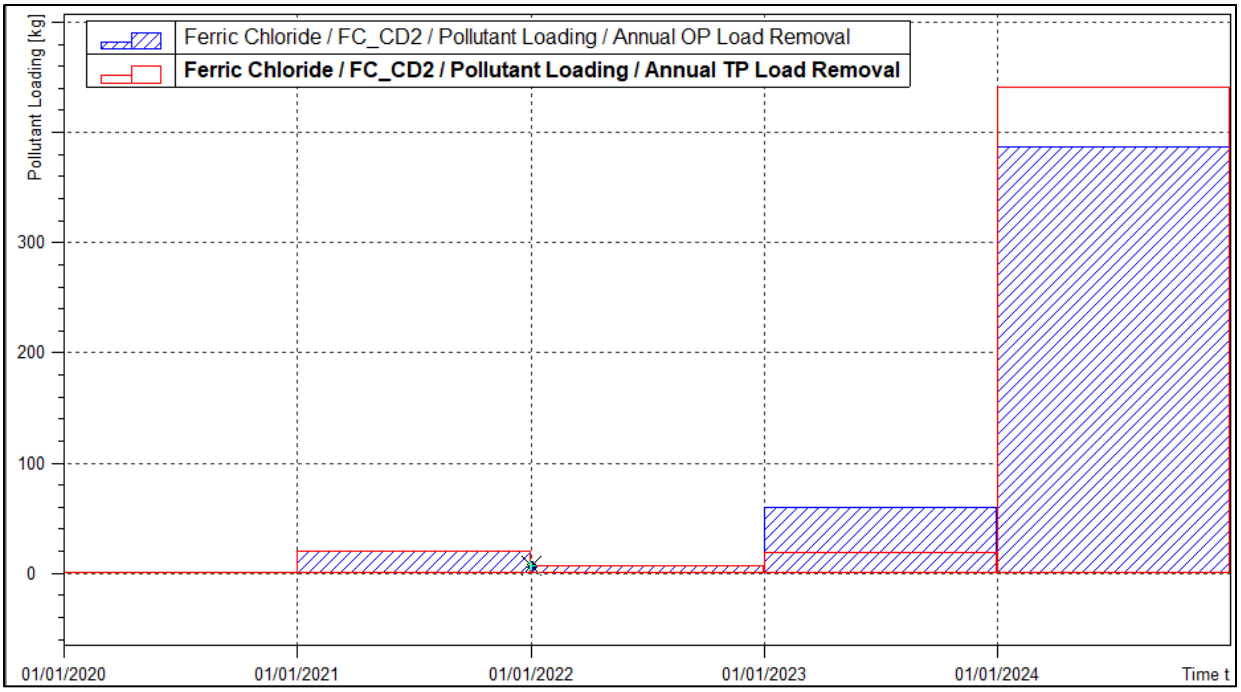

Figure 6. Annual Total Phosphorus (TP) and Orthophosphate (OP) Load Removal in Kilograms (kg).

The annual load reductions represented in Figure 6 above were calculated using the Districts WISKI database. The calculations show orthophosphate (OP), the dissolved form of phosphorus, representing near or over 100 percent of load reductions also shown in table 3. While orthophosphate only represents a fraction of total phosphorus (TP), the system data may be misleading only considering pre and post treatment analysis while other factors in the system might be influencing the results such as carp, seasonality, and pooling effects from high water on Spring Lake. District staff hypothesize that when OP is bound to $FeCl_3$ it represents a change in how lab analysis captures the data. Meaning, if OP is bound to $FeCl_3$, and exits the pond under, the lab analysis would show OP being reduced while TP might be unchanged.

Nevertheless, over the past five years, the Ferric Chloride treatment system has demonstrated its effectiveness in removing phosphorus from the watershed, as evidenced by the annual load removal data. In 2020, the system reporting was impacted by the installation of the carp barrier and results unable to be calculated using WIKSI. The following year, 2021, saw a significant increase in removal efficiency, with 35.80 lbs of TP and 35.96 lbs of OP being removed. In 2022, the system continued to perform well, removing 13.73 lbs of TP and 15.10 lbs of OP. The year 2023 marked a notable improvement, with the system removing 42.31 lbs of TP and an impressive 130.69 lbs of OP. Finally, in 2024, the system achieved its highest removal rates, with 972.94 lbs of TP and 851.75 lbs of OP being removed.

The variability in loading calculations shows the complexity of the system. The District is working to improve the accuracy of reporting, system efficiency, and is in the process of a feasibility study to understand current system performance and potential to improve efficiency through reduction of stormwater bypass.

Pre and Post Treatment Water Quality Monitoring

The following graphs display the monthly mean of samples analyzed between 2020 and 2024, before treatment at site SW-001 (FC_CD2) and after treatment, at SD-002 (FC_CD3). Samples began in March and some years taken until December. During that time, water quality sampling and monitoring was conducted once per week when the system is running. Drought conditions between 2021 and 2023 reduced the number of samples and readings. No samples or readings were taken during times of very low or no flow.

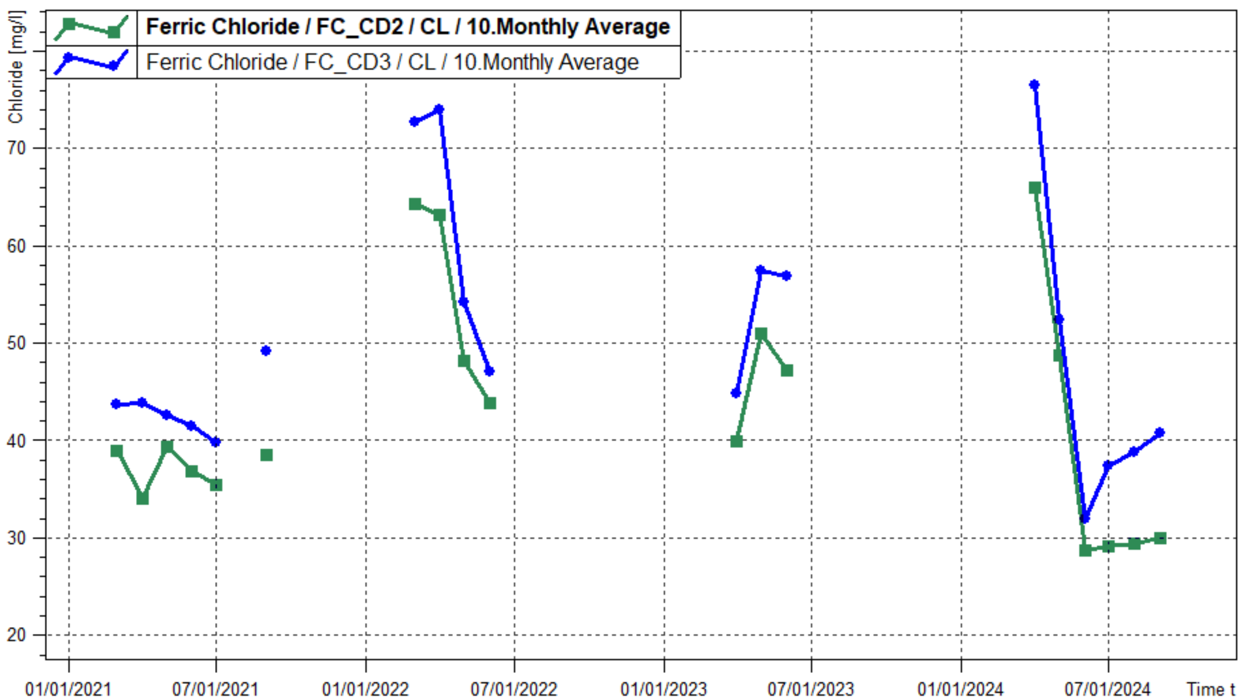

Figure 7. Chloride ions from FeCl3, de-icing salt, water softening, dust suppressant, fertilizer, and manure gets into lakes and streams and toxic to aquatic life. The state water quality standard for chlorides is 230 mg/l, which these sites are well below.

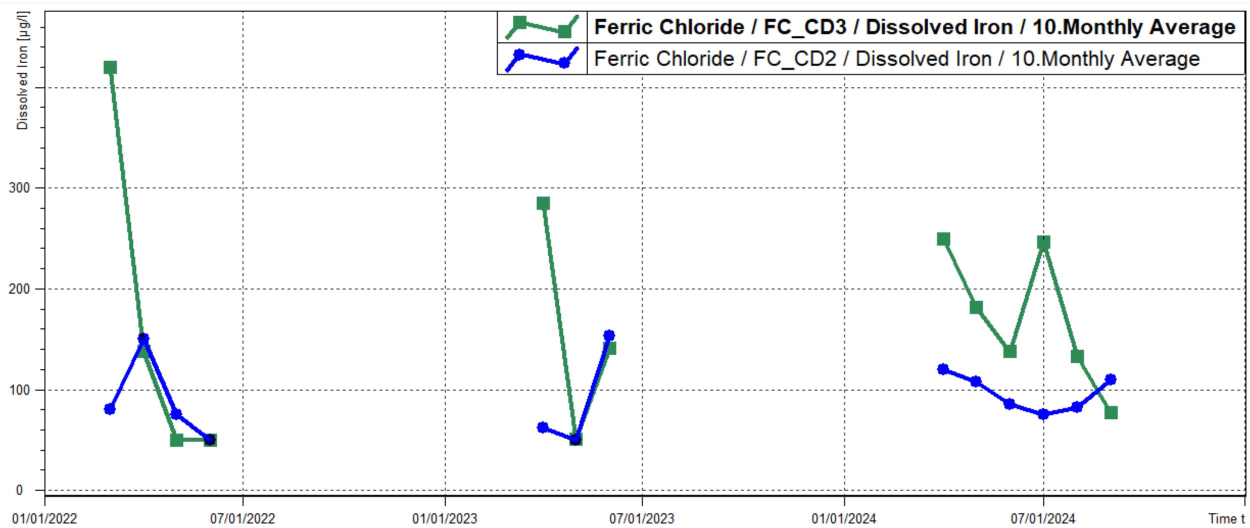

Figure 8. Average Monthly Dissolved Iron.

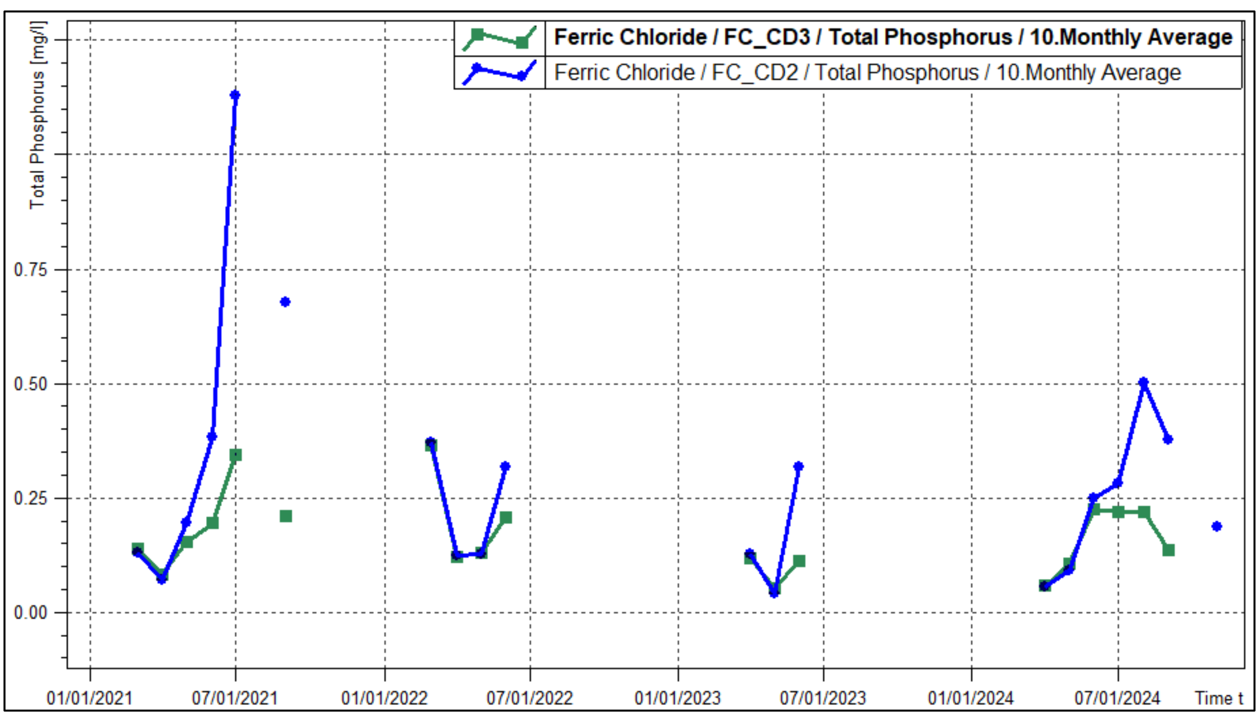

Figure 9. Average Monthly Total Phosphorus from 2020 through 2024.

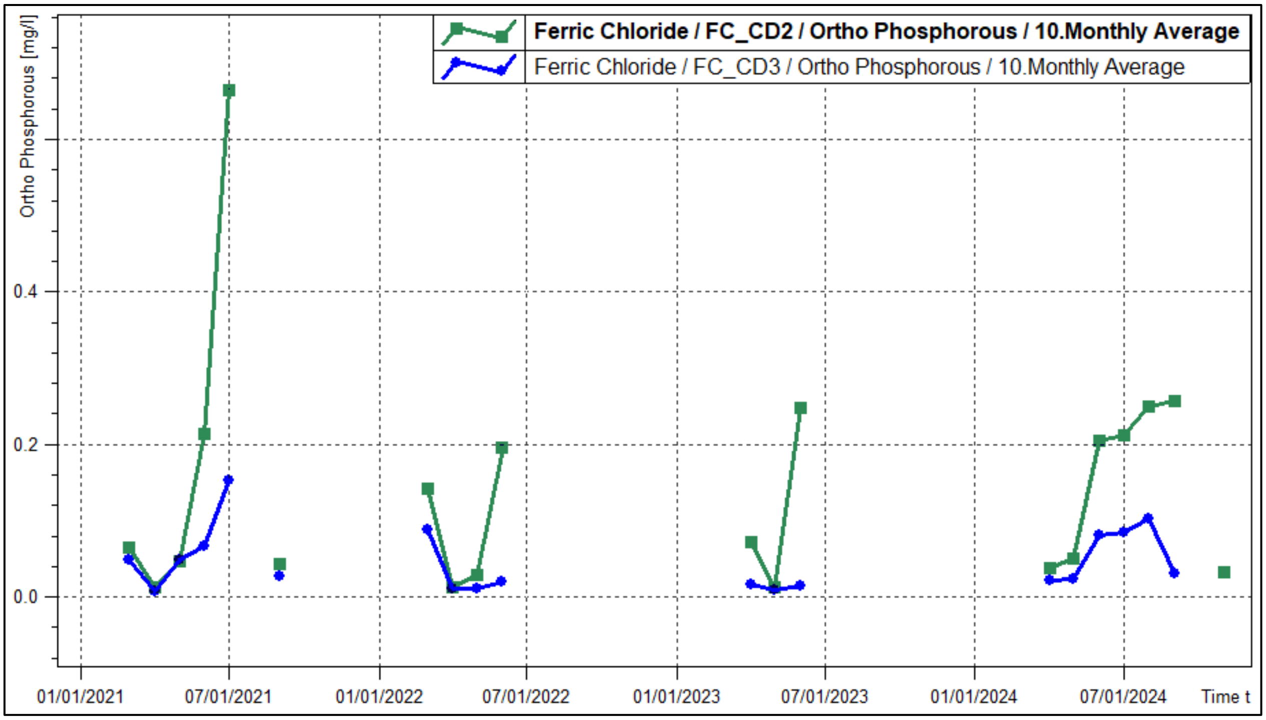

Figure 10. Average Monthly Dissolved Phosphorus from 2020 through 2024.

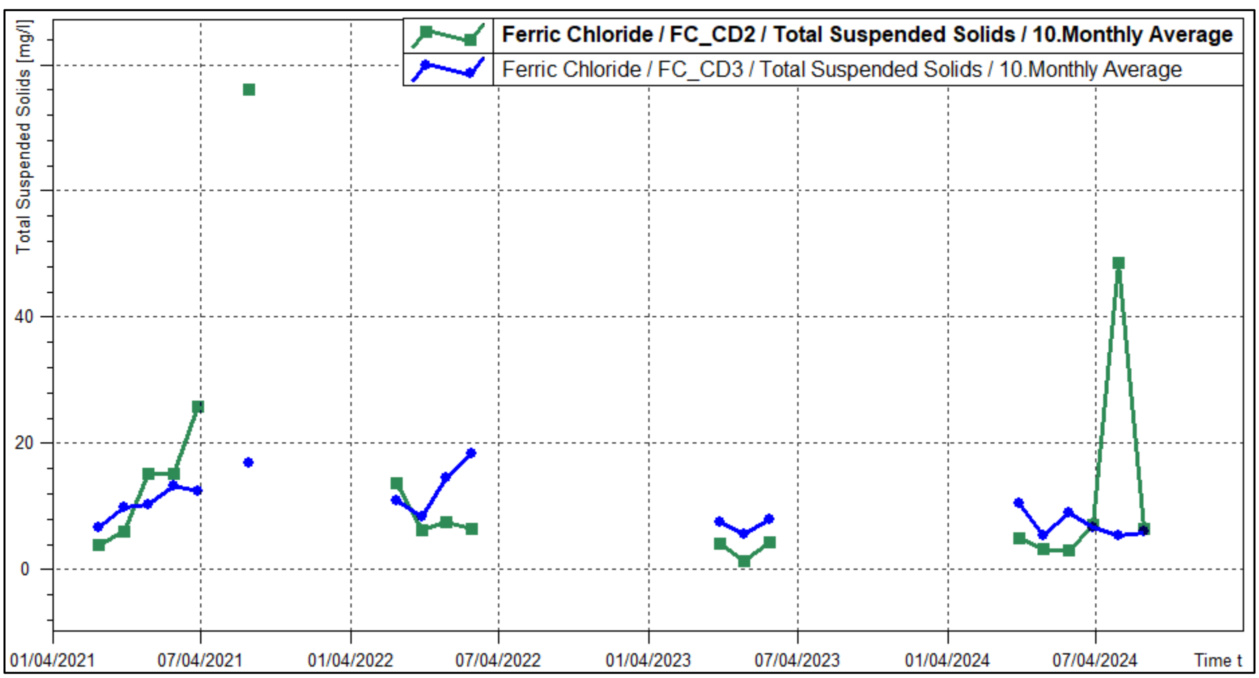

Figure 11. Average Monthly Total Suspended Solids from 2020 through 2024.

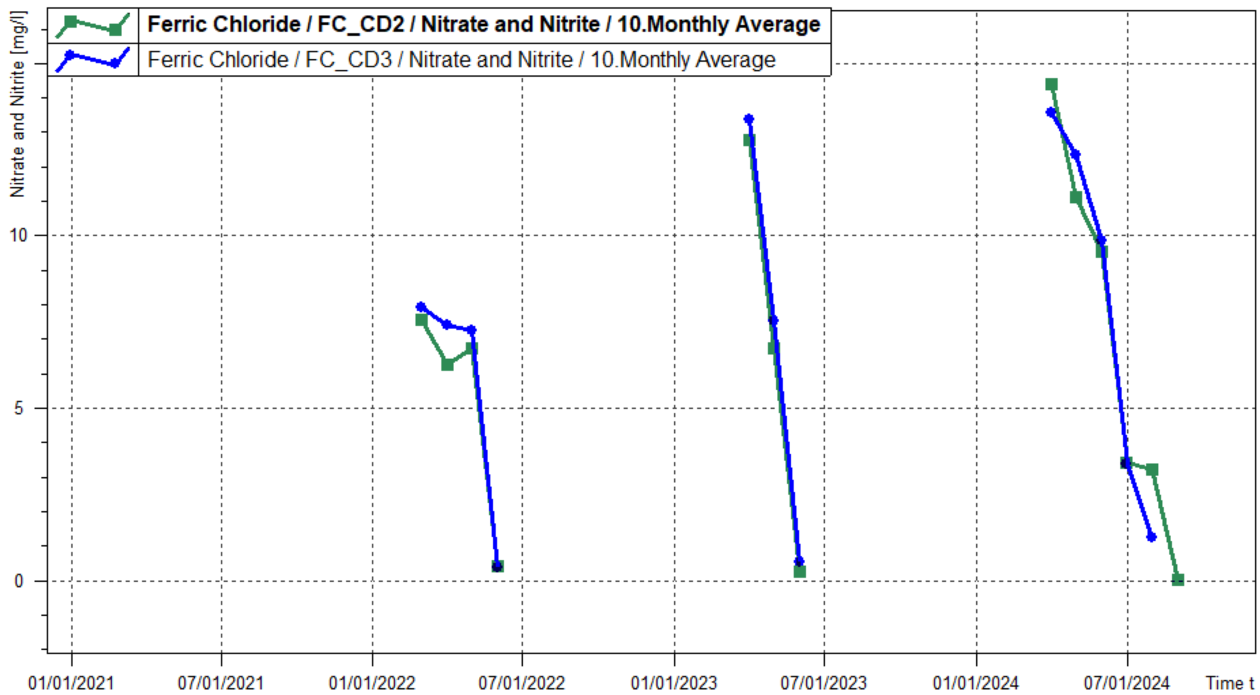

Figure 12. Average Monthly Nitrate + Nitrite from 2020 through 2024. Water samples were not analyzed for Nitrate + Nitrite in 2020 or 2021.

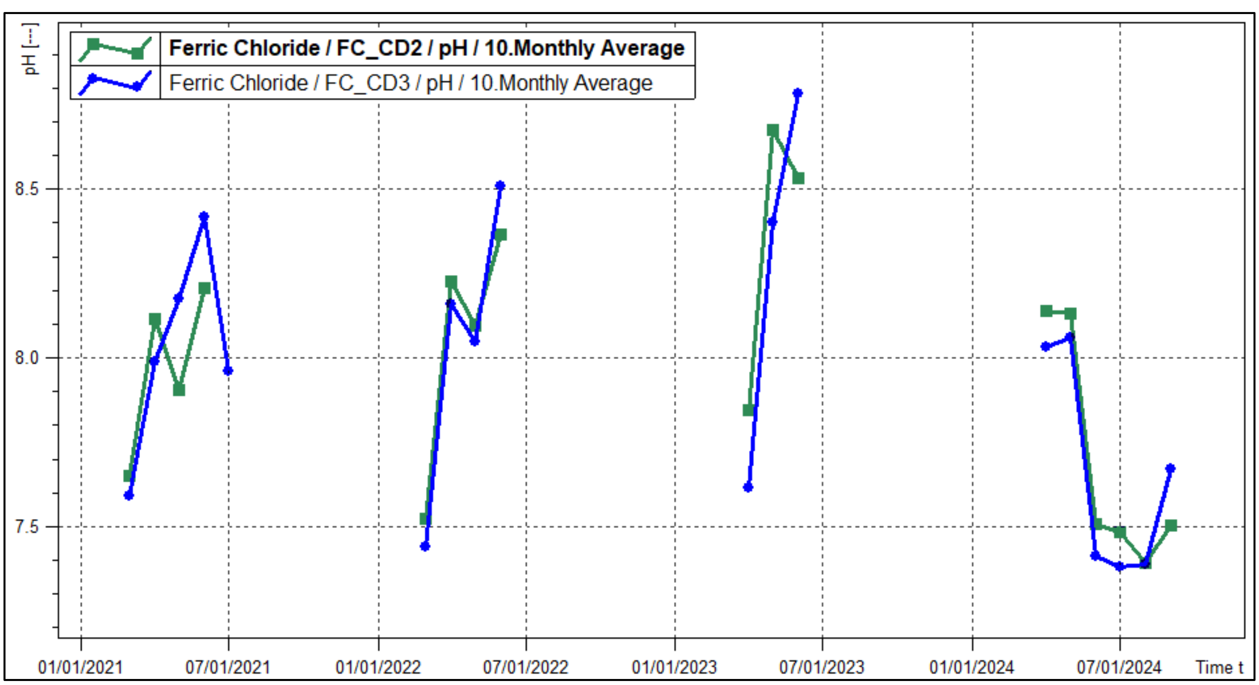

Figure 123. Average Monthly pH values from 2020 through 2024. pH values in 2020 were excluded due to faulty sensor.

Benefits to Spring Lake

Spring Lake has seen significant improvements in water quality thanks to the dedicated efforts of the watershed district's improvement projects and the local community advocating for better water quality. One of the most significant contributors to this success has been the Ferric Chloride ($FeCl_3$) treatment system, which has played a crucial role in removing phosphorus from the upper watershed through County Ditch 13.

Phosphorus, a key nutrient that has led to algal blooms and deteriorate water quality, was a major concern for Spring Lake. The Ferric Chloride treatment system was introduced as part of a comprehensive strategy to address this issue. By injecting $FeCl_3$ into the stormwater entering the lake, the system effectively binds with dissolved phosphorus, forming larger particles that can be easily removed through sedimentation. The impact of this treatment system has been described as one of the District's most successful projects. It is estimated that the Ferric Chloride system at County Ditch 13 removes about 30% of the total phosphorus load before entering Spring Lake. This significant reduction has helped to prevent eutrophication, improve water clarity, and support a healthier aquatic ecosystem in Spring Lake. In Figure 14 below, the annual average results of the three state lake standards for impaired water are graphically showing an improvement.

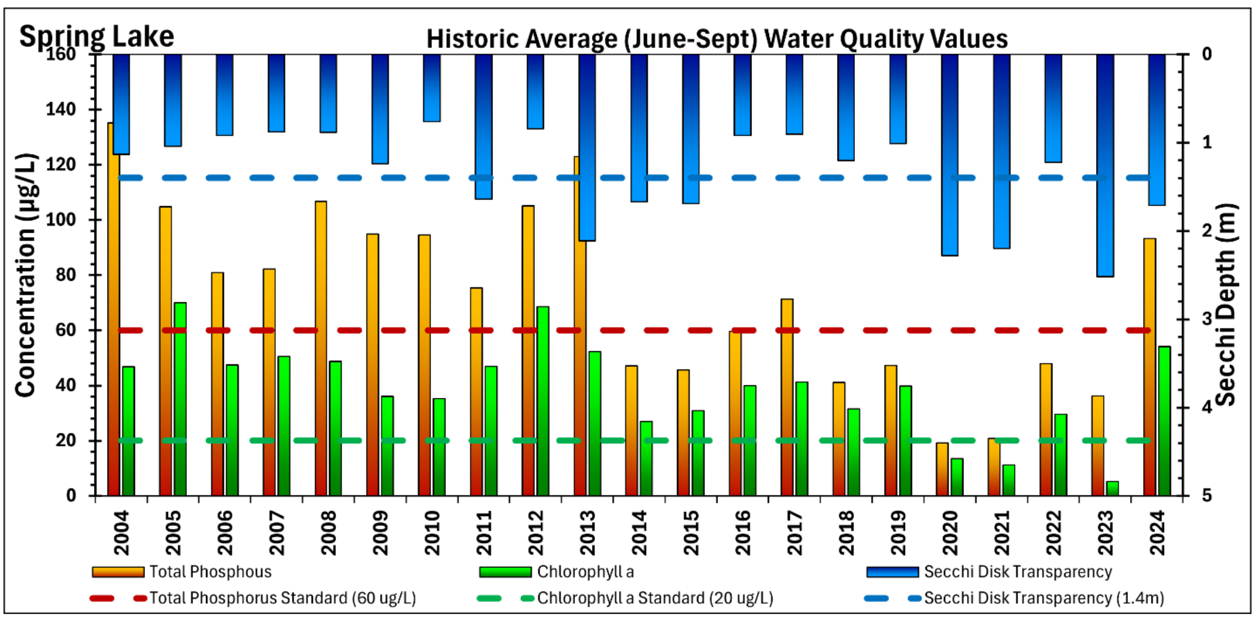

Figure 134. Annual average water quality vaule of Spring Lake from 2004 through 2024.

The success of the Ferric Chloride treatment system highlights the importance of innovative and targeted approaches in managing water quality. Overall, the improved water quality in Spring Lake is a testament to the effectiveness of the Ferric Chloride treatment system and the collaborative efforts of the community, Prior Lake-Spring Lake Watershed District, and Minnesota Pollution Control Agency. This achievement serves as a model for other regions facing similar challenges and underscores the value of proactive environmental stewardship.