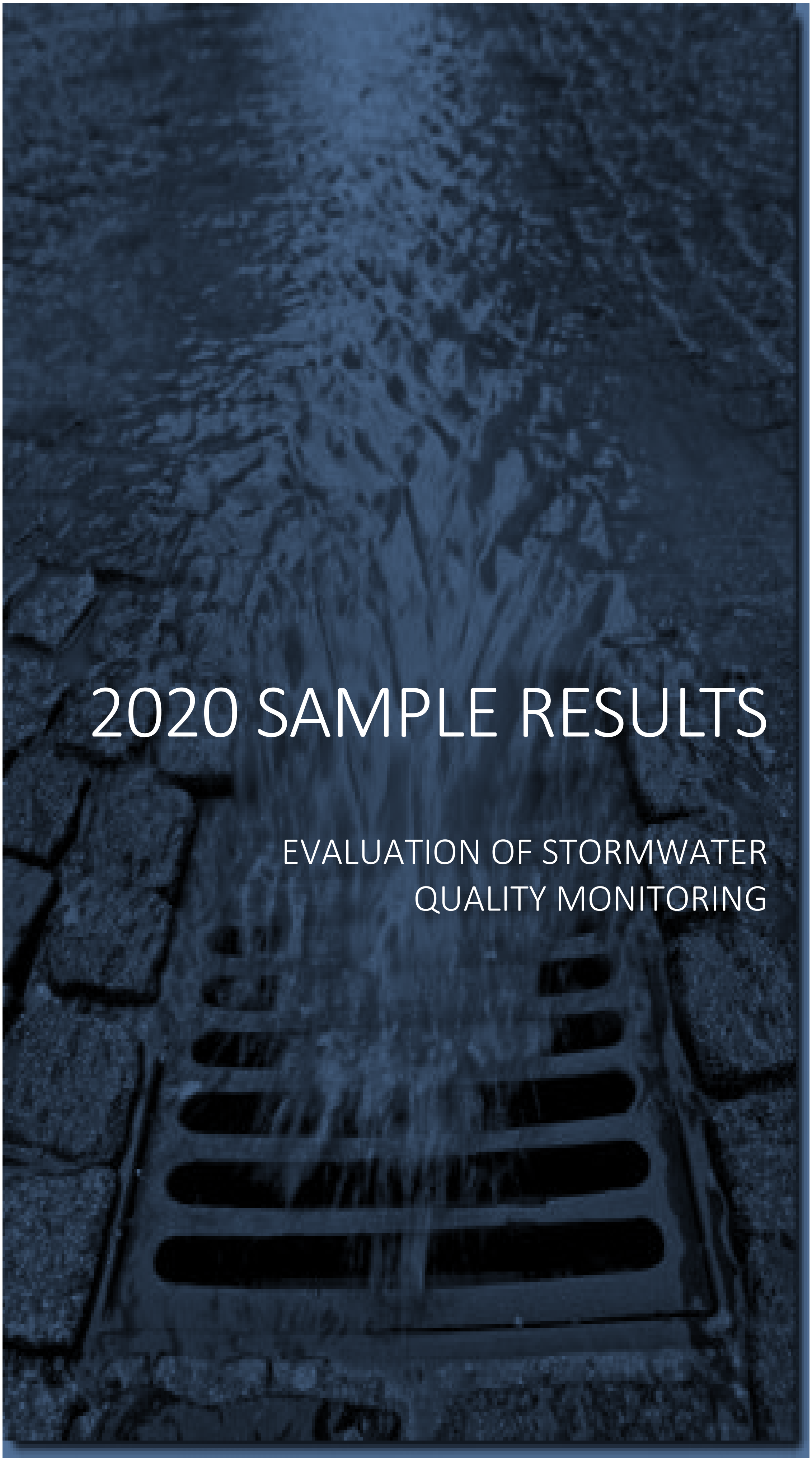

2020 SAMPLE RESULTS

EVALUATION OF STORMWATER QUALITY MONITORING

MPDES Permit
#MTR04005

CITY OF KALISPELL

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Introduction

The City of Kalispell operates its storm drainage system under the authorization of the Montana Pollution Discharge Elimination System (MPDES) General Permit for Storm Water Discharges Associated with Small Municipal Separate Storm Sewer Systems (MS4s). The current MS4 General Permit, issued by the Montana Department of Environmental Quality (MDEQ), is effective from January 1, 2017 through December 31, 2021.

Part III of the MS4 General Permit requires total maximum daily load (TMDL) related monitoring. The City has selected TMDL-related monitoring Option 2 to track and evaluate effectiveness of BMPs selected for reducing MS4 loading to impaired waterbodies.

Similarly, Part IV of the MS4 General Permit requires semi-annual monitoring (self-monitoring) that may be satisfied entirely or in part by the TMDL-related monitoring required under Part III. The City has selected self-monitoring Option 2 (see Part IV of the MS4 General Permit).

Stormwater grab samples are collected four times a year for TMDL-related monitoring and two times a year for self-monitoring. Note: three of the five sample locations are the same between the different sampling protocols. Annually, a total of 18 individual site samples are collected ((5 sites for TMDL and self-monitoring X 2x/year) + (4 sites for only TMDL monitoring 2x/year)).

Self-monitoring is completed at four stormwater discharge locations within the City of Kalispell. The sample locations were chosen to represent stormwater runoff (1) from a primarily commercial/industrial area, (1) from a primarily residential area, (1) from a large drainage area combining both commercial and residential areas, and (1) upstream, outside the MS4 boundary to evaluate water quality entering the MS4 (Table 1).

Table 1. Self-Monitoring Sample Locations

Name	Watershed	Receiving Waterbody	Location	Drainage Area (Acres)	Frequency	Sample Parameter(s)
001	SWR-4	Stillwater River	48°11'40.14"N 114°17'55.76"W	268	Semi-annual[1]	▪ Total Suspended Solids ▪ Chemical Oxygen Demand ▪ Total Phosphorus ▪ Total Nitrogen ▪ pH ▪ Copper ▪ Lead ▪ Zinc ▪ Estimated Flow ▪ Oil and Grease
002	SWR-7	Stillwater River	48°12'26.98"N 114°18'49.81"W	96	Semi-annual[1]	
003A	AC-A	Ashley Creek	48°11'43.49"N 114°22'23.71"W	NA	Semi-annual[1]	
004	AC-11	Ashley Creek	48°11'10.01"N 114°19'17.46"W	291	Semi-annual[1]	

[1] One sample must be collected between January 1st and June 30th of each permitted calendar year and the other sample between July 1st and December 31st.

TMDL-related monitoring overlaps with self-monitoring locations at 3 sites (SWR-4/001, SWR-7/002, AC-11/004). AC-A/003A (in-stream, outside MS4 boundary) is not included in TMDL-related monitoring. One additional site is included only in TMDL-related monitoring, SWR-4/001a. Monitoring locations were selected to evaluate best management practice (BMP) effectiveness (Table 2). Sites 001a and 001 are upstream and downstream respectively of an installed water quality treatment practice. Sites 002 and 004 are drainage basins that have planned water quality treatment practices. For more details regarding TMDL-related monitoring locations, see the "Kalispell MS4 Sampling Plan for TMDL Related Monitoring".

Table 1. TMDL-Related Monitoring Sample Locations

Name	Watershed	Receiving Waterbody	Location	Drainage Area (Acres)	Number of Samples (Annually)	Sample Parameter(s) (MS4 Listed Impairments)
001	SWR-4	Stillwater River	48°11'40.14"N 114°17'55.76"W	268	4	Sediment
001a	SWR-4	Stillwater River	48°11'40.70"N 114°17'57.38"W	268	4	Sediment
002	SWR-7	Stillwater River	48°12'26.98"N 114°18'49.81"W	96	4	Sediment
004	AC-11	Ashley Creek	48°11'10.01"N 114°19'17.46"W	291	4	TP, TN, DO, Sediment, Temperature

Methods

Sample Collection

Grab samples for self- and TMDL-related monitoring were collected once in the spring (5/12/20) and once in the fall (10/12/20) of 2020. Additionally, only TMDL-related monitoring samples were collected 6/8/20 and 10/21/20. Field personnel collected samples during rainfall events that produced a measurable volume of runoff flowing past/through the monitoring locations that allowed a sample to be collected. Clean, labeled bottles provided by the laboratory, on an extension pole, were used to obtain stormwater samples. Field logs were used to document the date, time, location, personnel, weather, conditions observed, samples collected, estimated duration of the storm event, and total rainfall of the storm event.

Sample Parameters and Analytical Methods

Stormwater samples were analyzed for the parameters listed in Table 1 and Table 2. Table 3 shows the parameters and the standard analytical methods used. Montana Environmental Labs processed all the samples and uses a combination of blanks, laboratory control spikes, surrogates, and duplicates to evaluate analytical results. Chain of custody forms accompanied all samples.

Table 3. Parameters and standard analytical methods

Parameter	Analytical Method	Reporting Limit (mg/L)	Sample Container	Preservative	Holding Time (days)
Total Suspended Solids	SM 2450 D	1	1 L plastic[2]	None[2]	Analyze immediately[2]
Total Phosphorus	E365.1	0.01			
Nitrogen – Kjeldahl, total[1]	E351.2	0.2			
Nitrate & Nitrite, total[1]	E353.2 E300A	0.01			
Chemical Oxygen Demand	E410.1 E410.4	1			
Total Recoverable Copper	E200.8	0.01			
Total Recoverable Lead	E200.8	0.001			
Total Recoverable Zinc	E200.7 E200.8	0.01			
Oil and Grease	E1664A	1	1 L glass (2)	H2SO4 to pH<2 Cool to 4°C	28
Estimated Flow	NA	NA	NA	NA	Analyze onsite[3]
Dissolved Oxygen	SM 4500-OG	0.1	NA	NA	Analyze onsite[3]
Temperature	NA	0.1°C	NA	NA	Analyze onsite[3]
pH	E150.1	0.1 unit	NA	NA	Analyze onsite[3]

[1] Total Nitrogen is calculated from Nitrogen – Kjeldahl, total and Nitrate & Nitrite, total.
[2] Samples will be immediately delivered to the Montana Environmental Lab in Kalispell. The lab staff will separate the 1L samples so that each parameter can be analyzed. Preservatives will be added by the lab staff, if necessary.
[3] The City analyzes estimated flow, dissolved oxygen, temperature, and pH, onsite.

Sample Analysis

Due to new sample locations being designated in 2017 and TMDL-related sampling beginning in 2018, statistical analyses are not appropriate because of the low number of samples. For self-monitoring, the City of Kalispell is required to calculate the long-term median concentration of all known monitoring results at an individual location for each parameter in Table 1 per Part IV.A. of the MS4 General Permit issued by MDEQ.

To compare individual parameters across locations, bar charts were created representing observed sample values from 2020 compared to the long-term median. To compare parameters at one location, parameter values were standardized and graphed over time by location.

The MS4 General Permit requires self-monitoring results to be used to evaluate measures taken to improve the quality of stormwater discharges. This includes an evaluation of the results relative to the long-term median, comparisons between monitoring locations, discussion of trends and outliers compared to the long-term median, discussion of pH values outside the range of 6.0 to 9.0, and a schedule and rationale for BMPs planned to improve water quality of stormwater discharges based on monitoring results.

The "Kalispell MS4 Sampling Plan for TMDL Related Monitoring" outlines the analysis of TMDL-related monitoring samples results. Analysis is designed to evaluate BMP effectiveness. The Plan states that the discussion of results will focus on the evaluation of the effectiveness of BMPs being implemented to address pollutants of impairment within each local watershed as well as changes in water quality over time.

Self-Monitoring: Results and Discussion

Results

Sample Comparison and Median Concentration

Table 4 is a summary of the 2020 sample parameter comparisons to the long-term median concentrations for each. Long-term median concentrations are calculated from all known monitoring results for each parameter at a monitoring location. **Please note, as monitoring locations were new in 2017, median concentrations have been calculated only with samples taken since 2017 (8 total samples per site).**

Figures 1-9 depict observed and median parameter concentrations by site location. Many of the sites had higher recorded parameter values in spring than fall. Observed parameter values somewhat to notably elevated include total phosphorus in the spring at SWR-7/002 and oil and grease in the fall at SWR-4/001.

Heavy Metals
Zinc and copper were greater for all stormwater sampling locations collected in the spring (not detected at AC-A/003A, the in-stream sample). Lead was greater in in spring at SWR-7/002, greater in fall for SWR-4/001 and AC-11/004, and not detected at AC-A/003A.

Nutrients
Nutrients (total phosphorus (TP) and total nitrogen (TN)) were greater in the spring for all locations except AC-A/003A. At AC-A/003A, TP was equivalent in both samples and TN was greater in the fall.

Sediment, Chemical Oxygen Demand, pH, & Oil and Grease
Total suspended solids (TSS) was greater in the spring for all locations.

Chemical oxygen demand (COD) was greater in the spring for all locations except for AC-A/003A.

pH was greater in fall for all locations.

Oil and grease values were greater in spring at SWR-7/002, not detected in spring and fall at AC-A/003A, and greater in fall at SWR-4/002 and AC-11/004.

Table 4. 2020 Parameter Comparison

Name	Watershed	Receiving Waterbody	Type	Date	TSS (mg/L)	COD (mg/L)	TP (mg/L)	TN (mg/L)	pH	Copper (mg/L)	Lead (mg/L)	Zinc (mg/L)	Oil & Grease (mg/L)	Flow (GPM)
001	SWR-4	Stillwater River	Residential 30%, Commercial 70%	5/12/20	232	266	0.4	3.19	8.34	0.024	0.0075	0.206	2	1559.269
001	SWR-4	Stillwater River	Residential 30%, Commercial 70%	10/12/20	161	143	0.35	1.48	8.64	0.02	0.0079	0.136	5	1559.27
				Median	**128.5**	**142.5**	**0.4**	**1.63**	**8.28**	**0.016**	**0.0069**	**0.132**	**2.5**	**1,559.27**
002	SWR-7	Stillwater River	Commercial/ Industrial	5/12/20	211	234	12.7	2.44	8.47	0.031	0.0051	0.143	1	160.1938
002	SWR-7	Stillwater River	Commercial/ Industrial	10/12/20	40	97	0.17	0.86	8.52	0.01	0.0022	0.06	ND	265.49
				Median	**169.5**	**211**	**0.36**	**1.71**	**8.335**	**0.023**	**0.0056**	**0.149**	**2.5**	**212.5969**
003A	AC-A	Ashley Creek	In-stream Outside MS4 Boundary	5/12/20	7	45	0.03	0.6	8.53	ND	ND	ND	ND	10931.06
003A	AC-A	Ashley Creek	In-stream Outside MS4 Boundary	10/12/20	3	72	0.03	1.19	8.68	ND	ND	ND	ND	5866.87
				Median	**7.5**	**36.5**	**0.03**	**0.785**	**8.48**	**0**	**0**	**0**	**0**	**20,943**
004	AC-11	Ashley Creek	Residential	5/12/20	118	188	0.49	4.58	8.03	0.012	0.0042	0.093	ND	162.782
004	AC-11	Ashley Creek	Residential	10/12/20	101	128	0.43	3.2	8.54	0.011	0.005	0.092	2	163.5
				Median	**104.5**	**159**	**0.46**	**2.755**	**7.96**	**0.0115**	**0.00438**	**0.088**	**1.5**	**118.891**

ND=Not detected at the reporting limit

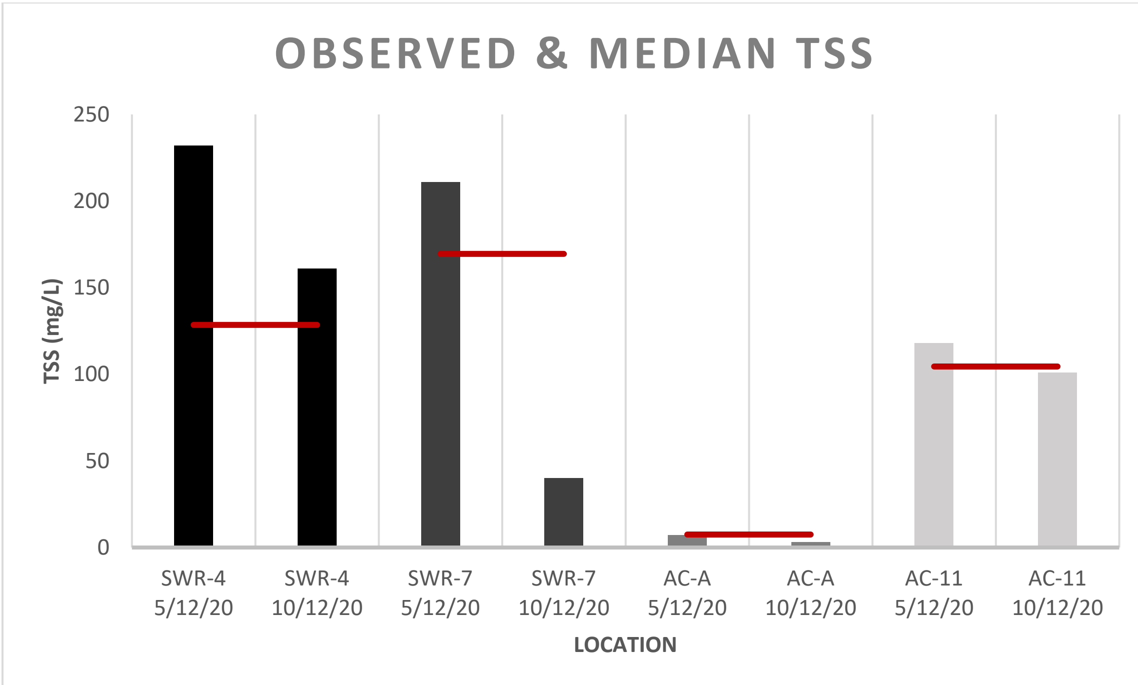

Figure 1. Observed (2020) and median (2017-2020) TSS (total suspended solids) concentrations by location. Horizontal red lines represent median concentrations.

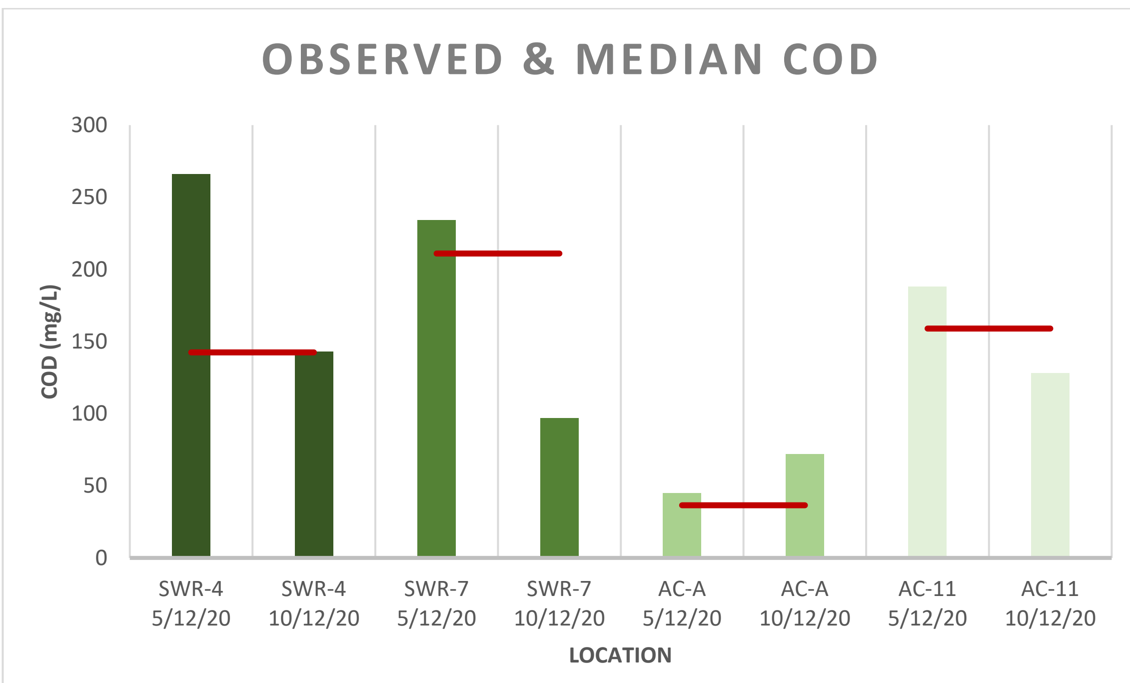

Figure 2. Observed (2020) and median (2017-2020) COD (chemical oxygen demand) concentrations by location. Horizontal red lines represent median concentrations.

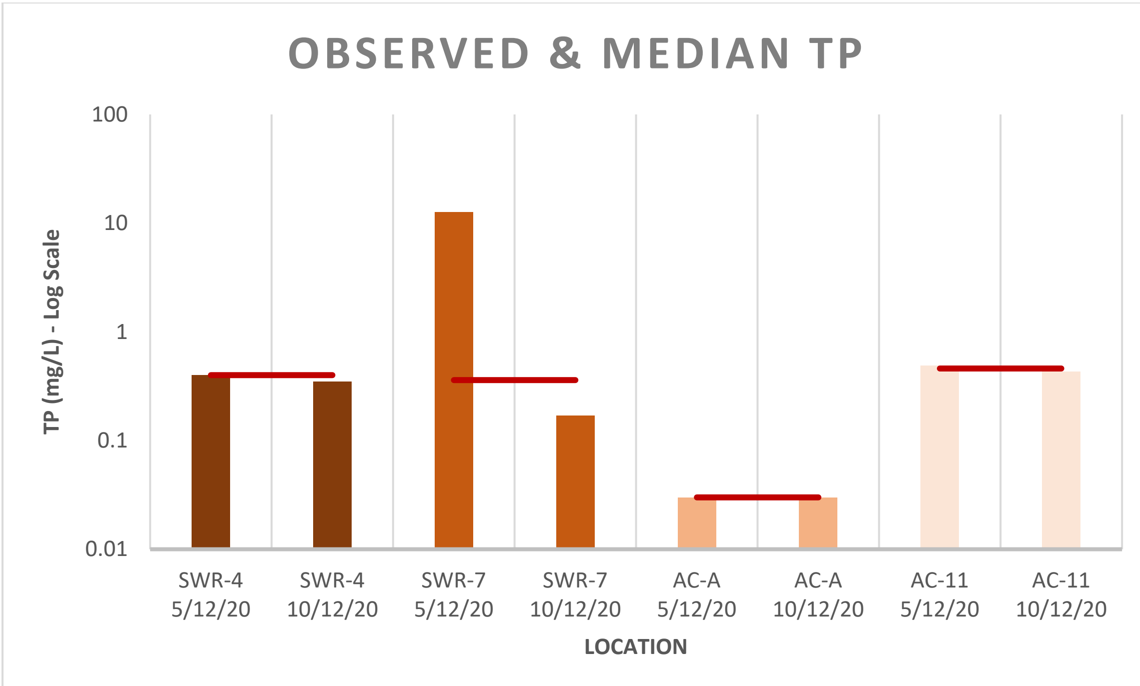

Figure 3. Observed (2020) and median (2017-2020) TP (total phosphorus) concentrations by location. Horizontal red lines represent median concentrations. Y-axis is on a log scale.

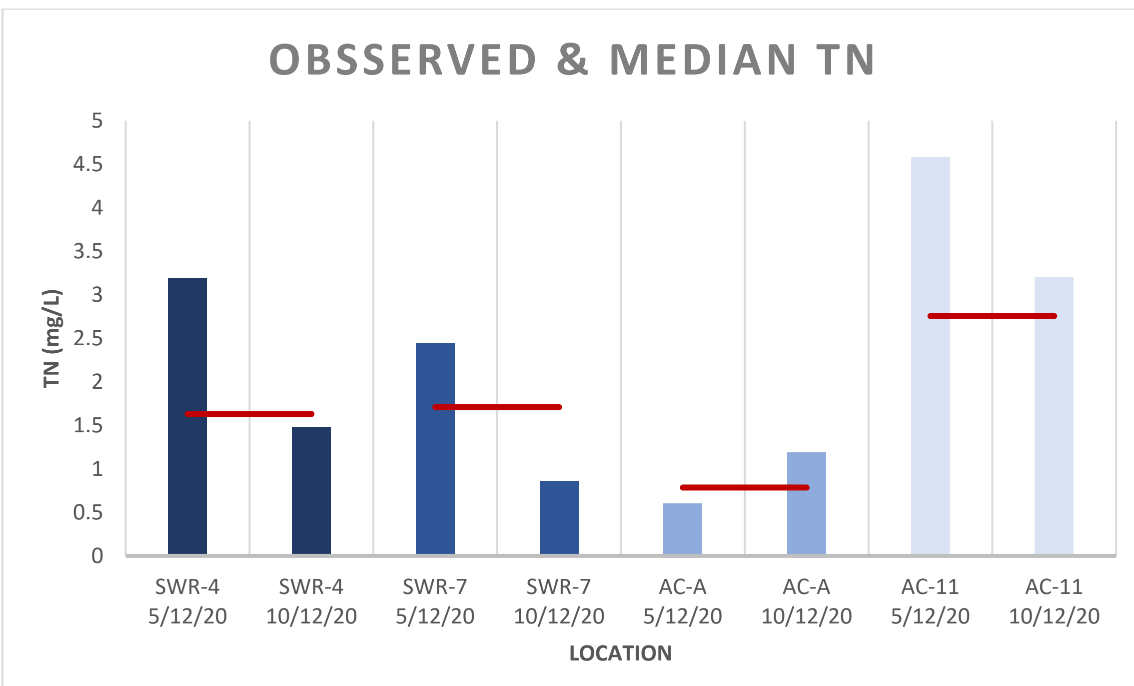

Figure 4. Observed (2020) and median (2017-2020) TN (total nitrogen) concentrations by location. Horizontal red lines represent median concentrations.

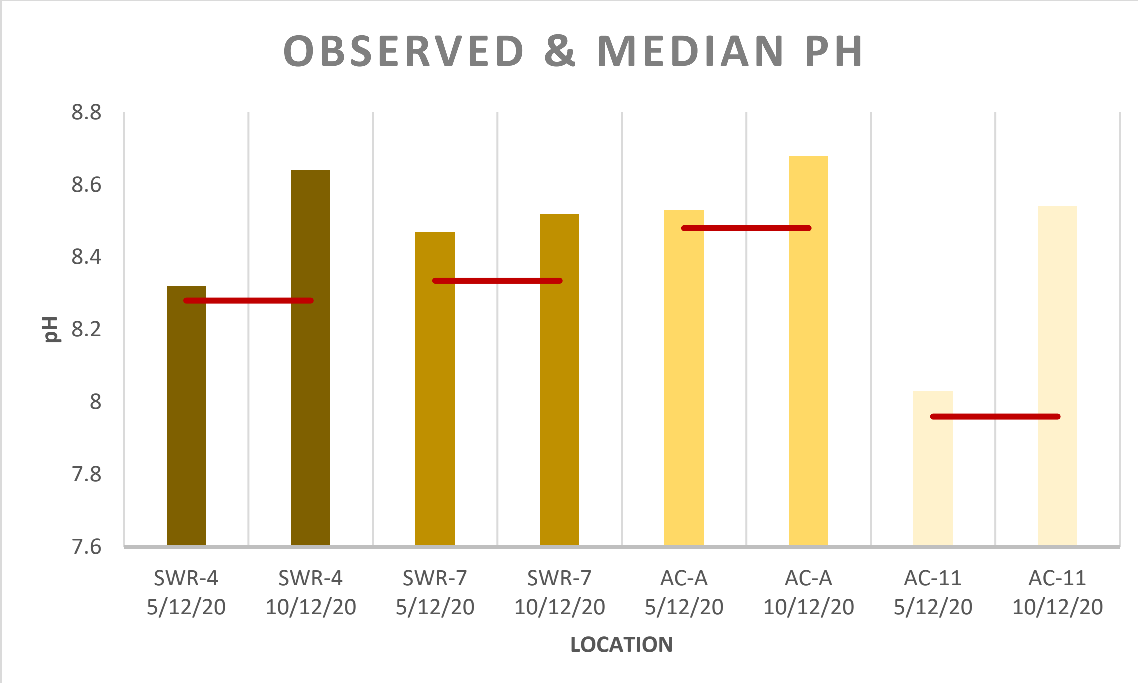

Figure 5. Observed (2020) and median (2017-2020) pH values by location. Horizontal red lines represent median concentrations.

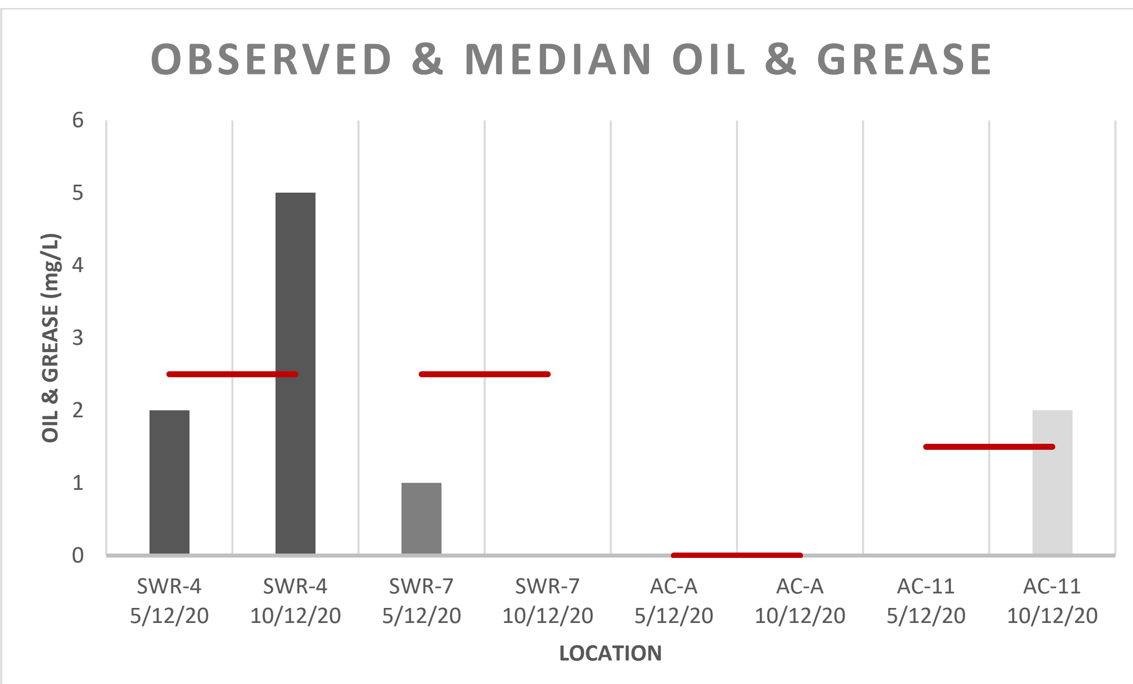

Figure 6. Observed (2020) and median (2017-2020) oil and grease concentrations by location. Horizontal red lines represent median concentrations.

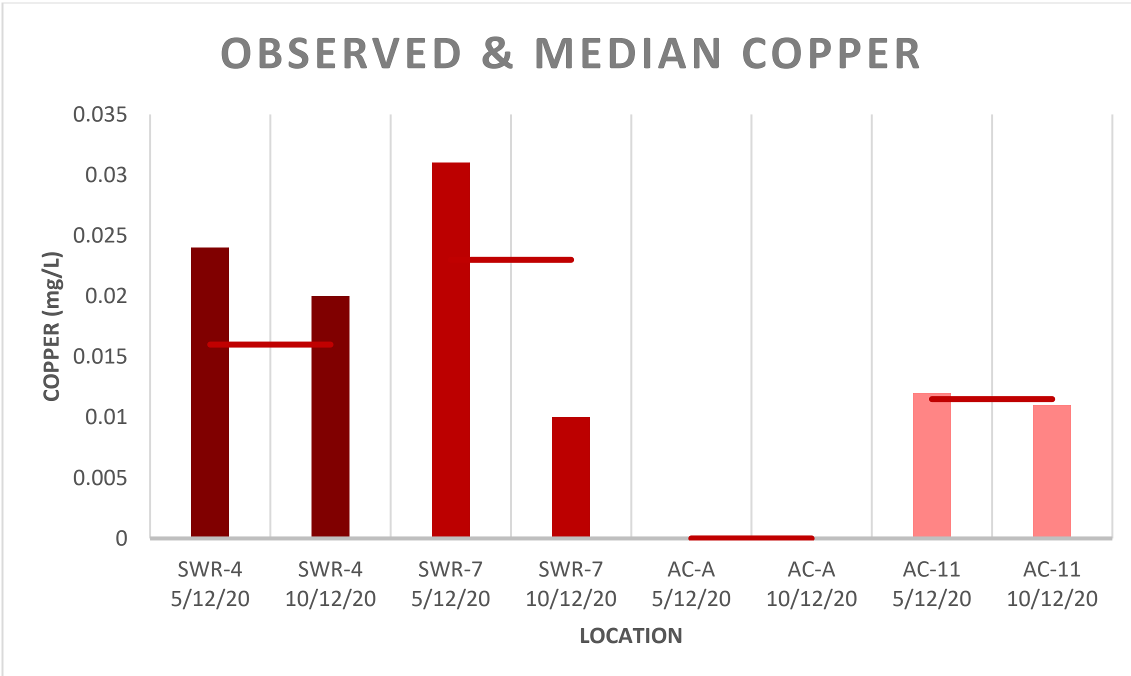

Figure 7. Observed (2020) and median (2017-2020) copper concentrations by location. Horizontal red lines represent median concentrations.

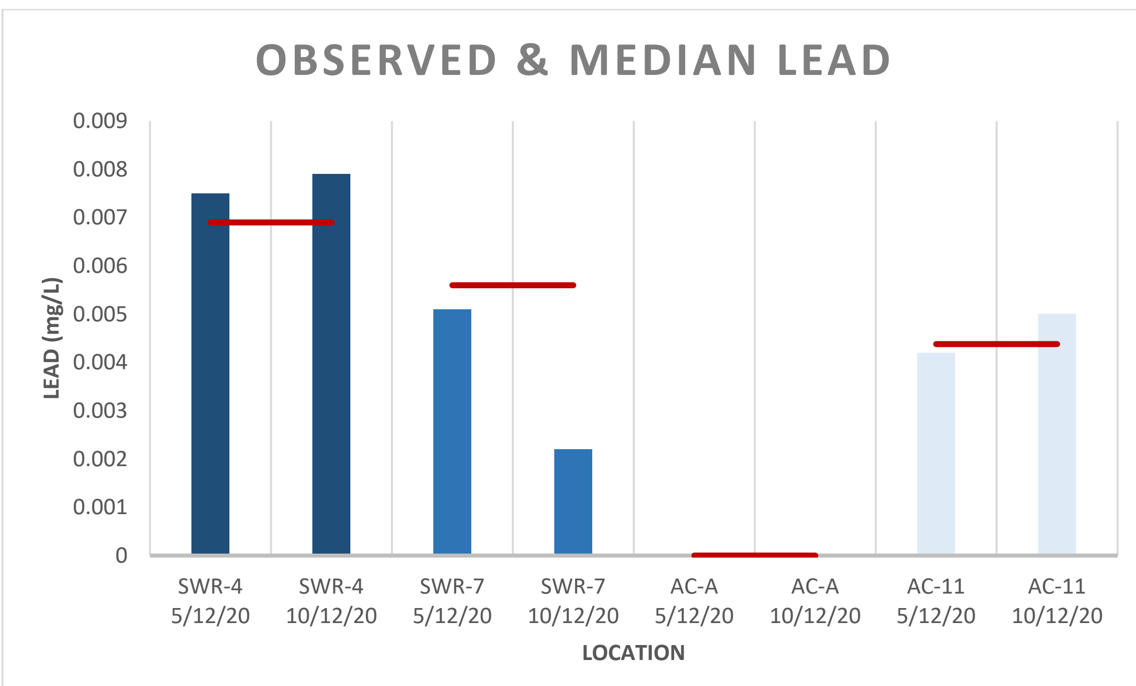

Figure 8. Observed (2020) and median (2017-2020) lead concentrations by location. Horizontal red lines represent median concentrations.

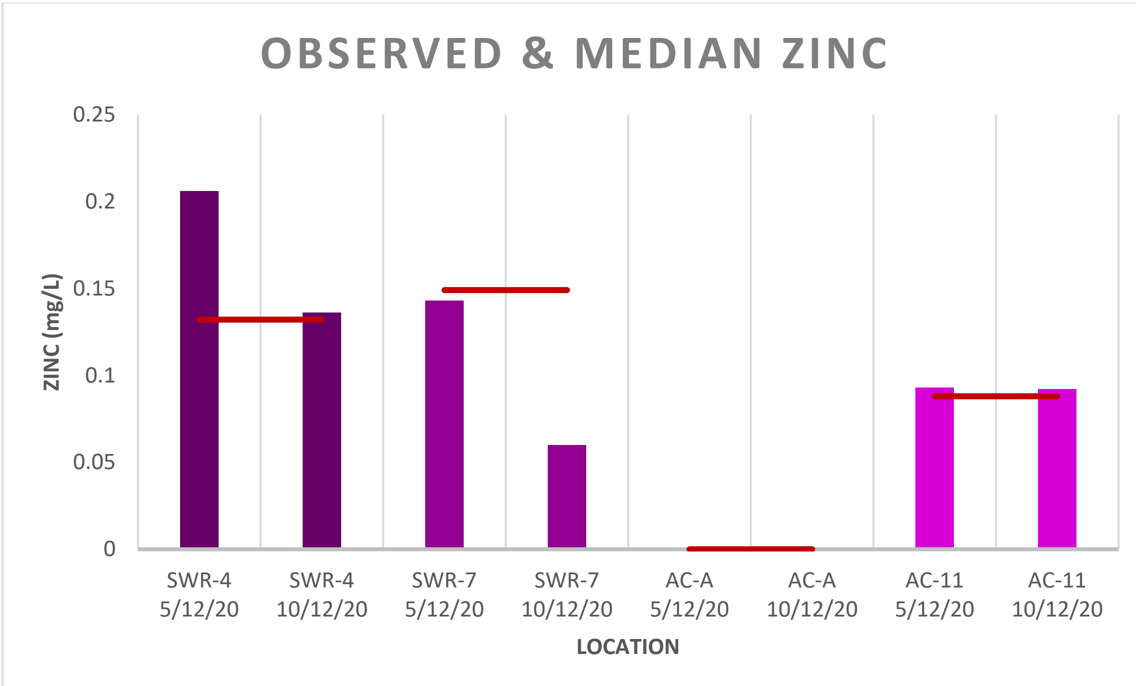

Figure 9. Observed (2020) and median (2017-2020) zinc concentrations by location. Horizontal red lines represent median concentrations.

Standardized Parameter Concentrations by Location

Figures 10-13 compare sample parameters at one site over time. Parameters have been standardized to make the variables comparable.

At most locations, many parameters co-vary together. Stormwater sample locations (SWR-4/001, SWR-7/002, AC-11/004) appear to generally have elevated values in spring and lower values in fall. The parameter values at the in-stream location (AC-A/003), typically, do not fluctuate as much as the stormwater samples.

The elevated TSS and oil and grease at SWR-4/001 in April 2018 appear to strongly co-vary, while the elevated TP at AC-11/004 in April 2018 and at SWR-7/002 in May 2020 does not strongly co-vary with any other parameters.

Standardized parameters in 2019 did not see as large of fluctuations as 2018. In 2020, fluctuations of the standardized parameters were generally small, however a few parameters were elevated during spring sampling.

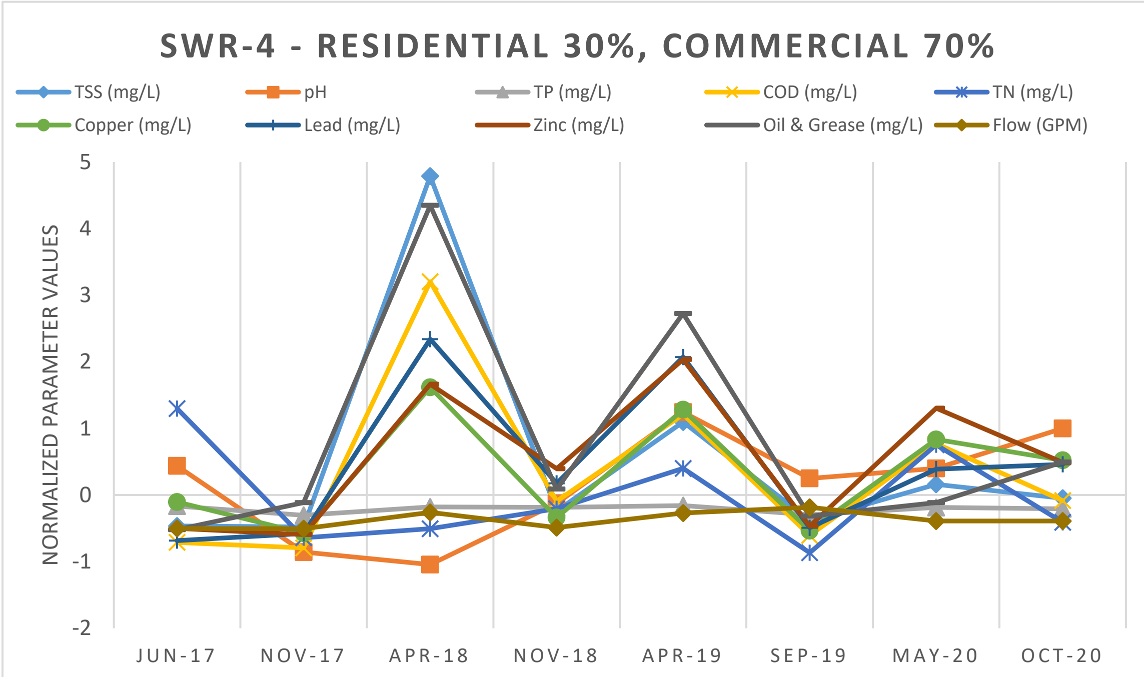

Figure 10. Standardized parameter values over time at SWR-4/001.

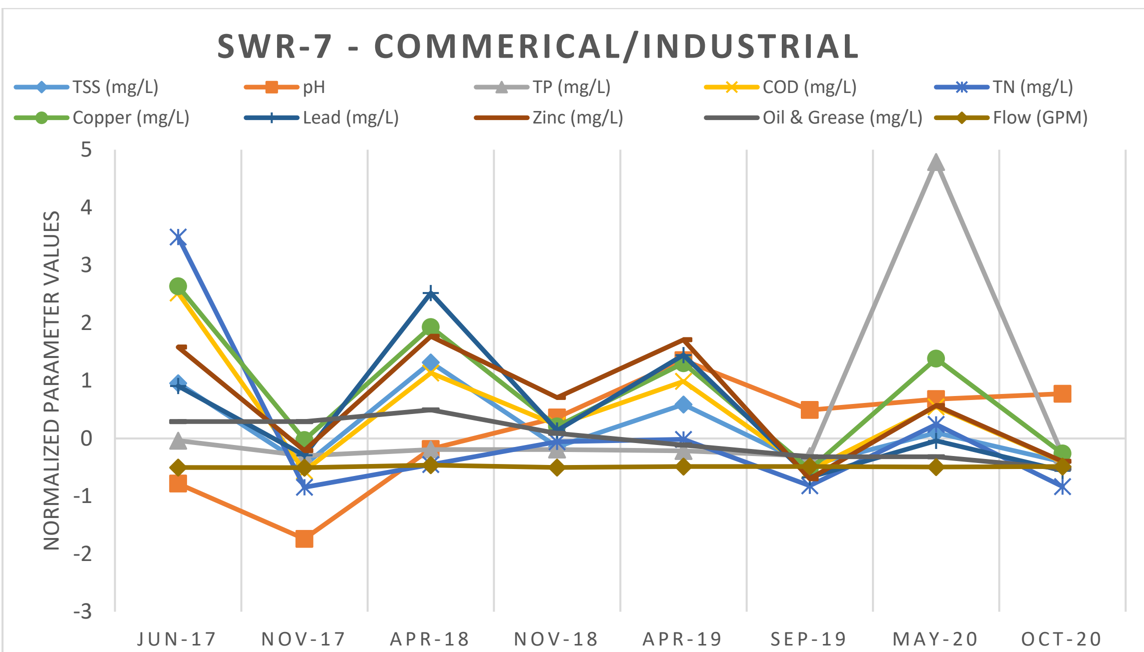

Figure 11. Standardized parameter values over time at SWR-7/002.

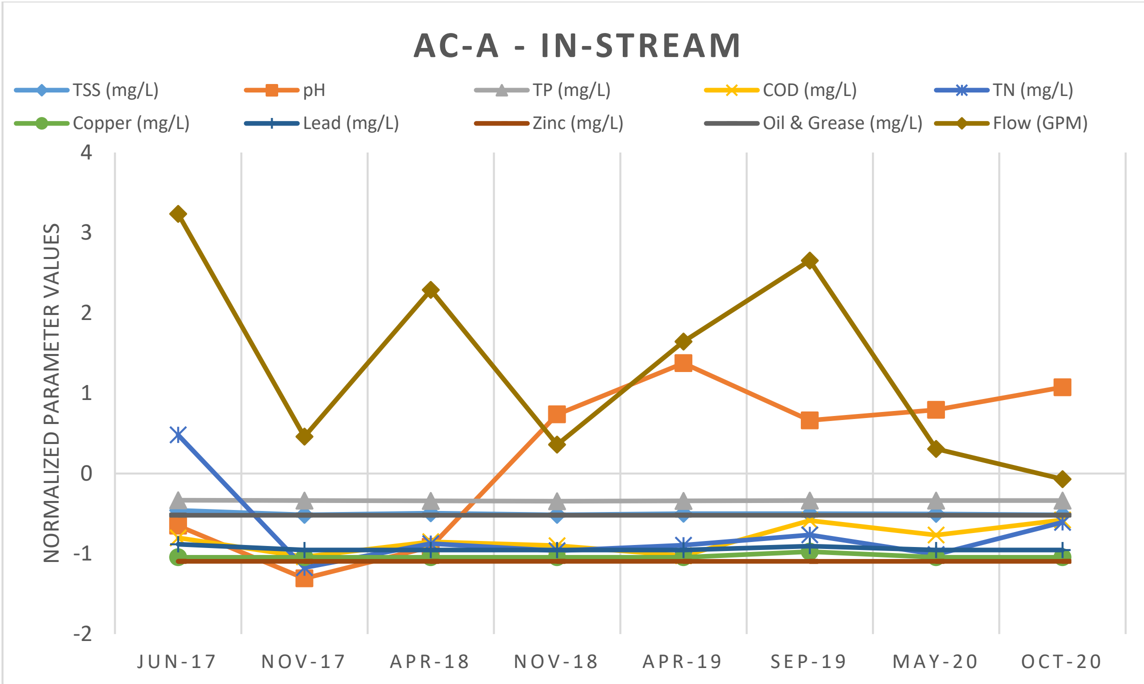

Figure 12. Standardized parameter values over time at AC-A/003 (2017-2018) and AC-A/003A (2019-Present).

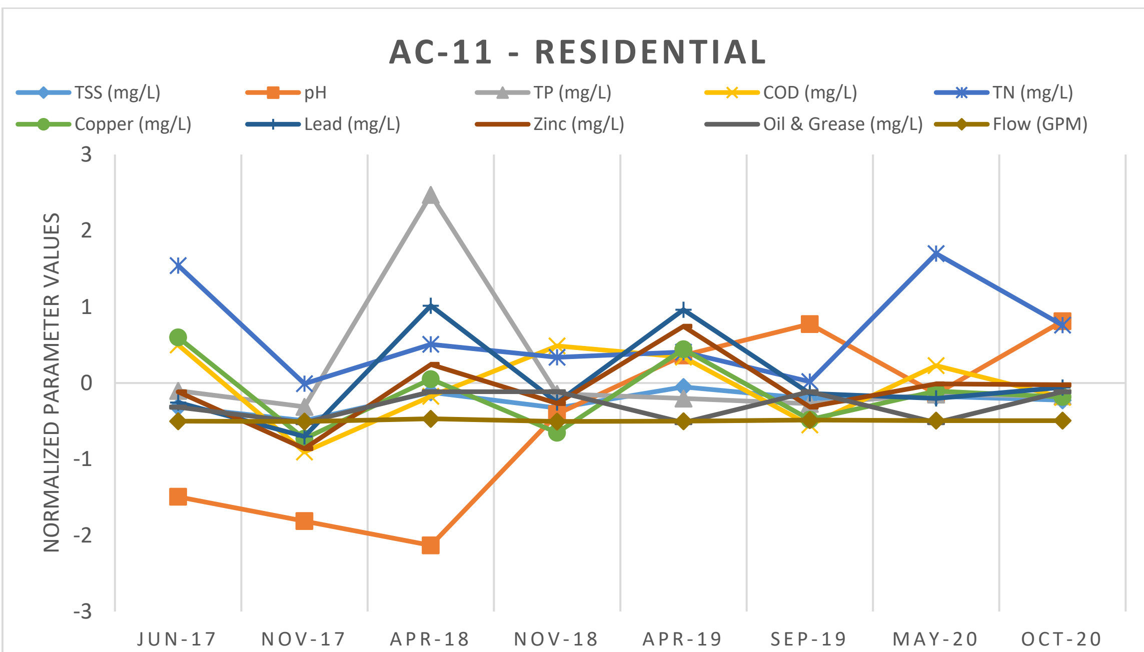

Figure 13. Standardized parameter values over time at AC-11/004.

Discussion: Trends, Outliers, and BMPs

The following analysis reviews the 2020 parameter trends and outliers compared to the calculated long-term median and examines results outside a pH range of 6.0 to 9.0 standard units. Additionally, explained is a schedule and rationale for BMPs planned to improve the water quality of stormwater discharges based on monitoring results.

Sampling Conditions

Spring samples were collected in May 2020. The winter leading up to this sample collection was mild, which lead to infrequent sanding and salt application. The parameter concentrations in the spring 2020 samples were generally lower than pervious year's spring samples.

Fall samples were collected in October 2020. Prior to sample collection, the summer was dry with very few rain events. The October event began with steady rain during the night which then let up in the morning. Periodic, short rain events continued through midday. Samples were collected near the beginning of the workday once the rain began again.

Spring samples generally had higher concentrations of all parameters. This same pattern was observed in the 2017 – 2019 sample results. This may be indicative of winter loading of contaminants. Additional measures to try to reduce spring runoff may be beneficial. Future sampling will help clarify trends and what BMPs will be most beneficial to minimize pollutant discharge.

Stillwater River

Two locations drain into the Stillwater River, which is listed as impaired for sediment. Location SWR-4/001 is characterized as mixed residential (30%) and commercial (70%) and location SWR-7/002 is characterized as commercial/industrial.

Mixed Residential (30%) and Commercial (70%) Location

Sample location SWR-4/001 drains about 266 acres and typically has elevated total suspended solids and chemical oxygen demand in the spring. However, the 2020 samples had lower pollutant concentrations than the notable highs seen in spring 2018.

In 2018, due to the elevated TSS and oil and grease, the surrounding storm system was inspected and cleaned. This sample location is downstream from two mechanical treatment units. Both treatment units were cleaned along with upstream manholes and sumps (if needed). A roll of Ram-Nek/manhole mastic was found in a manhole sump upstream and was removed. This could have contributed to higher oil and grease and COD readings in spring 2018.

The cleaning schedule of the two treatment units was updated to twice a year in 2018 and the biannual schedule has been maintained. After the wide-scale cleaning in 2018, TSS, oil and grease, and COD levels dropped during the next sampling event and have continued to stay below the spring 2018 levels.

Commercial/Industrial Location

The drainage area of SWR-7/002 is approximately 100 acres and is comprised mostly of commercial/industrial land use including highway managed by Montana Department of Transportation. At sample location SWR-7/002, from 2018 – 2020, the median of most parameters (excluding TP, TN, lead, and pH) was higher than other locations. Activities in industrial areas and highways, including material handling and storage, equipment maintenance and cleaning, and others, are often exposed to weather and may introduce pollutants into stormwater.

Total suspended solids and chemical oxygen demand readings were elevated, though not as high as SWR-4/001. In spring 2020, TP was notably high. All parameters will be monitored to try and further understand sources. Future sampling may help clarify trends and outliers at this location and what management practices will provide a reduction of the pollutant loads.

The City's Capital Improvement Program has a stormwater quality treatment facility planned for fiscal year 2021 to try to reduce the MS4's discharge of sediment to the Stillwater River. Samples collected prior to implementation may provide information on BMP effectiveness in a commercial/industrial location and help plan future BMPs in other commercial/industrial areas.

Ashley Creek

Two locations drain into Ashley Creek, which is listed as impaired for phosphorus, nitrogen, dissolved oxygen, sediment, and temperature. Location AC-A/003A is characterized as being in-stream and outside the MS4 boundary and AC-11/004 is characterized as residential.

In-Stream Outside MS4 Boundary Location

Sample location AC-A/003A did not have notable trends or outliers in monitoring results compared to the calculated long-term median. The in-stream sample results provide background readings of the pollutants in-stream during comparable rain events.

Residential Location

The drainage area of AC-11/004 is approximately 300 acres, comprised mostly of residential land use.

Sample location AC-11/004 results showed moderate levels of total suspended sediment, chemical oxygen demand, and total phosphorus. In 2018, total phosphorus was significantly elevated in the spring sample but was comparable to other sites in future samples. In 2017 and 2020, total nitrogen was slightly elevated in spring. Future sampling may help clarify trends and outliers at this location and what management practices will provide a reduction of the pollutant loads.

The City's Capital Improvement Program has a stormwater quality treatment facility planned for fiscal year 2023 to try to reduce the MS4's discharge of pollutants to Ashley Creek. Samples collected prior to implementation may provide information on BMP effectiveness in a residential location and help plan future BMPs in other residential areas.

Identified Pollutants

Several pollutants were identified as elevated through this evaluation (TP and oil and grease). As such, this section provides a schedule and rationale of BMPs planned to improve the water quality of the stormwater discharges from various pollutants.

Chemical Oxygen Demand (COD)

Potential Sources

Natural:

- Leaves and woody debris
- Dead plants and animals
- Animal manure

Industrial:

- Oils and grease from transportation and industrial/commercial site activities
- Benzene from gasoline
- Synthetic detergents
- Pesticides
- Herbicides
- Wood preservatives
- Synthetic organic industrial chemicals

Residential:

- Grass clippings and leaves
- Animal waste
- Failing septic systems
- Sugar-containing substances (milk, molasses, juice, vegetables, energy drinks, etc.)

Management Measures and BMPs

Table 5 outlines the potential sources, reasons, and management measures the City has or will implement for the MPDES MS4 permit. Dry weather screening will continue to be utilized to aid in identifying sources of chemical oxygen demand. Additionally, two locations have a planned stormwater quality treatment facility in the City's Capital Improvement Program.

Table 5. COD Evaluation

Potential Sources	Reasons	*Minimum Measure	BMP	Date(s) Implemented
Organic material i.e. leaves, grass clippings	Fallen Leaves Landscaping Pre-Winter Maintenance	1	Public Education Program	2015-Current
		6	Implement Pollution Prevention Good Housekeeping Guidance Manual for Kalispell Municipal Operations. Provide training to City employees.	2015-Current
			Street Sweeping Program	2015-Current
			Leaf Collection Program	2015-Current
			Storm Drainage System Inspection and Cleaning	2015-Current
			Residential Curbside Pickup Services	2013-Current

* Minimum Measures 1) Public education and outreach on stormwater impacts; 2) Public involvement/participation; 3) Illicit discharge detection and elimination; 4) Construction site stormwater runoff control; 5) Post-construction stormwater management in new development and redevelopment; and, 6) Pollution prevention and good housekeeping for municipal operations.

Total Suspended Solids (TSS)

Potential Sources

Natural:

- Erosion

Industrial:

- Land development
- Roadway material deterioration
- Road salt and sand
- Road paint
- Industrial/commercial site activities
- Gravel parking areas

Residential:

- Land development
- Road salt and sand
- Road paint
- Roadway material deterioration

Management Measures and BMPs

Table 6 outlines the potential sources, reasons, and management measures the City has implemented or will implement for the MPDES MS4 General Permit. Additionally, two locations have a planned stormwater quality treatment facility in the City's Capital Improvement Program.

Table 6. TSS Evaluation

Potential Sources	Reasons	*Minimum Measure	BMP	Date(s) Implemented
Construction Site Runoff	Subdivision Development Residential House Construction Municipal Operations Commercial Development	4	Ordinance 1831: Stormwater Regulations. Requires Construction Stormwater Permits for all land disturbance within City limits.	2015-Current
			Provide training for builders, engineers, and developers.	2015-Current
		1	Public Education Program	2015-Current
			Public Education Program 2010 Update to include commercial education.	2010-Current
		6	Implement Pollution Prevention Good Housekeeping Guidance Manual for Kalispell Municipal Operations. Provide training to City employees.	2015-Current
Sand on Roads	Winter condition road sanding	6	Implement Pollution Prevention Good Housekeeping Guidance Manual for Kalispell Municipal Operations. Provide training to City employees.	2015-Current
			Street Sweeping	2015-Current
			Storm Drainage System Inspection & Cleaning	2015-Current
Industrial and Commercial Sites	Generation of solid material from industrial and commercial site activities Dirt/gravel driveways and parking areas	1	Public Education Program	2015-Current
		3	Illicit Discharge, Detection, and Elimination Program	2015-Current
		5	Redevelopment standards implemented through Kalispell Design and Construction Standards	2015-Current
Residential	Yard Waste Management Native Landscaping Better Car and Equipment Washing	1	Public Education Program	2018-Current
		6	Residential Curbside Pickup Services	2013-Current
Commercial Landscaping	Yard Waste Management	1	Public Education Program	2018-Current

* Minimum Measures 1) Public education and outreach on stormwater impacts; 2) Public involvement/participation; 3) Illicit discharge detection and elimination; 4) Construction site stormwater runoff control; 5) Post-construction stormwater management in new development and redevelopment; and, 6) Pollution prevention and good housekeeping for municipal operations.

Oil and Grease

<u>Potential Sources</u>

Natural:

- Petroleum

Industrial:

- Automotive oils

Residential:

- Automotive oils
- Cooking oils

<u>Management Measures and BMPs</u>

Table 7 outlines the potential sources, reasons, and management measures the City has implemented or will implement for the MPDES MS General Permit. Additionally, two locations have a planned stormwater quality treatment facility in the City's Capital Improvement Program.

Table 7. Oil and Grease Evaluation

Potential Sources	Reasons	*Minimum Measure	BMP	Date(s) Implemented
Industrial Site Activities	Common industrial and commercial site activities	1	Public Education Program	2007-Current
			Public Education Program 2010 Update to include commercial education	2010-Current
		3	Illicit Discharge, Detection, and Elimination Program	2008-Current
Restaurants	Common restaurant activities	1	Public Education Program	2013-Current
Residential	Car Maintenance	1	Public Education Program	2018-Current
Mobile Cleaning Business	Common mobile cleaning activities (i.e. pressure washing)	1	Public Education Program	2018-Current
Gas Stations	Common gas station activities	1	Public Education Program	2018-Current

* Minimum Measures 1) Public education and outreach on stormwater impacts; 2) Public involvement/participation; 3) Illicit discharge detection and elimination; 4) Construction site stormwater runoff control; 5) Post-construction stormwater management in new development and redevelopment; and, 6) Pollution prevention and good housekeeping for municipal operations.

Total Phosphorous

Potential Sources

Natural:

- Soil and rocks
- Plant and leaf litter

Industrial:

- Fertilizers
- Wastewater Treatment Plant discharges
- Livestock and farm animals
- Commercial cleaning preparations
- Road salt

Residential:

- Fertilizers
- Failing septic systems
- Pet waste
- Disturbed land areas
- Road salt
- Plant and leaf litter

Management Measures and BMPs

Table 8 outlines the potential sources, reasons, and management measures the City has implemented or will implement for the MPDES MS General Permit. Additionally, two locations have a planned stormwater quality treatment facility in the City's Capital Improvement Program.

Table 8. Total Phosphorous Evaluation

Potential Sources	Reasons	*Minimum Measure	BMP	Date(s) Implemented
Fertilizer	Fall fertilizing of residential yards and commercial landscape area Fertilization storage, handling, and application	1	Public Education Program	2007-Current
Organic material i.e. leaves, grass clippings	Fallen leaves Landscaping Pre-Winter Maintenance Yard Waste Management	6	Street Sweeping Program	2011-Current
			Leaf Collection Program	2011-Current
			Storm Drainage System Inspection and Cleaning	2012-Current
			Review and update City Operational and Maintenance Activities as necessary. Provide training to City employees.	2007-Current
			Residential Curbside Pickup Services	2013-Current
Litter and animal waste	Pet waste	1	Public Education Program	2007-Current

* Minimum Measures 1) Public education and outreach on stormwater impacts; 2) Public involvement/participation; 3) Illicit discharge detection and elimination; 4) Construction site stormwater runoff control; 5) Post-construction stormwater management in new development and redevelopment; and, 6) Pollution prevention and good housekeeping for municipal operations.

TMDL-Related Monitoring: Results and Discussion

Results

Stillwater River

SWR-7/001 and 001a

At SWR-7/001 and 001a, the objective is to compare influent and effluent data for the Downstream Defender® hydrodynamic separator (installed August 2016). These sites ultimately drain to the Stillwater River, which is listed as impaired for sediment. Therefore, TSS is the pollutant of focus for TMDL-related monitoring. Sample sites are immediately upstream (001a) and downstream (001) of the hydrodynamic separator in order to evaluate its effectiveness at removing sediment from MS4 wet weather discharges.

BMP effectiveness was quantified by calculating percent change in pollutant concentration between influent (pre-treatment) and effluent (post-treatment). Figure 14 displays percent change from grab samples on each sample date. Only two rain events (11/17/19, 10/12/20) have had a positive percent change where effluent had lower TSS than influent. All other samples had greater TSS post-treatment than pre-treatment.

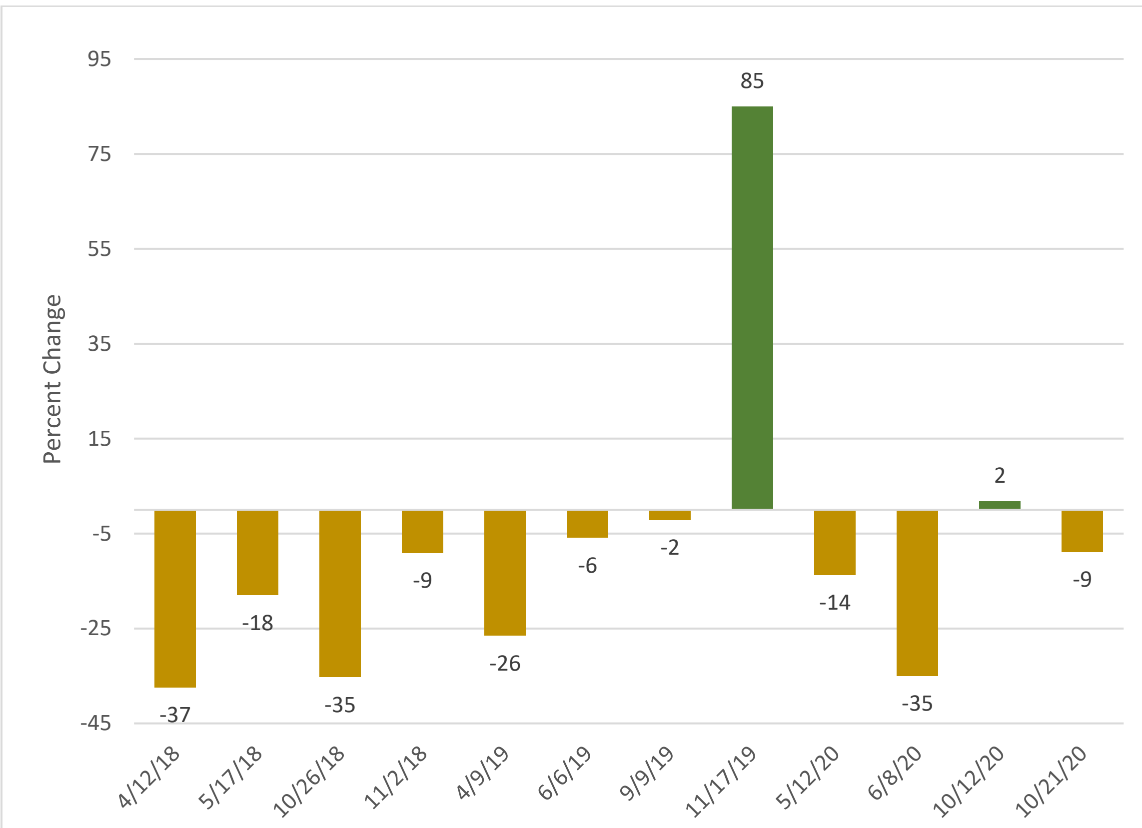

Figure 14. Percent change in TSS concentration between influent and effluent

Figure 15 displays the same sampling dates but visually depicts actual TSS concentrations pre-treatment (SWR-4/001a) and post-treatment (SWR-4/001). Many of the samples collected on the same data had similar TSS concentrations.

When looking at sample date 11/17/19 in both Figures 14 and 15, there was an 85% reduction in TSS post-treatment however, while the percent change was large the actual TSS concentrations were quite low compared to other sample dates.

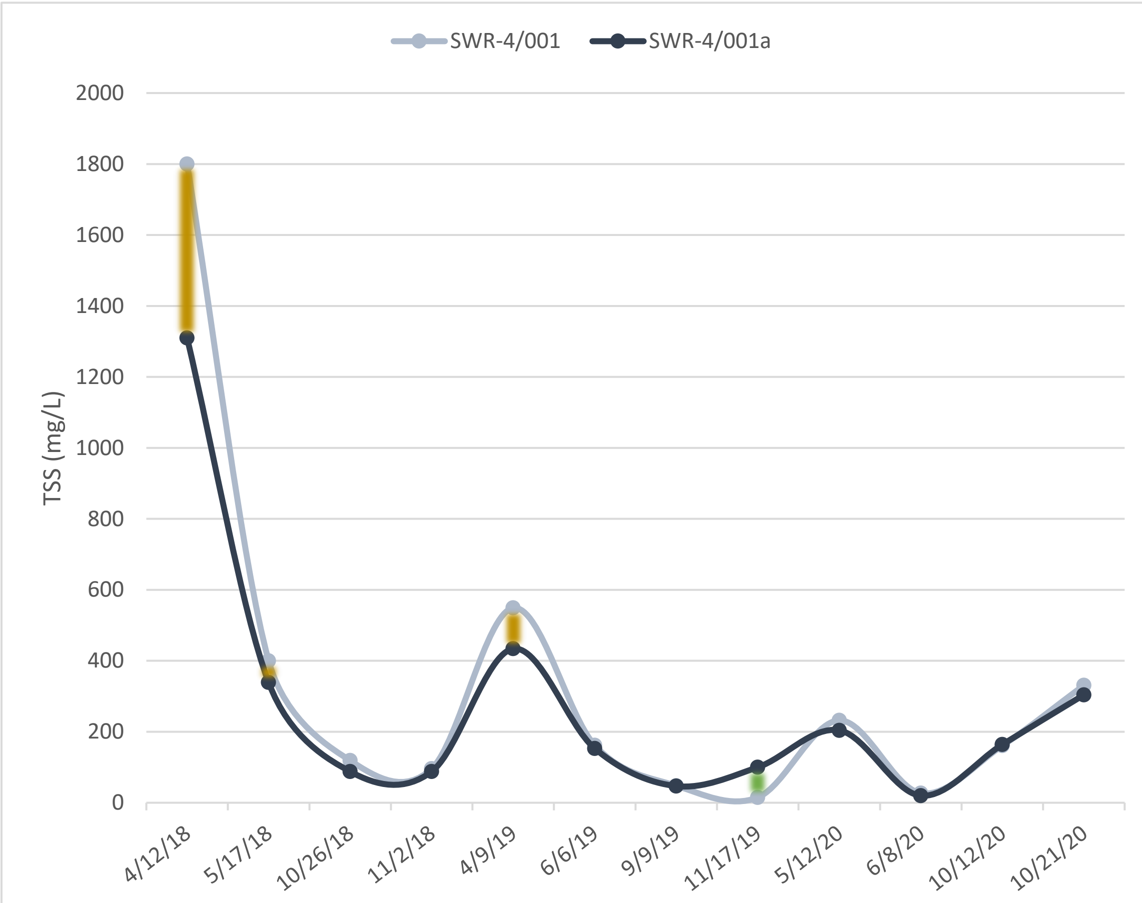

Figure 15. TSS concentration pre-treatment (SWR-4/001a) and post-treatment (SWR-4/001)

Figure 16 shows generally small increases in TSS concentrations post-treatment for most rain events. The data points are mostly above the solid line which shows that the effluent concentrations are greater than the influent concentrations. If the data was plotted along the line (1 to 1), this would indicate no difference between influent and effluent TSS concentrations.

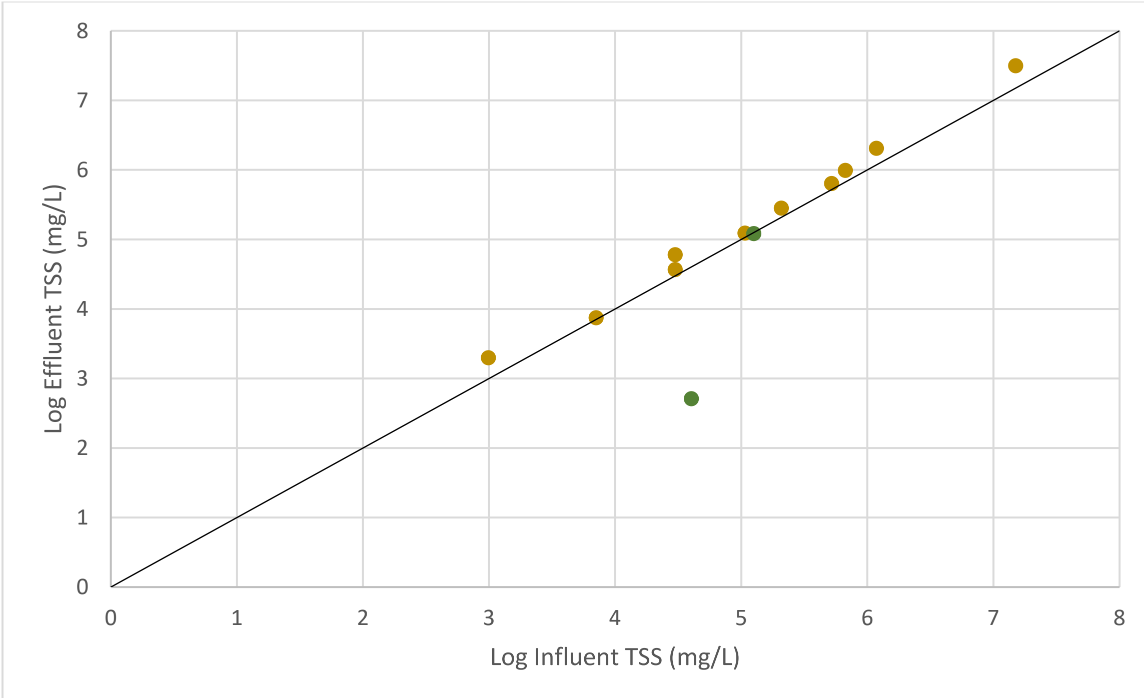

Figure 16. Scatterplot of observed influent and effluent TSS concentrations (log transformed)

SWR-4/002

SWR-4/002 also drains to the Stillwater River (impaired for sediment) and therefore, TSS is the pollutant of focus for TMDL-related monitoring. The City plans to install future BMPs within this mostly commercial/industrial drainage area to reduce the MS4's discharge of sediment to the Stillwater River.

Monitoring results from samples collected before the BMPs are implemented within the drainage area (baseline samples) are to establish existing conditions. Future monitoring results will be compared to the baseline samples as BMP(s) are added within the drainage basin. Figure 17 shows baseline TSS concentration at SWR-4/002.

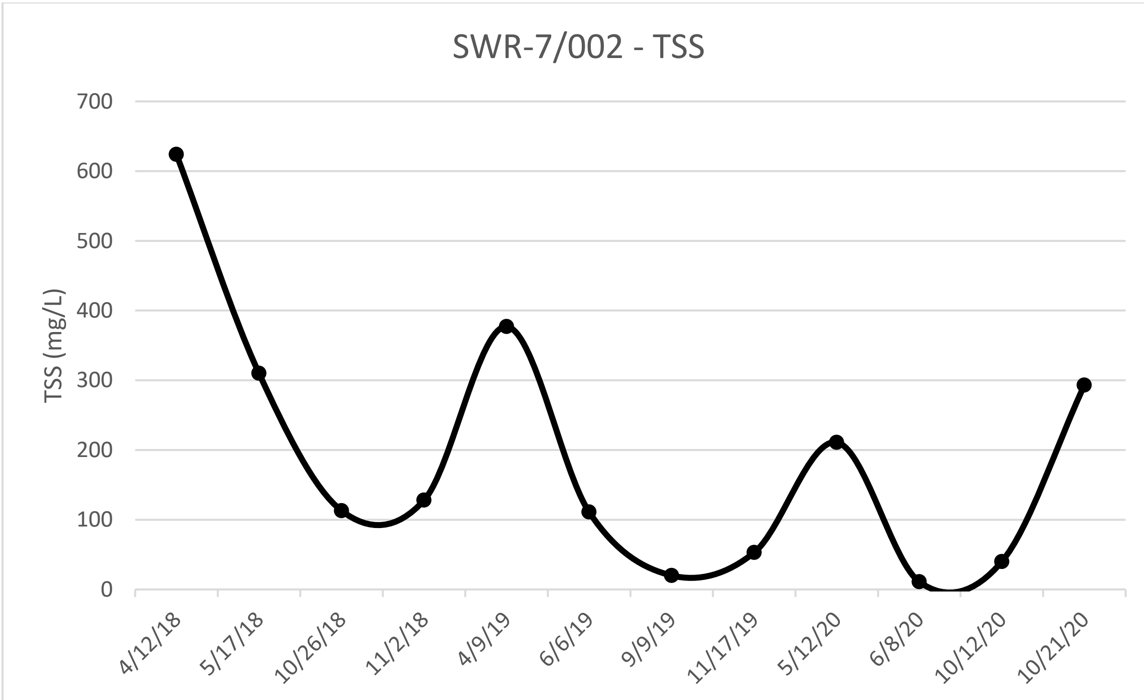

Figure 17. TSS concentration at SWR-7/002 over time

Ashley Creek

AC-11/004

AC-11/004 drains to Ashley Creek which is impaired for phosphorus, nitrogen, dissolved oxygen, sediment, and temperature. The City plans to install future BMPs within this mostly residential drainage area to reduce the MS4's discharge of pollutants to Ashley Creek.

Monitoring results from samples collected before the BMPs are implemented within the drainage area (baseline samples) are to establish existing conditions. Future monitoring results will be compared to the baseline samples as BMP(s) are added within the drainage basin. Figures 18 - 22 show baseline TSS, TP, TN, DO, and temperature readings respectively at AC-11/004.

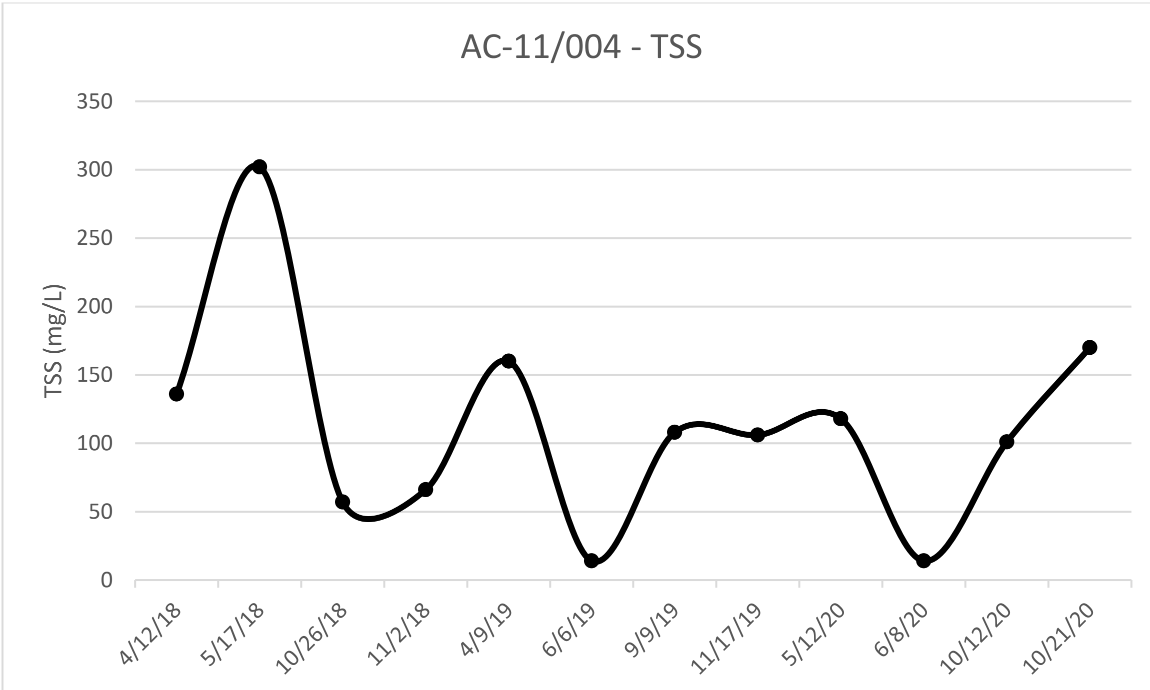

Figure 18. TSS concentration at AC-11/004 over time

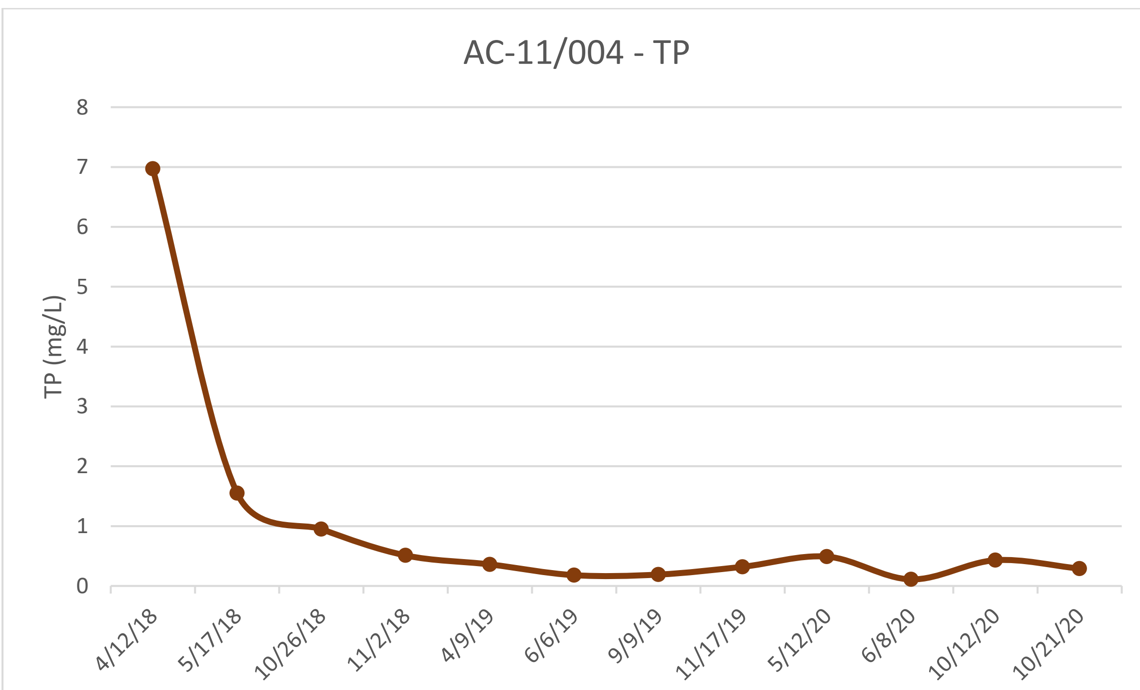

Figure 19. TP concentration at AC-11/004 over time

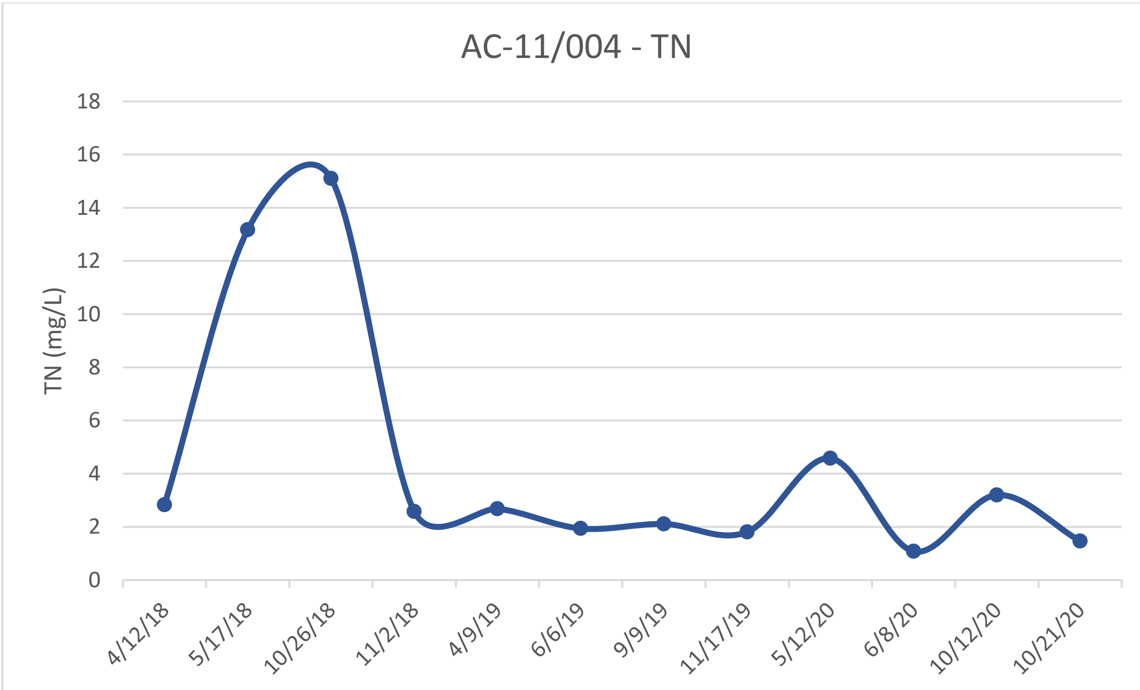

Figure 20. TN concentration at AC-11/004 over time

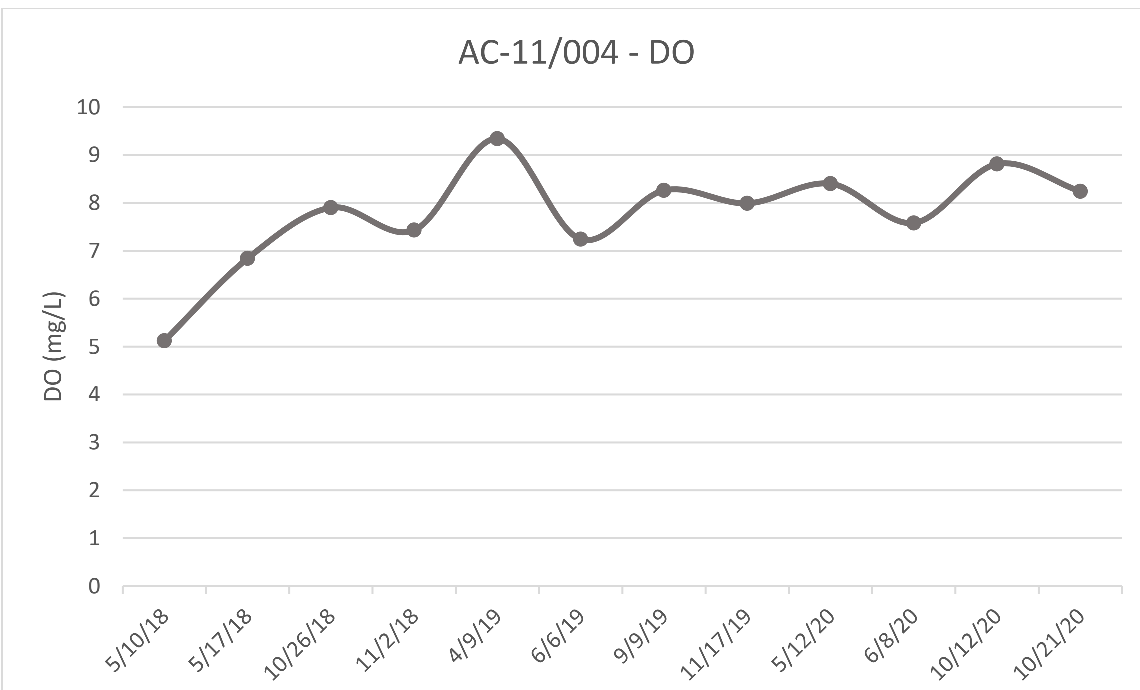

Figure 21. DO concentration at AC-11/004 over time

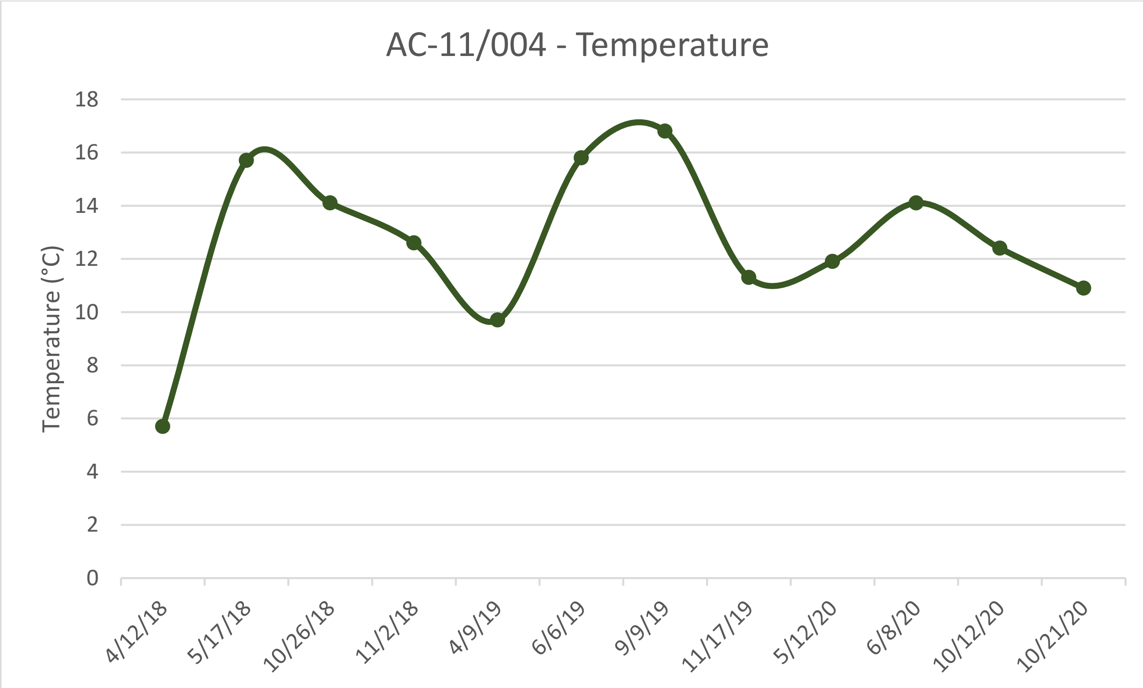

Figure 22. Temperature concentration at AC-11/004 over time

Discussion: Adaptive Management

Stillwater River

SWR-7/001 and 001a

Samples collected before and after treatment at SWR-7 are not consistently showing reduced TSS after treatment. This finding may have to do with several factors. Hydrodynamic separators are typically not best at removing very fine sediments. However, the MS4 Permit requires TSS to be sampled and TSS does not take into account sediment size. For example, we have evidence that the hydrodynamic separators are removing a significant amount of sediment and debris from regular maintenance activities. In 2020, ~44 tons of sediment were removed from the hydrodynamic separators effectively preventing the material from reaching the Stillwater River in this drainage basin alone.

Stormwater flows from the hydrodynamic separators into a detention basin. Although the detention basin was not designed for water quality treatment, it may be providing additional water quality benefits. To better understand the impacts of the entire stormwater system, an additional sample location at the end of the detention basin could be considered.

SWR-4/002

Further evaluation and discussion will be provided once the City installs additional BMPs within this drainage basin.

Ashley Creek

AC-11/004

Further evaluation and discussion will be provided once the City installs additional BMPs within this drainage basin.

APPENDIX A. Monitoring Parameters

The parameters required to be monitored can contribute to stormwater pollution. The following is a description of the potential sources of stormwater runoff contamination.

Total Suspended Solids (TSS)

TSS is a common stormwater pollutant and can be generated from construction sites, bare spots in lawns and gardens, wastewater from washing/trucks on driveways and parking lots, dirt roads and driveways, and sanding roads during winter conditions.

Chemical Oxygen Demand (COD)

Organic material such as leaves, grass, oils, grease, and litter become deposited in urban areas and become part of stormwater runoff flows. A COD test can be used to quantify the amount of organics in water. COD is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and the oxidation of inorganic chemicals such as Ammonia and nitrite. High COD concentrations lower dissolved oxygen concentration, progressively deteriorating conditions for fish and other aquatic life. Also, the absence of dissolved oxygen could result in the growth of microorganisms that produce by-products which cause foul odors in the water.

Total Phosphorus (TP)

Nutrients such as phosphorus are common constituents of nonpoint source runoff. The introduction of nutrients into receiving waters stimulates the growth of algae and other aquatic plants causing algal blooms and creating turbid conditions. Total phosphorus enters runoff from sources such as fertilizers, pesticides, grass clippings/leaves left on streets and sidewalks, detergents and washing fluids, animal waste, and seepage from septic tanks. Automobile lubricant emissions, food products, and various household cleaners, paints, fabrics and carpets contain phosphates which can also be transported by runoff.

Total Nitrogen (TN)

Plant nutrients, such as nitrogen, are common constituents of nonpoint source runoff. The introduction of nutrients into receiving waters stimulates the growth of algae and other aquatic plants causing algal blooms and creating turbid conditions. Total nitrogen enters runoff from sources such as fertilizers, grass clippings and leaves left on streets and sidewalks, detergents and washing fluids, animal wastes, and seepage from septic tanks.

pH

Most discharge flow types are neutral, having a pH value around 7, although groundwater concentrations can be somewhat variable. pH is a reasonably good indicator for liquid wastes from industries, which can have very high or low pH (ranging from 3 to 12). The pH of residential wash water tends to be rather basic (pH of 8 or 9). Although pH data is often inconclusive by itself, it can identify problem outfalls that merit follow-up investigations using indicators that are more effective.

Heavy Metals: Total Copper (Cu), Lead (Pb), Zinc (Zn)

Metal pollutants can be generated from the operation and maintenance of motor vehicles, the degradation of highway material, and industrial/commercial site activities. Heavy metals in water can cause bioaccumulation in animal tissues, affect reproduction rates and life spans of aquatic species, and ultimately affect recreational and commercial fisheries. Transportation-related sources of Zn include diesel fuel, crankcase and lubrication oils, grease, and decorative and protective coatings.

Copper in stormwater runoff can be generated from wear on brake pads, roofing and gutter runoff, and copper-based fungicides/fertilizers used for controlling algae, fungi, and mildew. Metal finishers, electroplaters, and semiconductor manufacturers may use copper-containing materials in their manufacturing processes. Vehicle services (engine repair and service, fueling, vehicle body repair, replacement of fluids, recycling, cleaning, and outdoor equipment storage and parking through dripping engines) can generate toxic hydrocarbons and other organic compounds, oils and greases, nutrients, phosphates, heavy metals, paints and other contaminants. Radiator repair and flushing operations are the most likely source of copper-containing waste streams.

The principal source of lead in highway and street stormwater runoff as well as soils in urban areas and near highways during the time of the NURP studies i.e., about 1980, was the use of lead as an additive in gasoline. Other sources of lead in stormwater runoff include yellow and white road marking paints used on parking lots, streets, buildings, building cavity dust and other demolition waste from buildings and structures, and vehicular sources including leaded petrol (auto exhaust), auto paint (which can still contain 10% lead), lead-acid batteries, lubricating oil and grease, and bearing wear.

Oil and Grease (O&G)

Oil and grease pollutants can be generated from leaks and spills of oil and gas, used oil dumping, and commercial and industrial activities. These organic pollutants cannot be easily decomposed through biological action and may persist for long periods.

APPENDIX B. Correlation Matrix

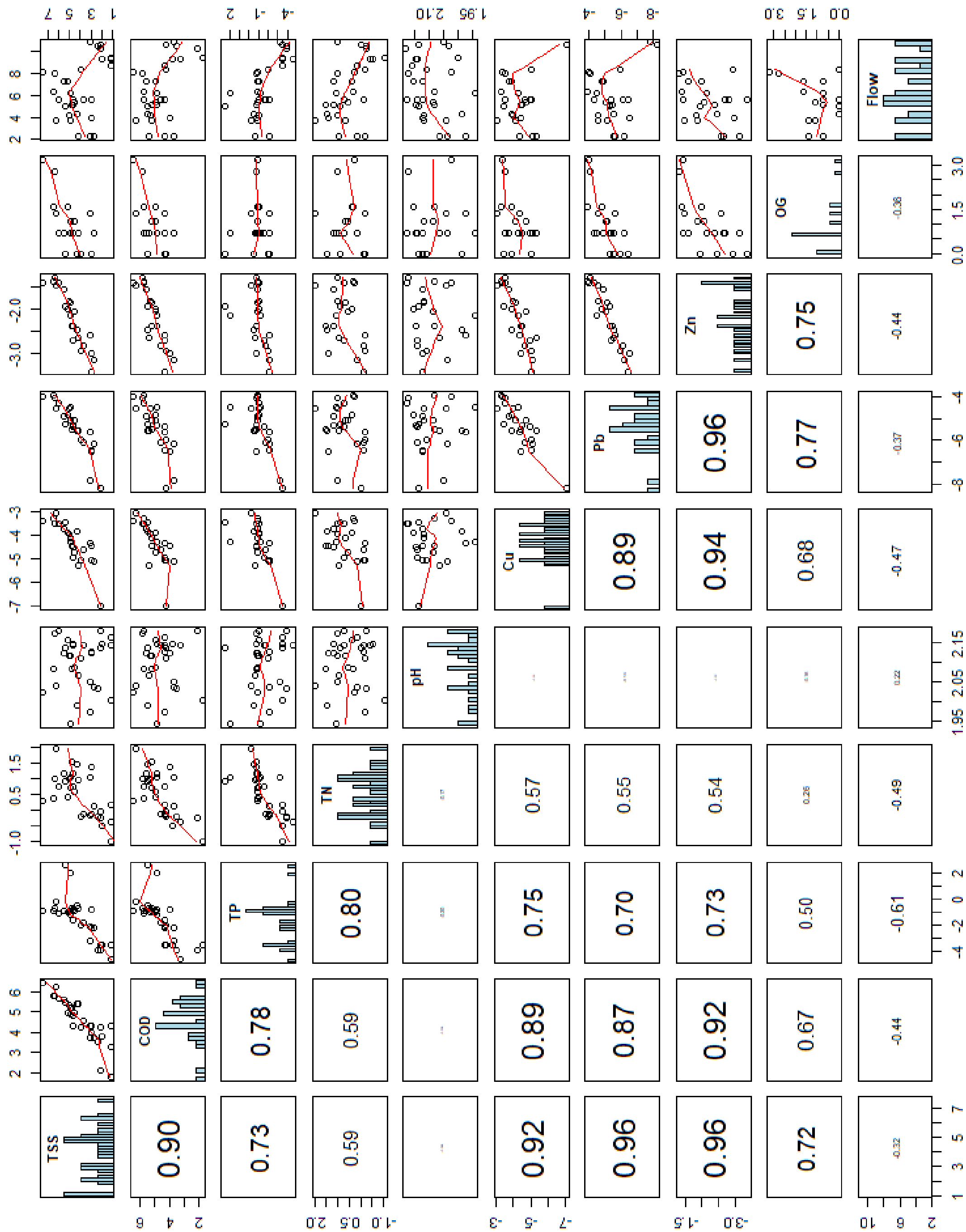

Figure B1. Correlation matrix of water quality variables. Correlations (r) are represented on the lower left, histograms on the diagonal, and x-y plots on the upper right. For normality, variables have been log transformed. TSS = total suspended solids, COD = chemical oxygen demand, TP = total phosphorus, TN = total nitrogen, Cu = total copper, Pb = total lead, Zn = total zinc, OG = oil and grease