Updated Trend Analysis for Petronila Creek Above Tidal Implementation-Plan (I-Plan) for Three Total Maximum Daily Loads for Chloride, Sulfate, and Total Dissolved Solids (TDS)
2007 - 2016

INTRODUCTION

The water quality data analysis that was conducted on three historic monitoring sites (Figure 1 – green dots) on the main stem as part of the 2014 I-Plan Revision included data from 1971 to 2012. Two sets of data graphs were created – one for the full date range and one from 2007 (date of the initial I–Plan) to 2012. The first updated analysis, completed in September 2016, added data collected in 2013 through 2015 and noted any changes in the 2007 – 2013 trends. For this updated analysis, data collected in 2016 have been added to the trend analysis. The change in trends from the September 2016 analysis have also been noted.

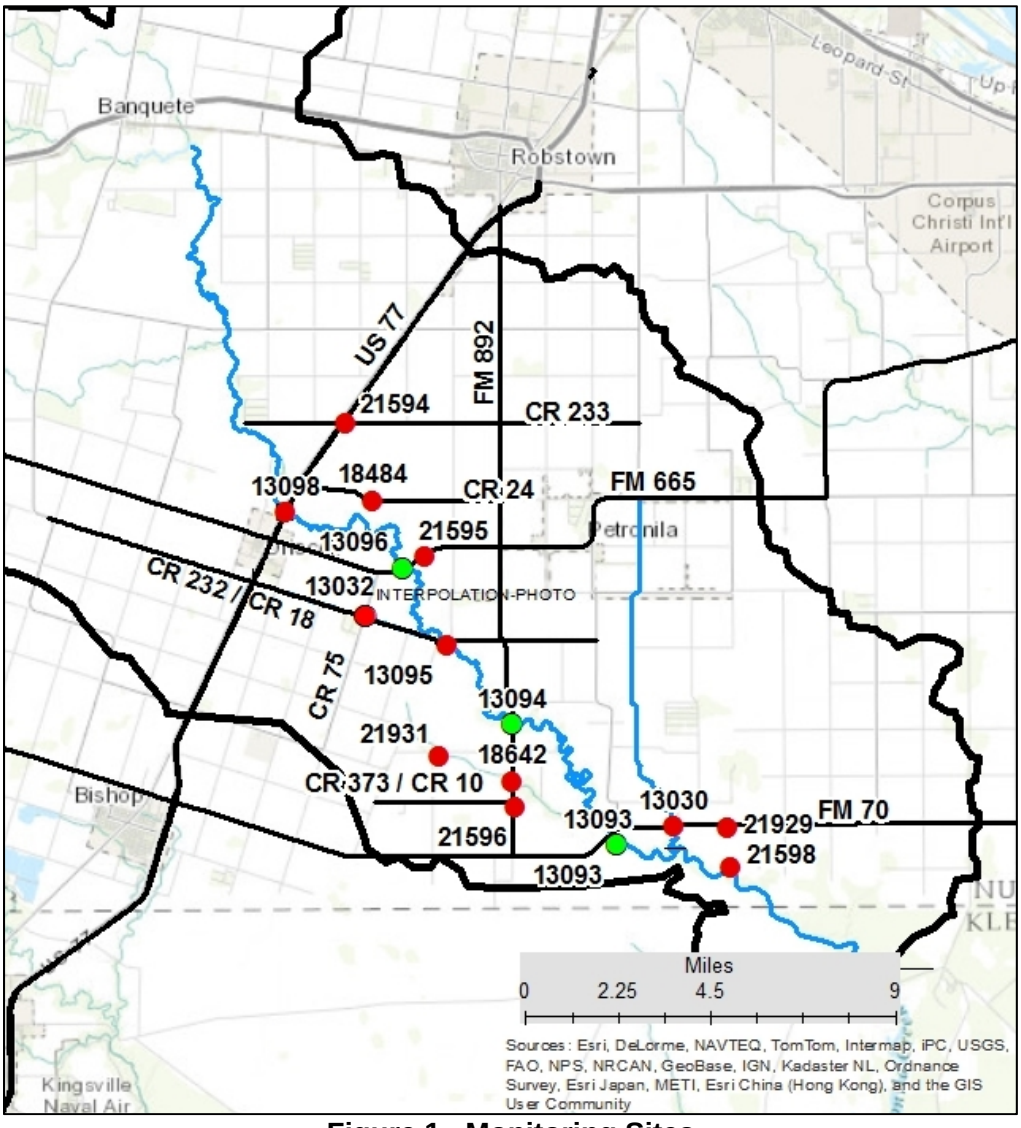


Figure 1. Monitoring Sites

Graphs of the chloride, sulfate, and TDS values measured on the tributaries in fiscal years 2015 through 2017 (Figure 1 – red dots) are also included in this report. Nine sites were monitored in 2015, seven sites in 2016, and ten sites in 2017. Stations 13092, 21929, and 21931 were added for 2017 to further enhance potential tributary source information.

MAIN STEM ANALYSIS

It should be noted that the accuracy of the trend analysis increases with each additional year of monitoring. Ten years is an accepted minimum, but for the purpose of this update, Station 13093 has seven years of data (beginning in 2010 because of no sampling in 2006 through 2009) and 13094 and 13096 each have ten years of data. The trend analysis used the Excel graphing option to 'Add Trendline' to determine the R^2 value. The larger the absolute value, the greater the trend. Absolute values <0.05 are not considered to have a trend. The Excel 'Correlation' function was used to determine if rainfall played a role in concentrations values. The closer the absolute value is to 1, the greater the correlation. Rainfall recorded at Kingsville Naval Air Station (https://www.wunderground.com/history/airport/KNQI) was used for the analysis. It is the closest station with consistent information. The raw data is including in Appendix A.

Chlorides – Standard 1,500 mg/l

At all three stations, from 2012 through 2015, the yearly average chloride concentration was less than the previous year's average. For 2016, all the yearly averages are higher than in 2015, but below the 2013 yearly averages. (Figure 2).

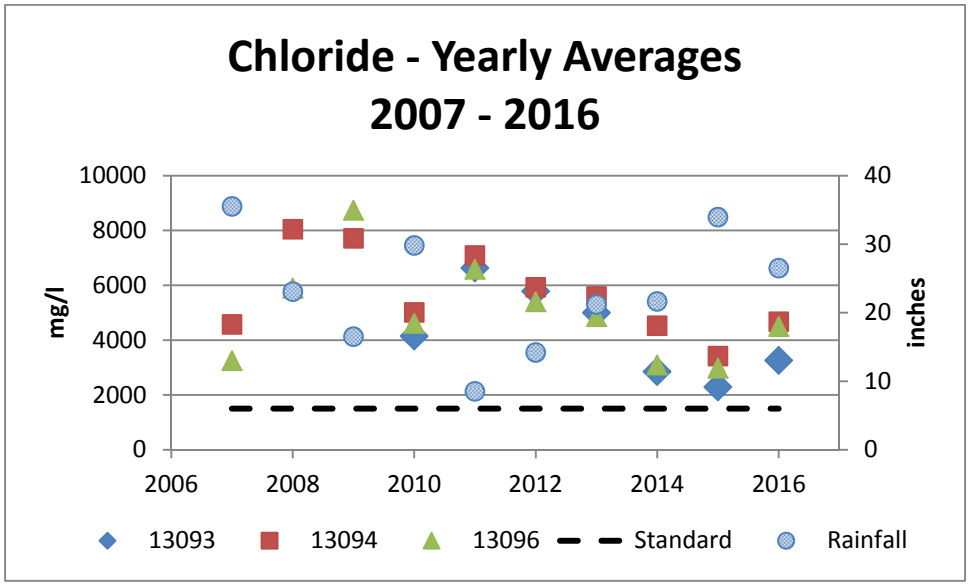


Figure 2. Chloride Yearly Averages

Statistical analysis of the data (Table 1) shows that there was an increasing trend in concentration levels at stations 13093 and 13096 and no trend at station 13094 from 2007 through 2012. With the additional four years of data, there are now decreasing trends at each station.

The analysis shows that there is an inverse relationship between rainfall and chloride concentrations at all stations.

Table 1: Statistical Analysis of Chloride Concentrations

Station	2007 thru 2012	2007 thru 2016		Rainfall Correlation	
		(2007 – 2015 Value)			
13093	Increasing: R^2 = 0.418	Decreasing: R^2 = 0.474	(0.463)	-0.86	(-0.85)
13094	No Trend: R^2 = 0.002	Decreasing: R^2 = 0.318	(0.288)	-0.68	(-0.67)
13906	Increasing: R^2 = 0.062	Decreasing: R^2 = 0.152	(0.159)	-0.70	(-0.69)

Sulfate – Standard 500 mg/l

At all three stations, from 2012 through 2015, the yearly average chloride concentration was less than the previous year's average. For 2016, all the yearly averages are higher than 2015: Station 13093's 2016 yearly average was below the 2013 yearly average, and Stations 13094 and 13096 2016 yearly averages were below their respective 2014 yearly averages. (Figure 3).

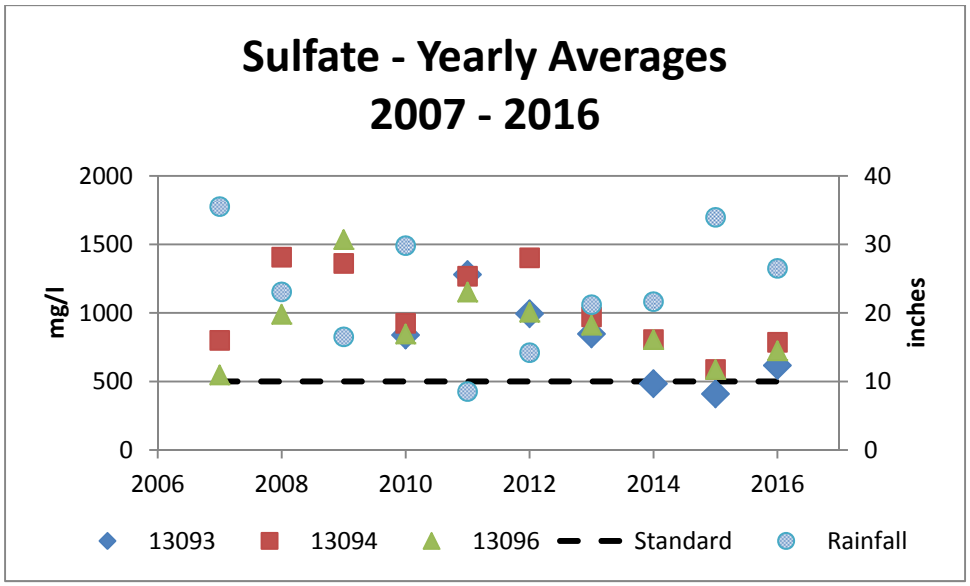


Figure 3. Sulfate Yearly Averages

Statistical analysis of the data (Table 2) shows that there was an increasing trend in concentration levels at all three stations from 2007 through 2012. With the additional four years of data, there are now decreasing trends at each station. The average yearly concentration at Station 13093 was below the 500 mg/l standard in 2015.

The analysis shows that there is an inverse relationship between rainfall and sulfate concentrations at all stations.

Table 2: Statistical Analysis of Sulfate Concentrations

Station	2007 thru 2012	2007 thru 2016		Rainfall Correlation	
		(2007 – 2015 Value)			
13093	Increasing: R^2 = 0.120	Decreasing: R^2 = 0.547	(0.598)	-0.81	(-0.80)
13094	Increasing: R^2 = 0.189	Decreasing: R^2 = 0.259	(0.194)	-0.76	(-0.76)
13906	Increasing: R^2 = 0.116	Decreasing: R^2 = 0.094	(0.052)	-0.78	(-0.77)

TDS – Standard 4000 mg/l

At all three stations, from 2012 through 2015, the yearly average chloride concentration was less than the previous year's average. For 2016, all the yearly averages are higher than 2015: Station 13093's 2016 yearly average was below the 2013 yearly average, and Station 13094's 2016 yearly average was below the 2014 yearly average, and 13096 2016's yearly average was below the 2012 yearly average. (Figure 4).

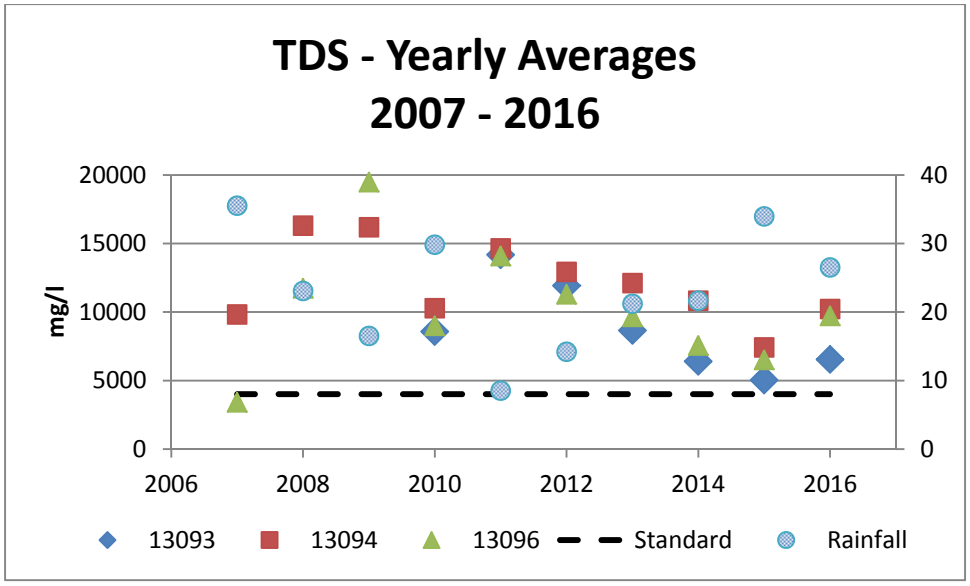


Figure 4. TDS Yearly Averages

Statistical analysis of the data (Table 3) shows that there was an increasing trend in concentration levels at stations 13093 and 13096 and no trend at 13094 from 2007 through 2012. With the additional four years of data, there are now decreasing trends at stations 13093 and 13094 and still no trend at station 13096.

The analysis shows that there is an inverse relationship between rainfall and TDS concentrations at all stations.

Table 3: Statistical Analysis of TDS Concentrations

Station	2007 thru 2012	2007 thru 2016	Rainfall Correlation
		(As of 2015 Report)	
13093	Increasing: R^2 = 0.354	Decreasing: R^2 = 0.500 (0.483)	-0.88 (-0.88)
13094	No Trend: R^2 = 0.008	Decreasing: R^2 = 0.262 (0.226)	-0.74 (-0.73)
13906	Increasing: R^2 = 0.130	No Trend: R^2 = 0.028 (0.030)	-0.75 (0.76)

TRIBUTARY ANALYSIS

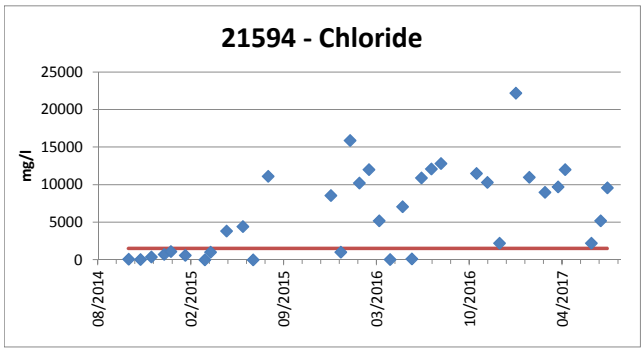
The following pages contain graphs of the chloride, sulfate, and TDS sampling results from FY 2015 through FY 2017. Conductivity vs previous 21-day rainfall graphs are also included. An inverse relationship between conductivity and rainfall are apparent at most sites (Table 4). Because the sampling was conducted monthly, allowing for more data points, trend analysis was conducted on the stations that have been sampled all three years. The ↑ symbol in the table below indicates an increasing trend. Not all stations had all 36 data points – either the site was dry or too muddy for access.

Table 4: Conductivity vs Previous 21-day rainfall

Station (# samples)	Rainfall Correlation	Chloride Trend	Sulfate Trend	TDS Trend
13030 (n=36)	-0.62	R^2 = 0.295 ↑	R^2 = 0.050 ↑	R^2 = 0.187 ↑
13032 (n=7)	-0.56			
13095 (n=36)	-0.74	R^2 = 0.187 ↑	R^2 = 0.197 ↑	R^2 = 0.187 ↑
13098 (n=12)	-0.45			
18484 (n=33)	-0.42	R^2 = 0.118 ↑	R^2 = 0.056 ↑	R^2 = 0.131 ↑
18642 (n=36)	-0.71	R^2 = 0.134 ↑	R^2 = 0.099 ↑	R^2 = 0.134 ↑
21594 (n=35)	-0.59	R^2 = 0.310 ↑	R^2 = 0.300 ↑	R^2 = 0.257 ↑
21595 (n=11)	-0.18			
21596 (n=33)	-0.66	R^2 = 0.305 ↑	R^2 = 0.425 ↑	R^2 = 0.265 ↑
21598 (n=32)	-0.67	R^2 = 0.223 ↑	R^2 = 0.339 ↑	R^2 = 0.098 ↑
21929 (n=11)	-0.86			
21931 (n=11)	-0.54			

RECOMMENDATIONS

Water quality sampling should be continued until at least 10 years of data are collected so that the trend analysis is more statistically valid.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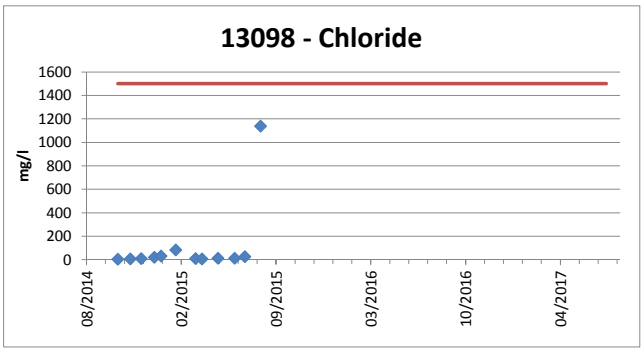
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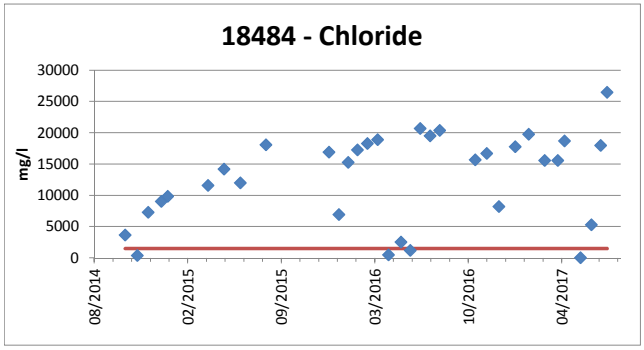
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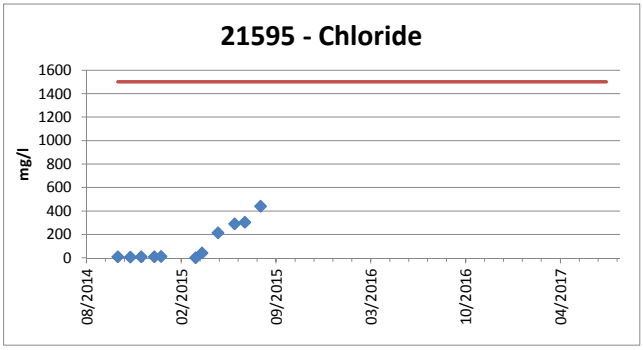
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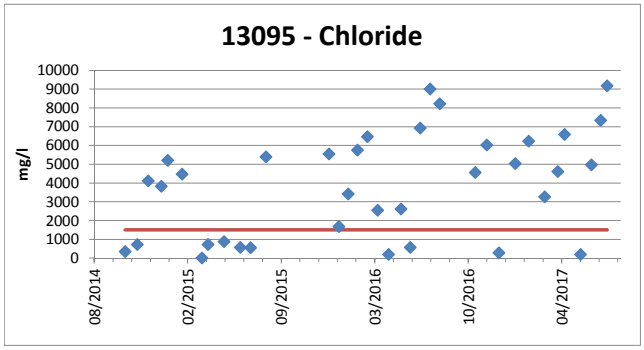
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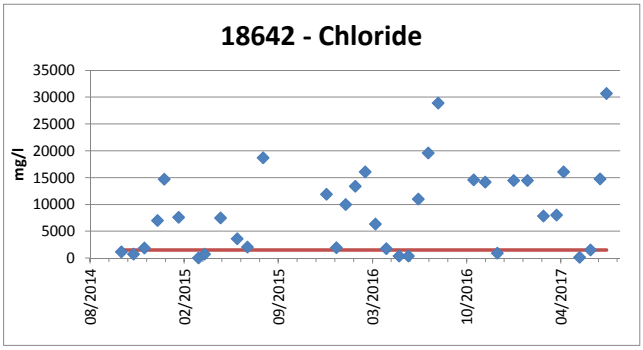
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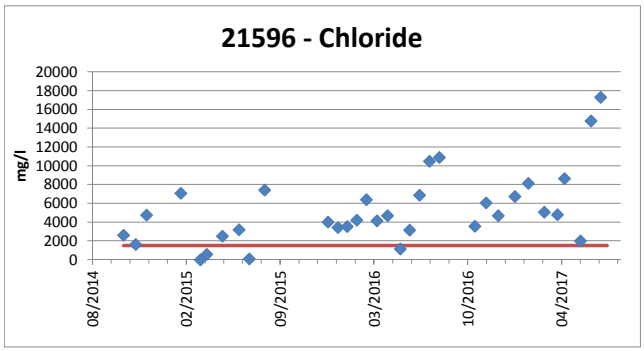
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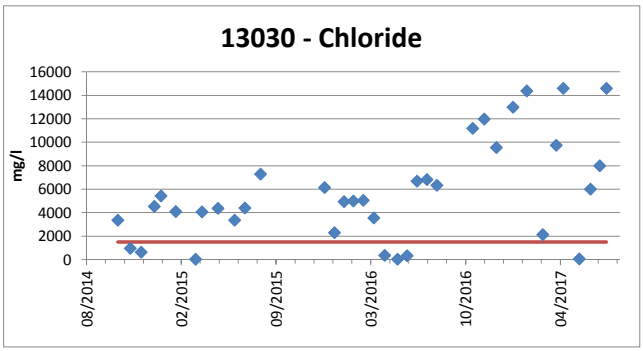
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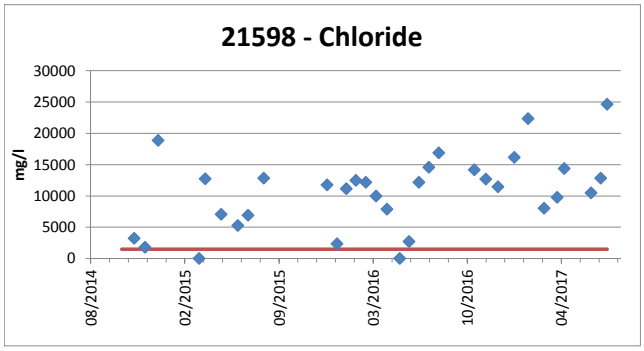
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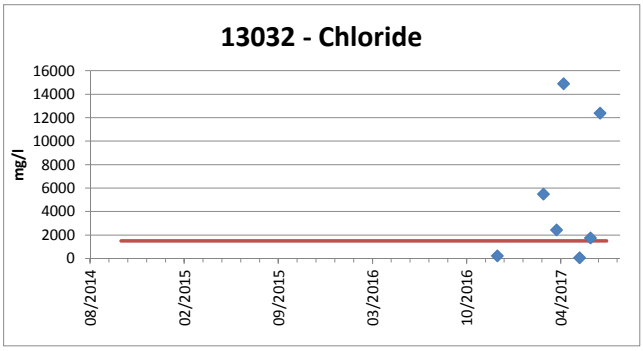
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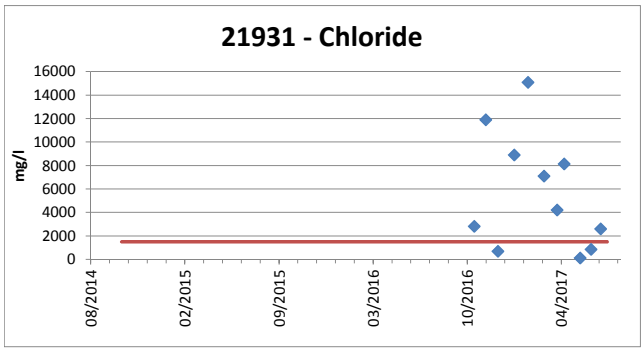
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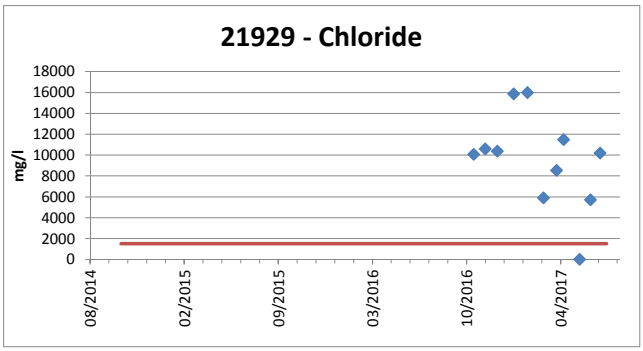
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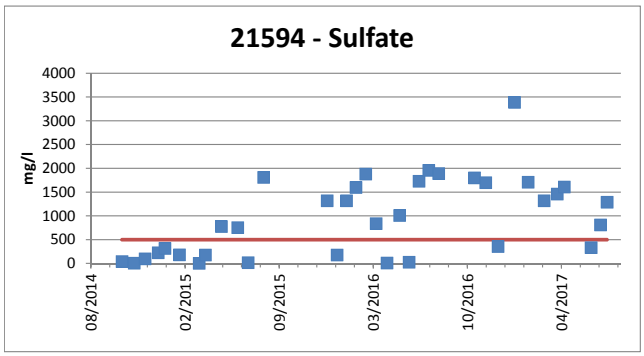
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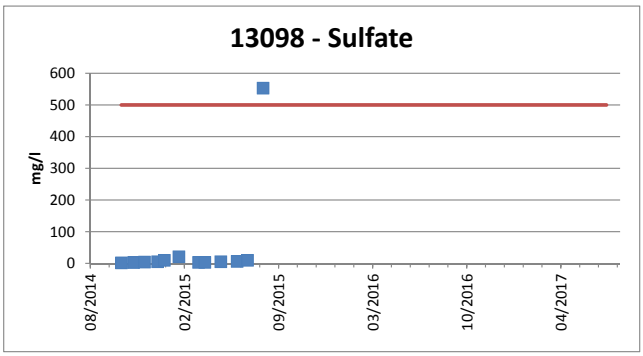
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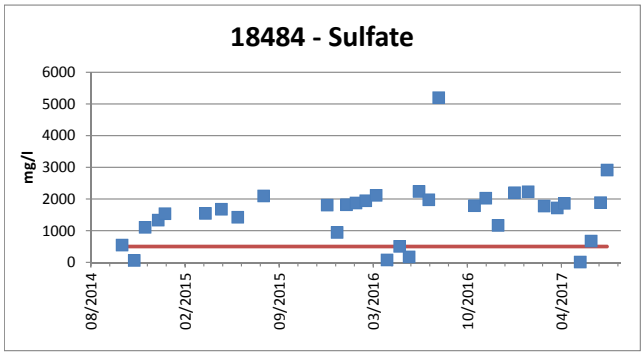
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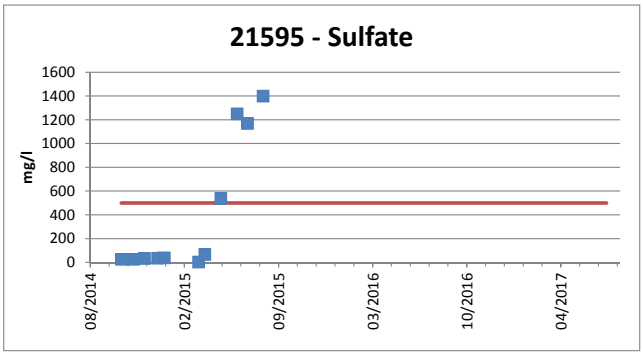
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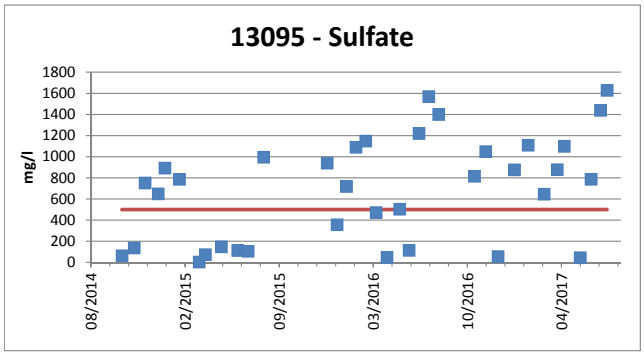
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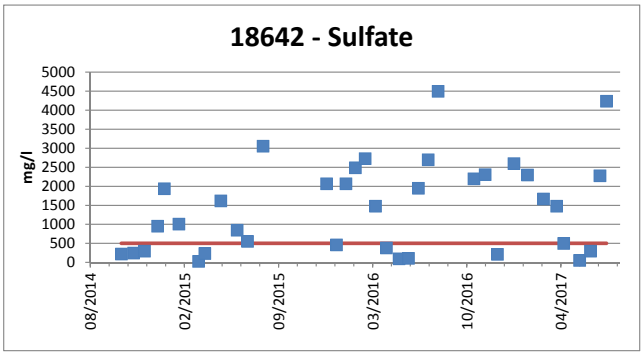
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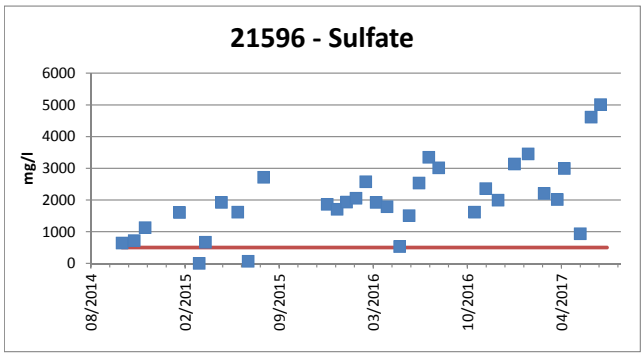
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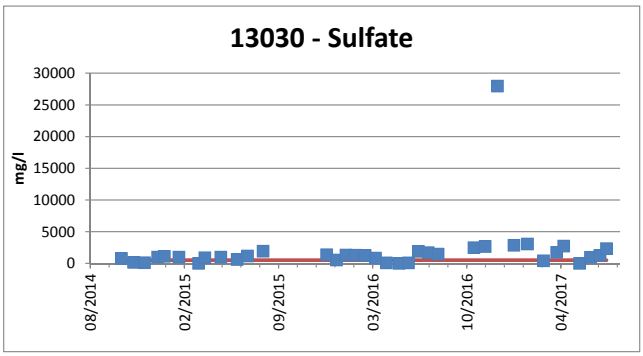
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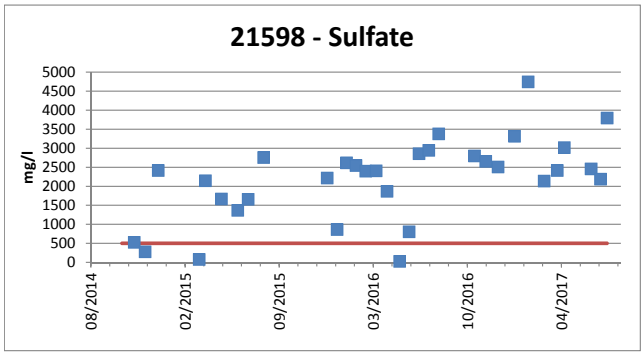
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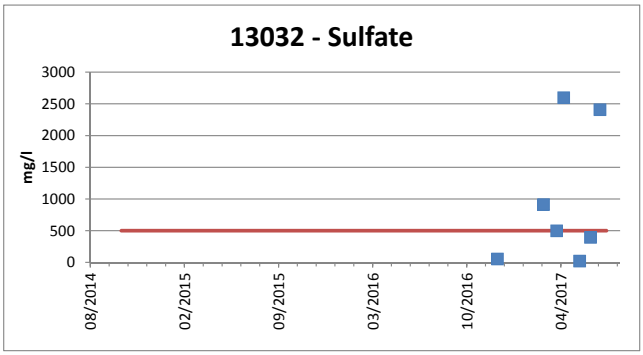
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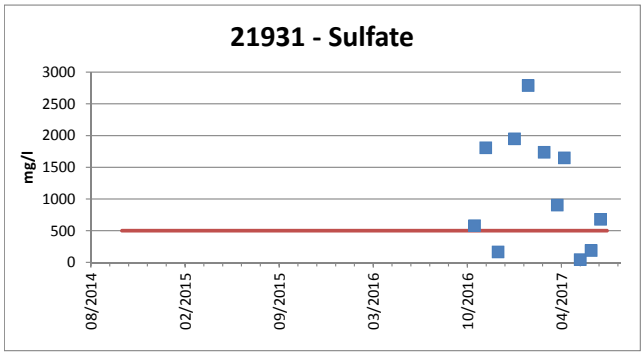
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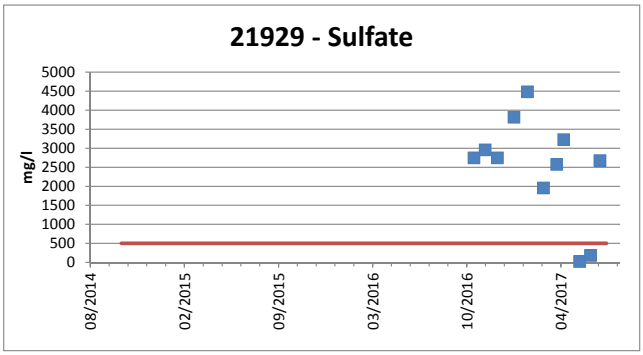
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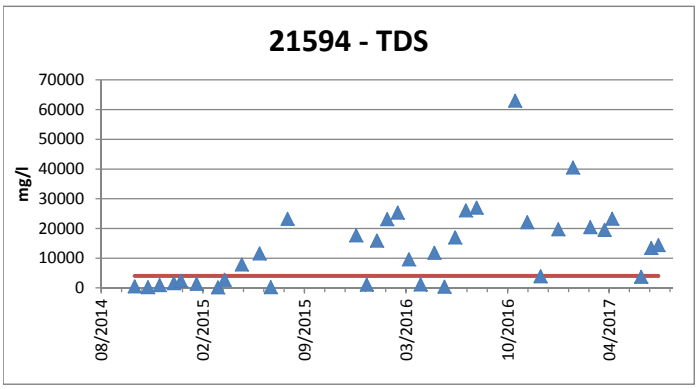
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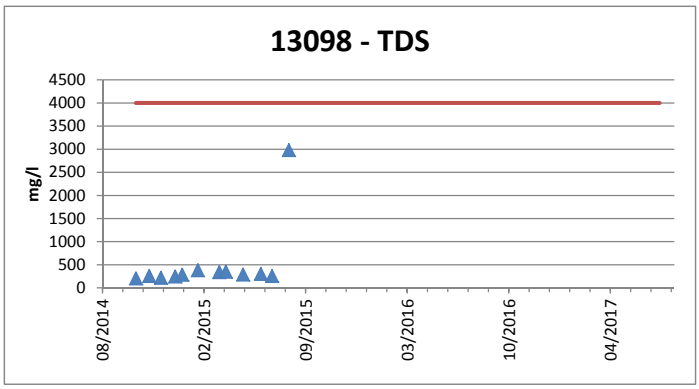
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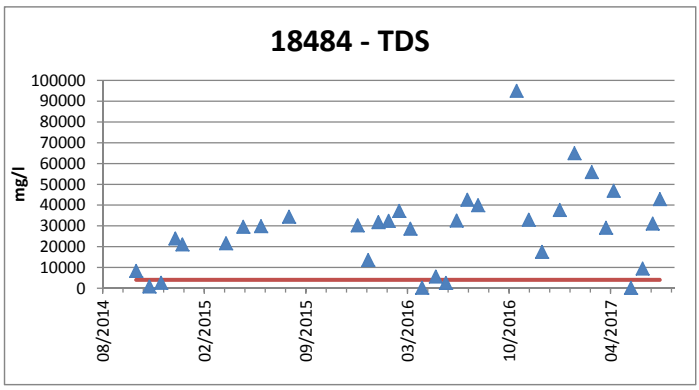
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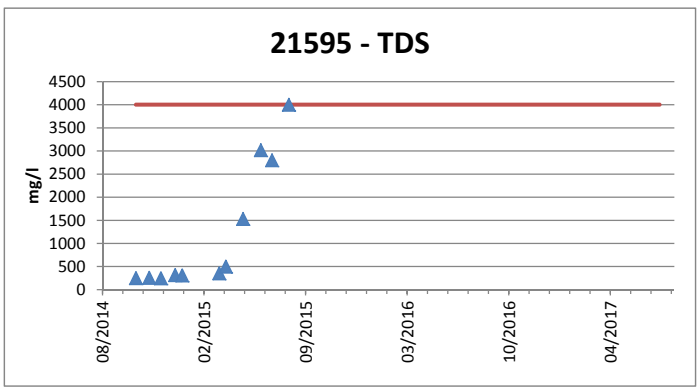
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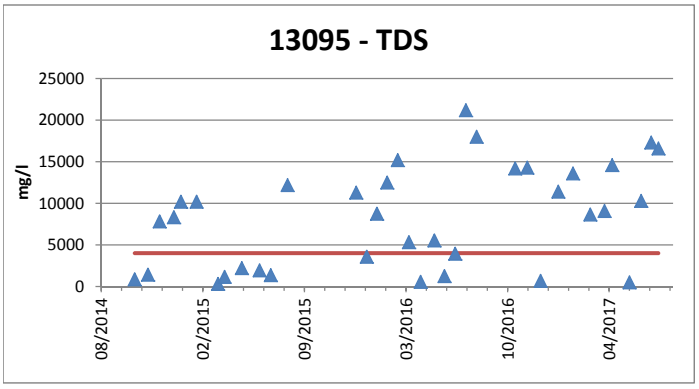
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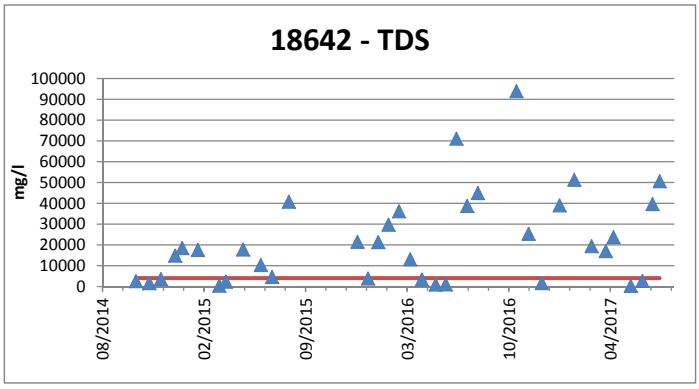
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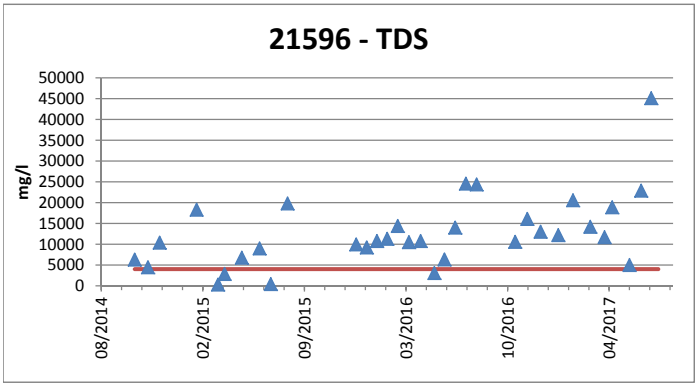
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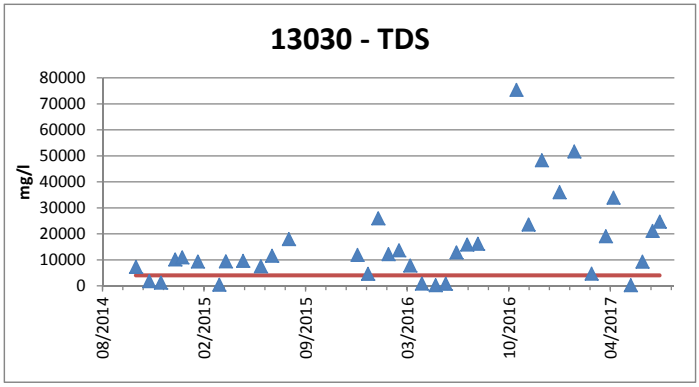
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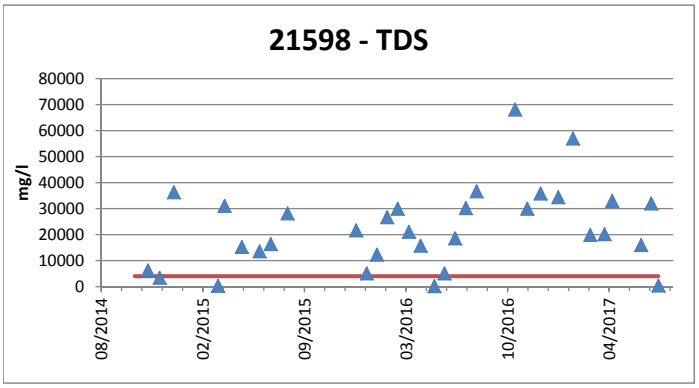
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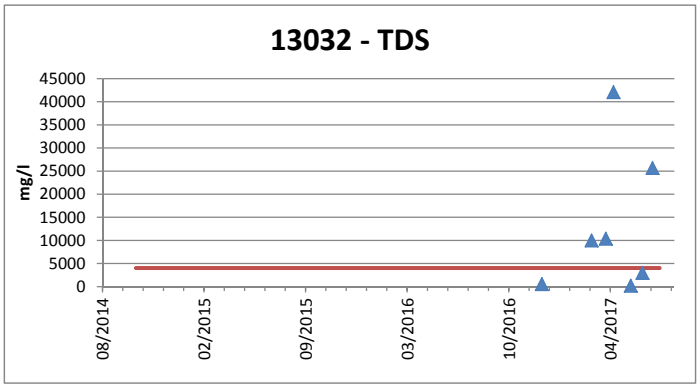
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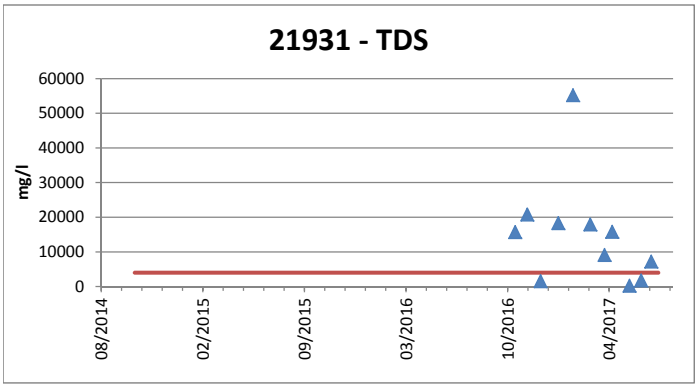
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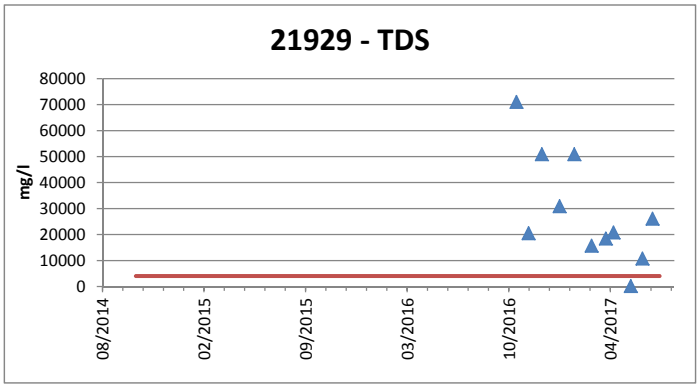
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