FERRIC CHLORIDE WATER TREATMENT FACILITY
2017 ANNUAL REPORT

NPDES/SDS PERMIT NO: MN0067377

Mailed to:
Submittals Center
Minnesota Pollution Control Agency
520 Lafayette Road North
Saint Paul, MN 55155

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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 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 a ferric chloride ($FeCl_3$) treatment system to precipitate SRP out of stormwater from County Ditch 13, the main inflow to Spring Lake. The system was constructed as part of a Minnesota Pollution Control Agency (MPCA) Clean Water Partnership Implementation Project. The treatment system began operating 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. The District applied to the MPCA for a renewed permit in 2009. That permit was approved in 2012.

The treatment system involves the injection of 32.5% 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.

FIGURE 1 FERRIC CHLORIDE SHED AND WEIR

Prior to 2013, the $FeCl_3$ system had not operated since 2011 because it no longer met the requirements of the permit. During this time, the District was working toward a design that would meet 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 old 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 new design transfers $FeCl_3$ underground for 900 feet from the treatment building through a double walled pipe to a culvert north of Highway 13 that flows directly into the desiltation basin (see Figure 5). 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. A new pump was also installed by Vessco in 2013 in order to accommodate the new pumping requirements.

The retrofit project was designed by consultants Bolton and Menk, Inc. and installed by S.M. Hentges & Sons, Inc. The new design allowed 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 was designed to overtop a bypass weir (and flow around the desiltation basin) before the flows reached a point of resuspension in the pond. This allows for the maximum amount of phosphorus to be treated without resuspending the material in the desiltation basin. Staff reviewed the project design and confirmed it was operating as designed.

FIGURE 3 BYPASS WEIR AT DESILT POND

FIGURE 2 BERM AND INJECTION POINT AT DESILT POND

FIGURE 4 DESILT POND, STANDING AT OUTLET

FIGURE 5 AERIAL MAP OF FERRIC CHLORIDE TREATMENT SYSTEM

OPERATIONS AND MAINTENANCE

Access is needed to the Desilt pond outlet and injection site. A grass path to the outlet of the Desilt pond was regularly mowed by the homeowner, Gary Stevens. When the water level of the outlet was low enough, he voluntarily drove his lawnmower across the outlet and mowed a path from the outlet of the Desilt pond to the injection site at the berm. When water conditions were too high, staff weed whipped a path to the injection site.

FIGURE 6 WEED WHIPPED PATH FROM DESILT POND OUTLET TO INJECTION SITE

The Scott County Highway department cleared brush and mowed the edges of the driveway to the Ferric Chloride shed. Mowing and clearing is necessary for the Ferric Chloride delivery truck to have a clear path to the shed and to reduce encroachment on the driveway. In 2015, the Highway Department delivered and spread gravel on the driveway to the shed, as well as part of the driveway to the Geis' household, to sustain the weight of the delivery truck. Scott County Highway Department completed this work at no cost to the District for either labor or material.

City of Prior Lake staff (Public Works Water Department) helps PLSLWD staff maintain the pump, hoses, and injection site every year. Each spring, City staff inspects the pump and hoses, replaces old and worn parts, re-installs the injector, starts the pump, and ensures proper pumping. In fall, the City staff winterizes the facility by purging the ferric line to prevent freezing and removes, cleans, and stores the injector in a City facility over-winter.

City staff is also called upon when there are issues with the pump or lines during the operating season. On July 25, the pump indicated a leak was detected and the pump was shut off automatically. The pump was restarted, but failed again shortly thereafter. The city repaired the pump on August 2nd, but after the repair, it was discovered that the pump was dosing almost twice as much (2 gallons per hour) as it was programmed to pump, from August 3 to October 6. This caused no harm and did not exceed permit regulations; it was just excess usage. The City of Prior Lake staff and the pump manufacturer inspected the pump and determined there was something wrong with the computer board and the pump needed to be replaced.

Installation of the new pump (Figure 7) occurred on October 30, but was unable to be started because the power had to be disconnected due to some road maintenance from October 23 to November 9. The new pump resumed pumping on November 15. After verification that the new pump was working, it was shut off for the winter on November 30. The City of Prior Lake winterized the pump and system on December 1. All the work from the City was done at no charge to the District.

FIGURE 7 NEW FERRIC CHLORIDE PUMP

Other routine maintenance by PLSLWD staff included cleaning the staff gauge, removing debris from the Ferric Chloride and Bypass weir, installing snowmobile signs, downloading and calibrating the ultrasonic distance sensor, inspecting the facility 3 times per week, taking flow measurements and weekly samples, and cleaning in and around the shed.

FIGURE 8 FERRIC CHLORIDE DELIVERY

FERRIC USAGE

Three shipments of Ferric Chloride, totaling 8800 gallons, were delivered in 2017:

- 3300 gallons on April 25
- 3000 gallons on August 23
- 2500 gallons on November 29

The tank contained 1,970 gallons at the beginning of the season and 3,500 gallons were left in the tank at the end of the season. A total of 5,300 gallons of Ferric Chloride treated the ditch water before it reached Spring Lake. When flow of water in the ditch increased, the Ferric Chloride dose increased as well. From August 3 to October 6, the pump was malfunctioning and dosing twice as much as it needed to (two gallons per hour), but was still within the allowable treatment rate. The system operated well and treated between 0.5 and 3.0 gallons per hour of Ferric Chloride between March 5 and November 30, except July 25 through August 2 and October 6 through November 15 when the pump was not working, or the power was disconnected. The maximum rate of treatment is 4 gallons per hour, but flows did not get high enough to warrant that dose.

FUTURE MAINTENANCE

Carp have been observed in the wetland adjacent to the Ferric Chloride shed (Highway 13 Wetland) and the water has become noticeably more turbid in the past few years (visually and in data). The turbid water could be a sign of carp infestation. Because the current fish barrier is missing tines and inoperable, an engineer at WSB consulting designed a new concept for the fish barrier in 2017. Another option includes an electric barrier immediately downstream of the weir. A carp population estimate should also be conducted. These options will be further evaluated in 2018 and if funding is available, construction may take place.

The Ferric Chloride weir is also showing signs of age. Repair is anticipated to take place in 2018 to address the cracks, loose boards, and unstable railings.

FIGURE 9 FERRIC CHLORIDE WEIR AND FISH BARRIER

DESILT POND

The desilt pond needs to be cleaned out (dredged) when the pond starts filling up with sediment. In 2016, a company called Platypus mapped the bathymetry of the pond using a remote-control boat and the District's BioBase software. The pond was found to be about 7-8 feet deep in the middle and many years away from needing to be dredged. Vegetation density and bottom hardness are also simultaneously mapped and available upon request. The bathymetry map is shown below.

The last time the pond was dredged was 2012 and it was dredged down to 902 feet in mean sea level. During the time of mapping in 2016, the pond bottom was about 903.5'. 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.

Some historic pond dredging and survey information is summarized here:

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 mapped by Platypus and estimated to be 903.5' using BioBase software

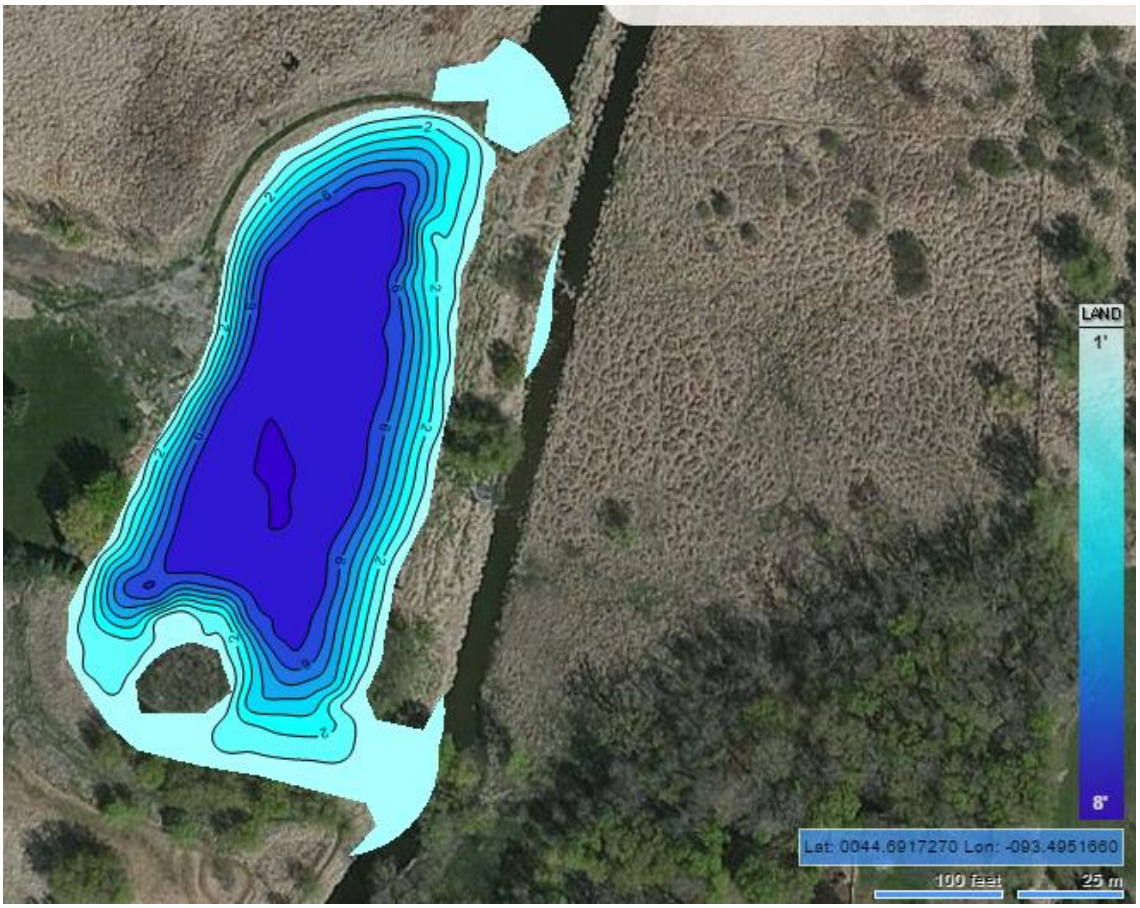


FIGURE 10 BATHYMETRIC MAP CREATED USING BIOBASE SOFTWARE AND PLATYPUS BOAT

RESULTS

During operation in 2017, the system treated approximately 938 million gallons (MG) of ditch water. The system reduced the average concentration of Total Phosphorus (TP) by 0.08 mg/L (35%) and removed a calculated 534 pounds of total phosphorus. The concentration of dissolved phosphorus (also referred to as SRP or Soluble Reactive Phosphorus) was reduced by an average of 0.04 mg/L (58%) and approximately 240 pounds of SRP were removed from the system.

TABLE 1 – PHOSPHORUS CONCENTRATIONS AND PERCENT REMOVAL

	SW001 Monthly Mean		SD002 Monthly Mean		% Change after Treatment	
Month	**Total Phosphorous (mg/l)**	**SRP (mg/l)**	**Total Phosphorous (mg/l)**	**SRP (mg/l)**	**Total Phosphorous (mg/l)**	**SRP (mg/l)**
March	0.059	0.027	0.047	0.012	-20%	-56%
April	0.098	0.029	0.076	0.015	-22%	-48%
May	0.123	0.052	0.097	0.019	-21%	-63%
June	0.229	0.037	0.097	0.017	-58%	-54%
July	0.338	0.153	0.18	0.072	-47%	-53%
August	0.28	0.052	0.161	0.020	-43%	-62%
September	0.239	0.064	0.097	0.008	-59%	-88%
October	0.17	0.094	0.12	0.048	-29%	-49%
November	0.08	0.022	0.069	0.011	-14%	-50%
Average 2018	**.18**	**.06**	**.10**	**.02**	**-35%**	**-58%**

*The $FeCl_3$ system was **not** dosing July 25 - August 2 or October 6 - November 15. Any samples taken during those times were not treated and not included in the calculations above (7/25, 8/2, 10/25).

TABLE 2 SUMMARY OF PHOSPHORUS REMOVALS SINCE 2011

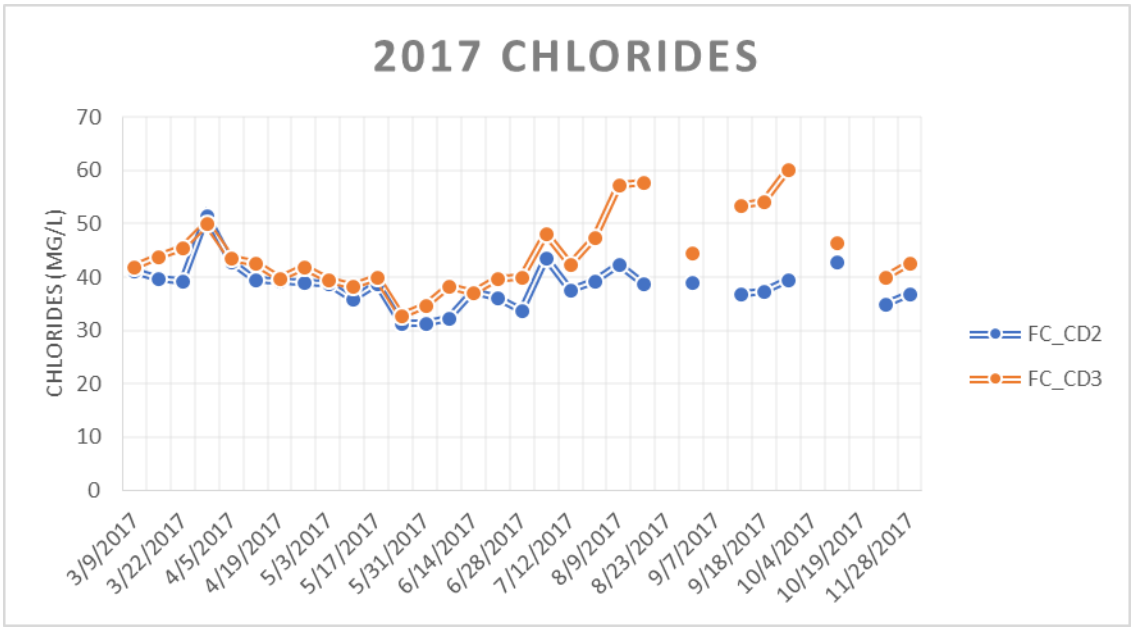
Year	Lbs P Removed	Lbs SRP Removed	% TP Reduction	% SRP Reduction	MG of Water Treated	Notes
2011	N/A	N/A	14% while treating; 1% with no treatment	54% while treating; 5% with no treatment	N/A	Only 30 days total treatment in 2011.
2012	N/A	N/A	12% (no treatment)	7% (no treatment)	N/A	No Treatment this year
2013	449	323	47% (while treating)	56% (while treating)	635	Only 2 months treated
2014	550	752	43%	72%	959	Treatment Apr 1 - Oct 31
2015	402	103	48%	51%	348	Treatment Apr 1 – Oct 31
2016	578	323	36%	64%	1327	Treatment Mar 11 – Nov 10
2017	534	240	35%	58%	938	Treatment Mar 5 – Nov 30

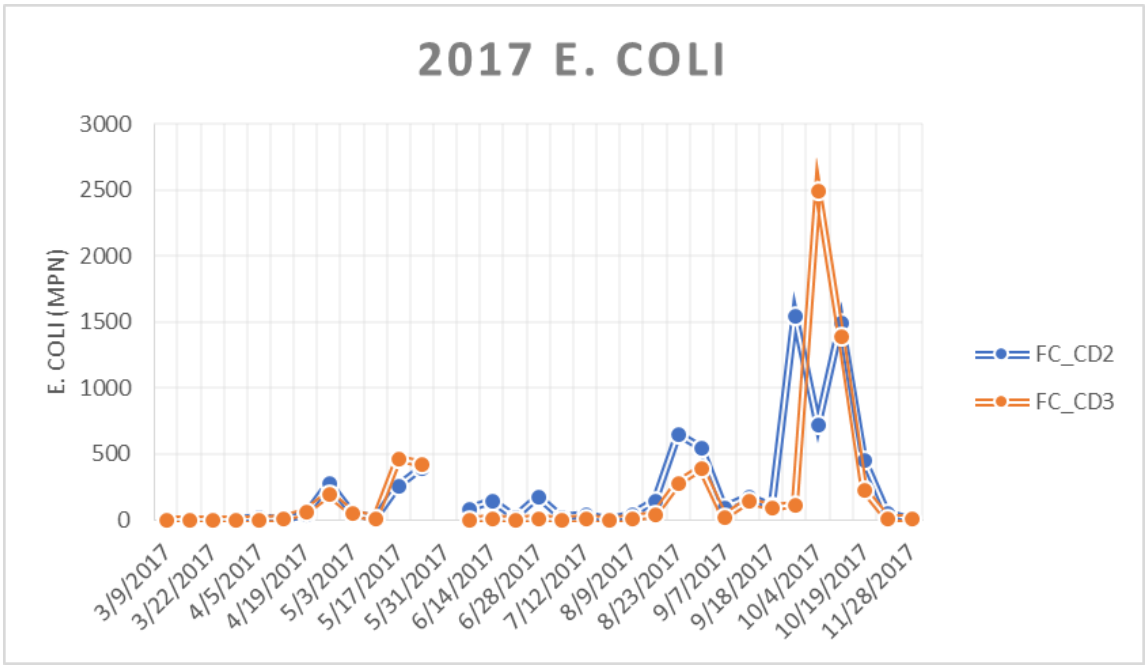
Table 3 Phosphorus Load Reductions

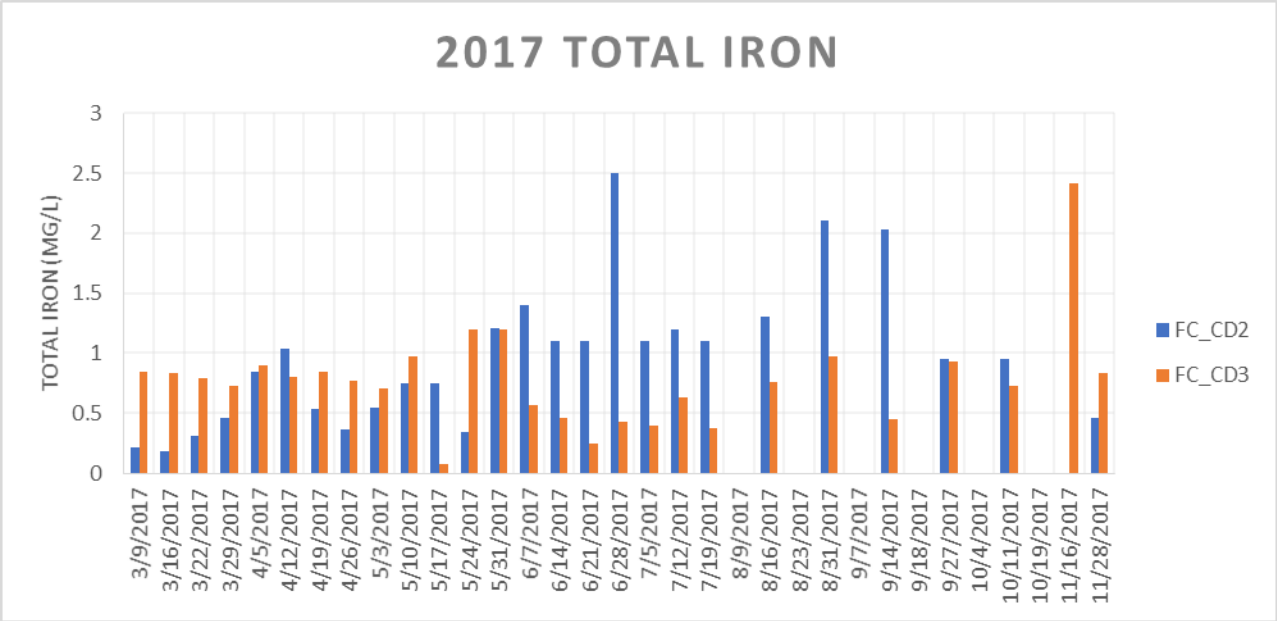
		SW-001	SD-002
March	Average SRP (mg/L)	0.027	0.012
	Average TP (mg/L)	0.059	0.047
	Treated Water (MG)		93
	SRP Load Reduction (pounds)		12
	TP Load Reduction (pounds)		9
April	Average SRP (mg/L)	0.029	0.015
	Average TP (mg/L)	0.098	0.076
	Treated Water (MG)		169
	SRP Load Reduction (pounds)		20
	TP Load Reduction (pounds)		31
May	Average SRP (mg/L)	0.052	0.019
	Average TP (mg/L)	0.123	0.097
	Treated Water (MG)		114
	SRP Load Reduction (pounds)		31
	TP Load Reduction (pounds)		25
June	Average SRP (mg/L)	0.037	0.017
	Average TP (mg/L)	0.229	0.097
	Treated Water (MG)		120
	SRP Load Reduction (pounds)		20
	TP Load Reduction (pounds)		132
July	Average SRP (mg/L)	0.153	0.072
	Average TP (mg/L)	0.338	0.180
	Treated Water (MG)		66
	SRP Load Reduction (pounds)		45
	TP Load Reduction (pounds)		87
August	Average SRP (mg/L)	0.052	0.020
	Average TP (mg/L)	0.28	0.161
	Treated Water (MG)		145
	SRP Load Reduction (pounds)		39
	TP Load Reduction (pounds)		144
September	Average SRP (mg/L)	0.064	0.008
	Average TP (mg/L)	0.239	0.097
	Treated Water (MG)		39
	SRP Load Reduction (pounds)		18
	TP Load Reduction (pounds)		46
October	Average SRP (mg/L)	0.094	0.048
	Average TP (mg/L)	0.17	0.120
	Treated Water (MG)		131
	SRP Load Reduction (pounds)		50
	TP Load Reduction (pounds)		55
November	Average SRP (mg/L)	0.022	0.011
	Average TP (mg/L)	0.08	0.069
	Treated Water (MG)		61
	SRP Load Reduction (pounds)		6
	TP Load Reduction (pounds)		6
Total	**Total Treated Water (million gallons)**		938
	Total SRP Load Reduction (pounds)		240
	Total TP Load Reduction (pounds)		534

GRAPHS

The following graphs display the monthly mean of samples taken in 2017, before treatment at site SW-001 (FC_CD2) and after treatment, at SD-002 (FC_CD3). Treatment began on March 5 and ceased on November 30. During that time, samples were taken once per week. Samples taken on July 25, August 2, and October 25 were not receiving treatment at the time of the sample and were therefore not included in the graphs below.






2017 TOTAL IRON
TOTAL IRON (MG/L)
3
2.5
2
1.5
1
0.5
0
3/9/2017
3/16/2017
3/22/2017
3/29/2017
4/5/2017
4/12/2017
4/19/2017
4/26/2017
5/3/2017
5/10/2017
5/17/2017
5/24/2017
5/31/2017
6/7/2017
6/14/2017
6/21/2017
6/28/2017
7/5/2017
7/12/2017
7/19/2017
8/9/2017
8/16/2017
8/23/2017
8/31/2017
9/7/2017
9/14/2017
9/18/2017
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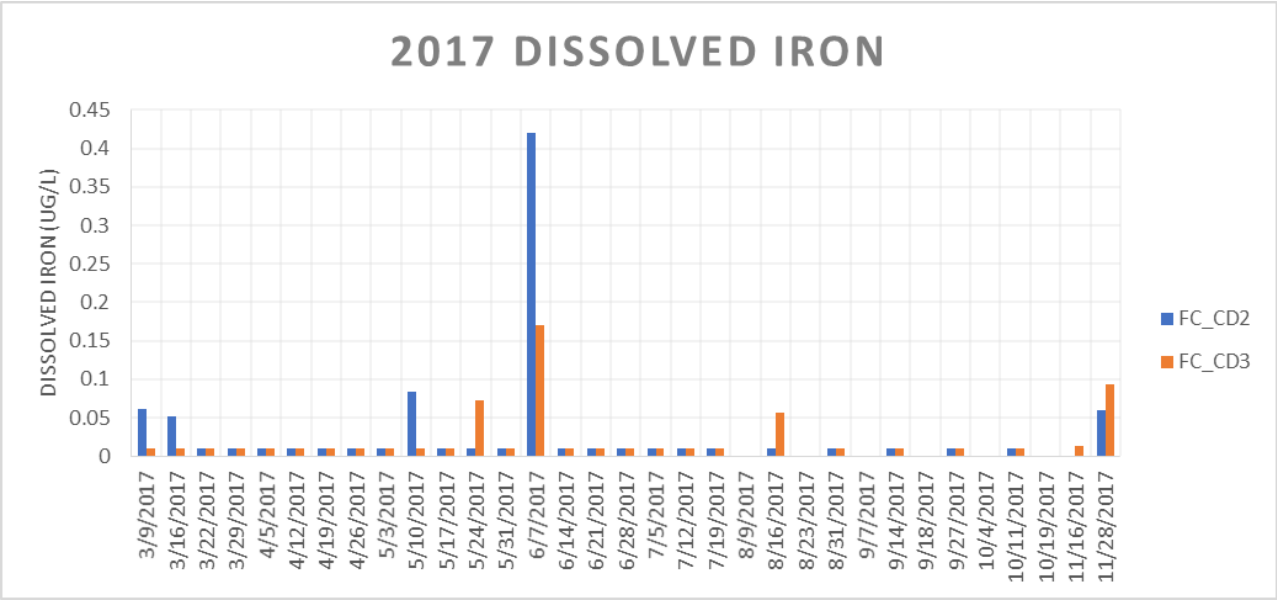
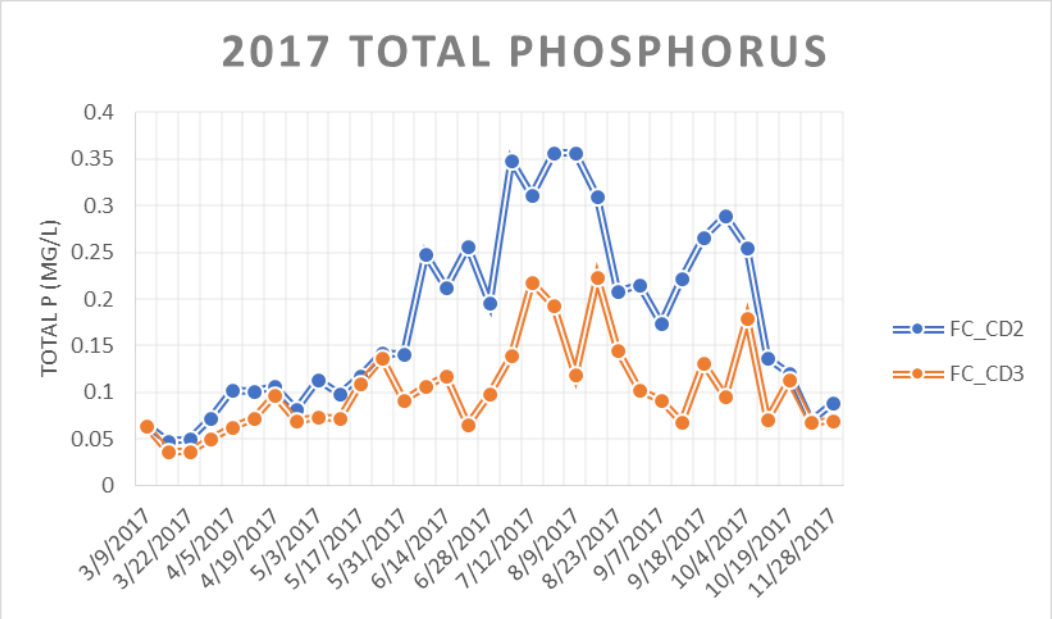
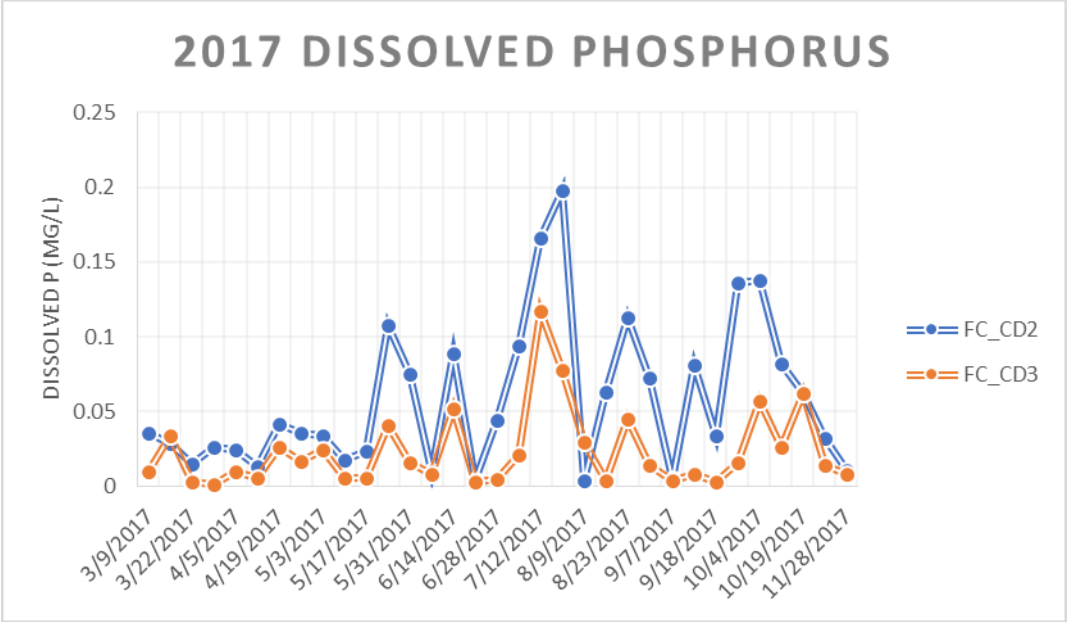
10/4/2017
10/11/2017
10/19/2017
11/16/2017
11/28/2017
FC_CD2
FC_CD3


2017 DISSOLVED IRON
DISSOLVED IRON (UG/L)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
3/9/2017
3/16/2017
3/22/2017
3/29/2017
4/5/2017
4/12/2017
4/19/2017
4/26/2017
5/3/2017
5/10/2017
5/17/2017
5/24/2017
5/31/2017
6/7/2017
6/14/2017
6/21/2017
6/28/2017
7/5/2017
7/12/2017
7/19/2017
8/9/2017
8/16/2017
8/23/2017
8/31/2017
9/7/2017
9/14/2017
9/18/2017
9/27/2017
10/4/2017
10/11/2017
10/19/2017
11/16/2017
11/28/2017
FC_CD2
FC_CD3


2017 TOTAL PHOSPHORUS
TOTAL P (MG/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
3/9/2017
3/22/2017
4/5/2017
4/19/2017
5/3/2017
5/17/2017
5/31/2017
6/14/2017
6/28/2017
7/12/2017
8/9/2017
8/23/2017
9/7/2017
9/18/2017
10/4/2017
10/19/2017
11/28/2017
FC_CD2
FC_CD3


2017 DISSOLVED PHOSPHORUS
DISSOLVED P (MG/L)
0.25
0.2
0.15
0.1
0.05
0
3/9/2017
3/22/2017
4/5/2017
4/19/2017
5/3/2017
5/17/2017
5/31/2017
6/14/2017
6/28/2017
7/12/2017
8/9/2017
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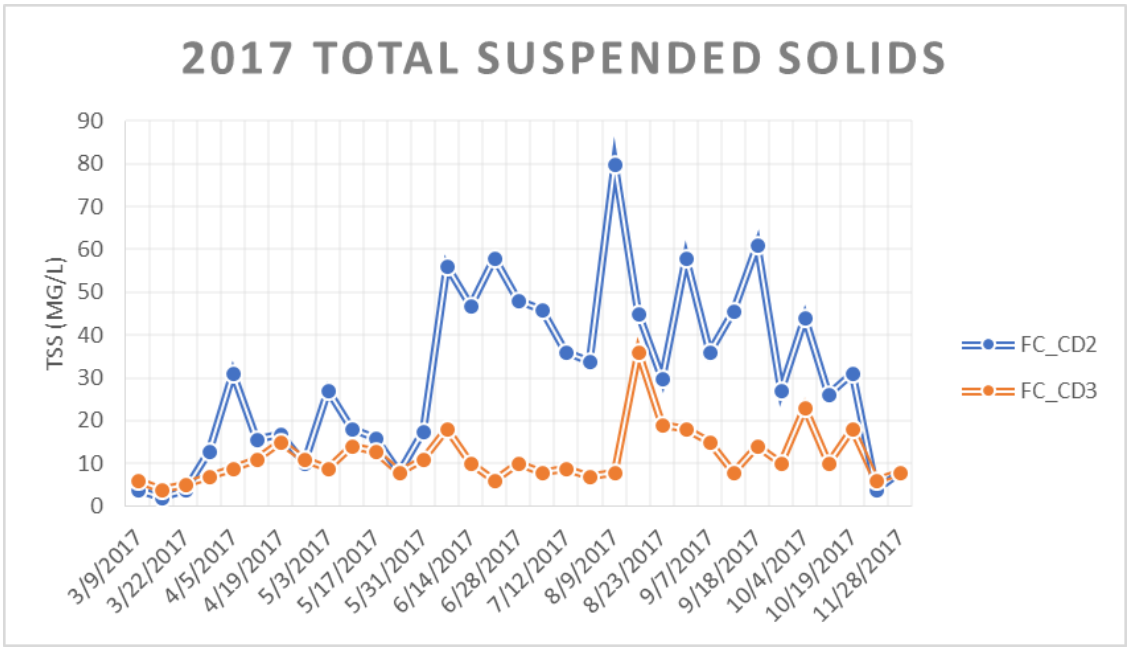
9/7/2017
9/18/2017
10/4/2017
10/19/2017
11/28/2017
FC_CD2
FC_CD3


2017 TOTAL SUSPENDED SOLIDS
TSS (MG/L)
90
80
70
60
50
40
30
20
10
0
3/9/2017
3/22/2017
4/5/2017
4/19/2017
5/3/2017
5/17/2017
5/31/2017
6/14/2017
6/28/2017
7/12/2017
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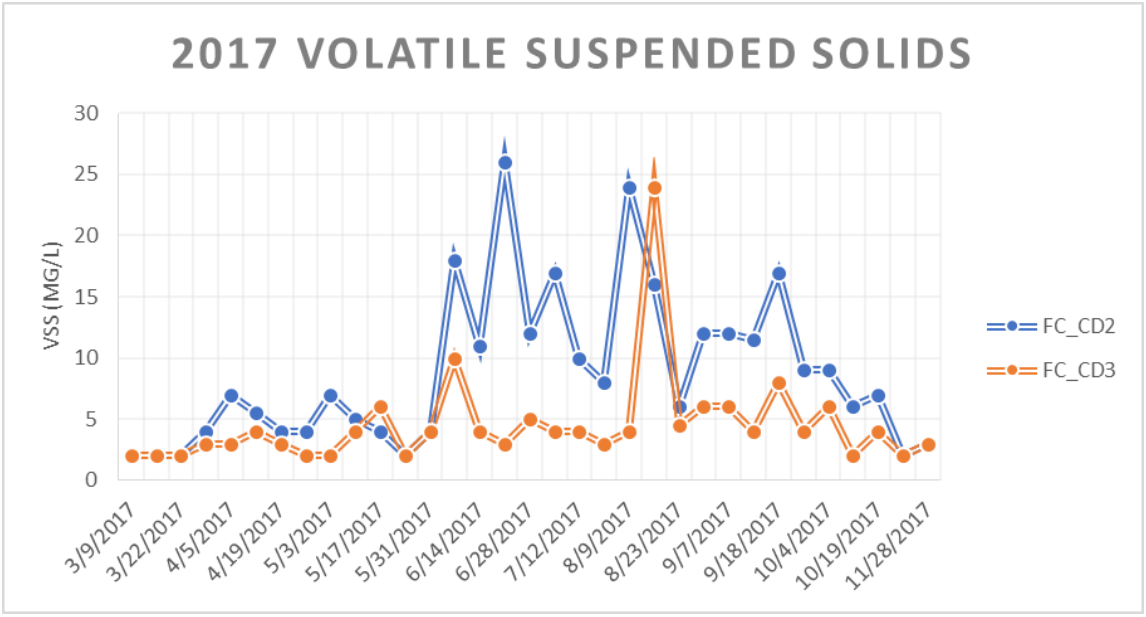
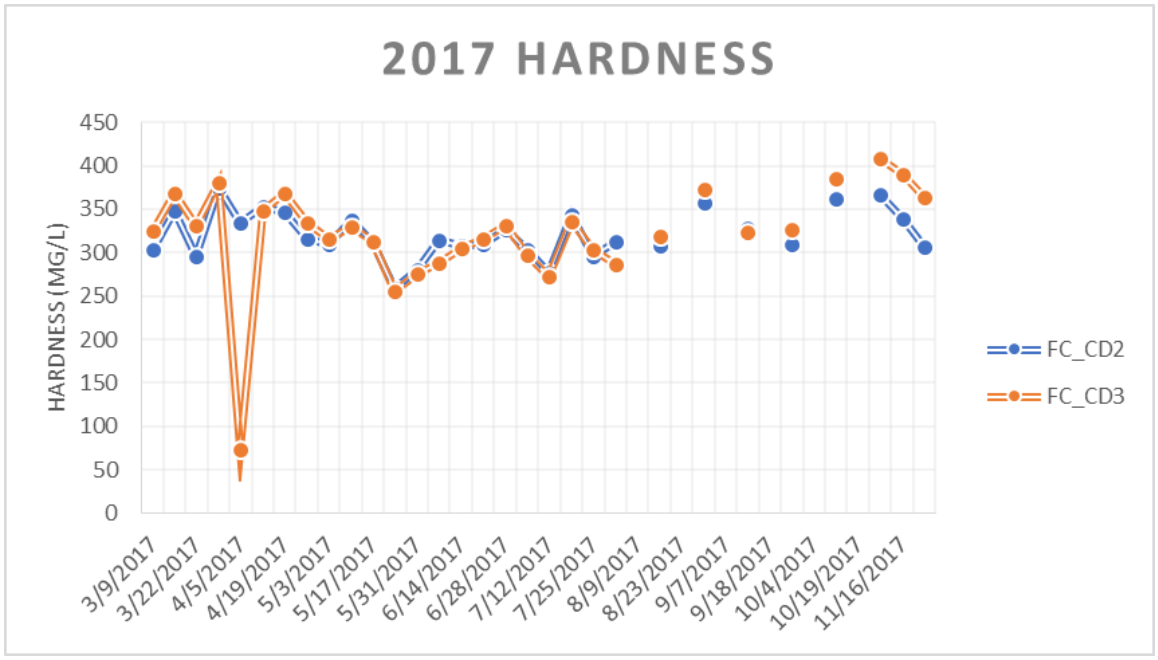
10/4/2017
10/19/2017
11/28/2017
FC_CD2
FC_CD3


2017 VOLATILE SUSPENDED SOLIDS
VSS (MG/L)
30
25
20
15
10
5
0
3/9/2017
3/22/2017
4/5/2017
4/19/2017
5/3/2017
5/17/2017
5/31/2017
6/14/2017
6/28/2017
7/12/2017
8/9/2017
8/23/2017
9/7/2017
9/18/2017
10/4/2017
10/19/2017
11/28/2017
FC_CD2
FC_CD3


2017 HARDNESS
HARDNESS (MG/L)
450
400
350
300
250
200
150
100
50
0
3/9/2017
3/22/2017
4/5/2017
4/19/2017
5/3/2017
5/17/2017
5/31/2017
6/14/2017
6/28/2017
7/12/2017
7/25/2017
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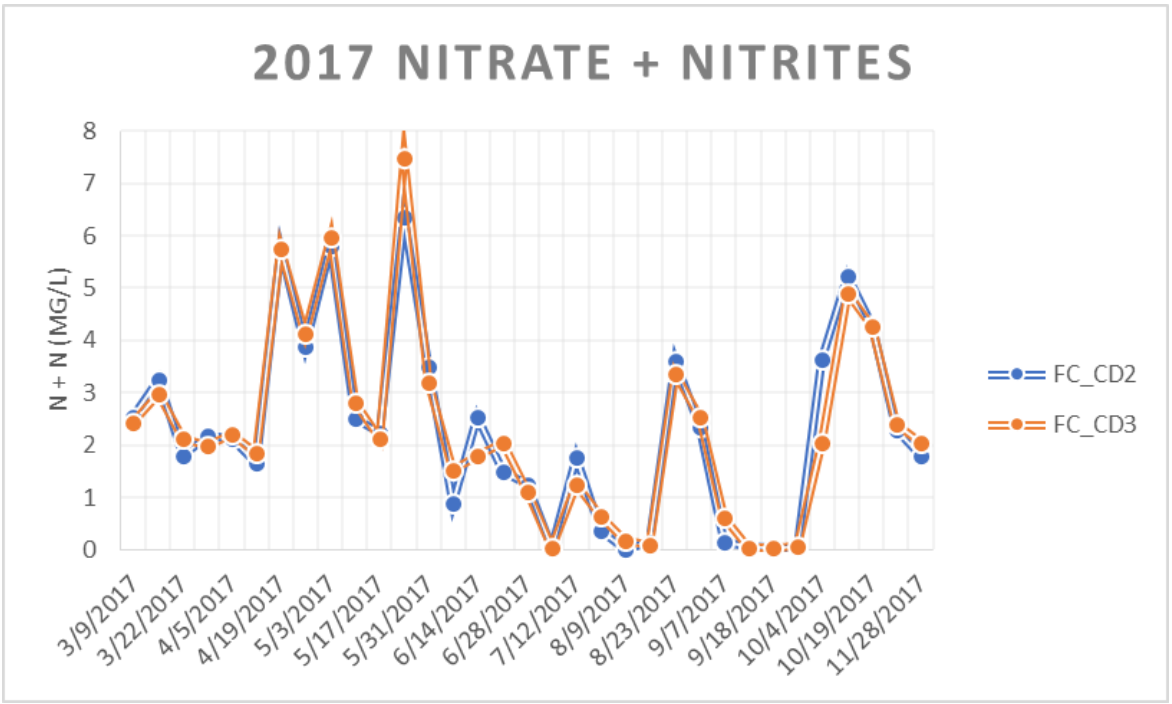
10/19/2017
11/16/2017
FC_CD2
FC_CD3


2017 NITRATE + NITRITES
N + N (MG/L)
8
7
6
5
4
3
2
1
0
3/9/2017
3/22/2017
4/5/2017
4/19/2017
5/3/2017
5/17/2017
5/31/2017
6/14/2017
6/28/2017
7/12/2017
8/9/2017
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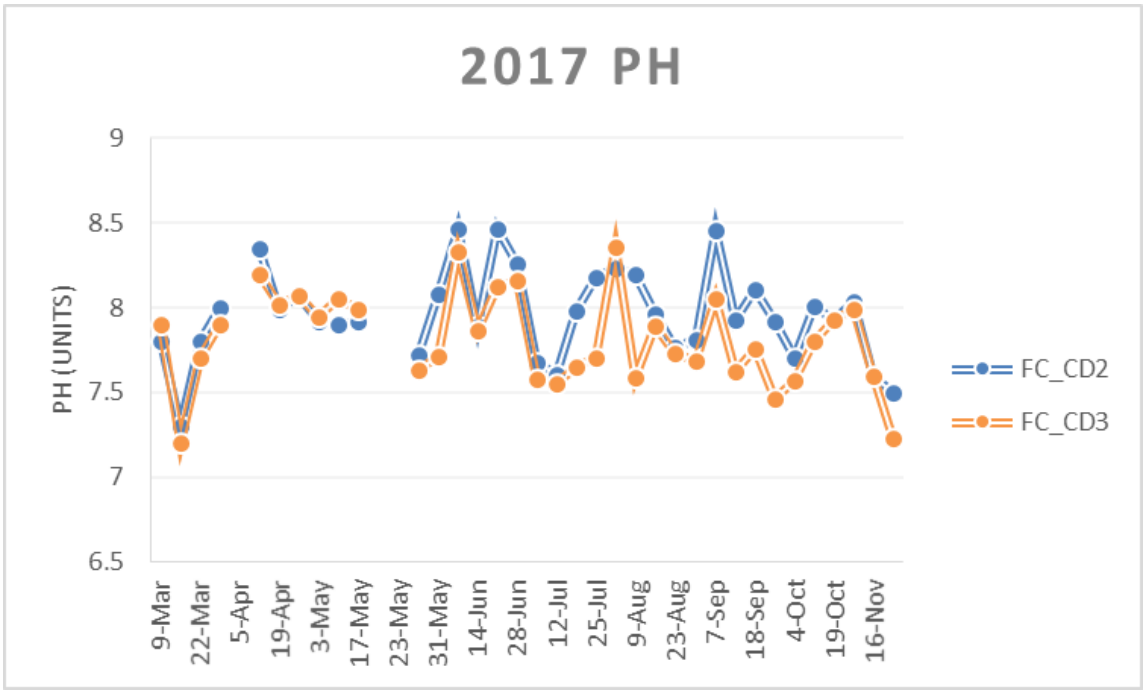
10/4/2017
10/19/2017
11/28/2017
FC_CD2
FC_CD3


2017 PH
PH (UNITS)
9
8.5
8
7.5
7
6.5
9-Mar
22-Mar
5-Apr
19-Apr
3-May
17-May
23-May
31-May
14-Jun
28-Jun
12-Jul
25-Jul
9-Aug
23-Aug
7-Sep
18-Sep
4-Oct
19-Oct
16-Nov
FC_CD2
FC_CD3