Centennial Coal

CLARENCE COLLIERY

Wollangambe River Environmental Monitoring Program Report

March 2018 to August 2018

December 2018

Centennial Coal Environment Matters

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1. INTRODUCTION

On 25 September 2015 Clarence Colliery (Clarence), in compliance with Clean Up Action 6 of Clean Up Notice No. 1532719, submitted a Draft Environmental Monitoring Program (EMP) to the NSW Environmental Protection Authority (EPA).

The EPA required the EMP to be developed to obtain information about the recovery of the Wollangambe River after a spill of coal fines on 2 July 2015. The objective of the EMP was to determine the state of the aquatic ecosystem of the Wollangambe River following completion of the clean-up activities, with monitoring for a period of time not less than 18 months, concentrating on sections of the River below where coal fines entered the River and downstream for at least 12 kilometres.

Following its review of the Draft EMP, the EPA proposed changes to the program based on the following;

- The importance of sediments in the affected part of the River as the sink for coal fines remaining in the River.
- The need to assess the impact of the coal fines spill for a period of not less than 18 months.
- The confounding factors relating to the impact of the non-spill factors from Clarence, such as the ongoing impact of the discharge of treated underground water and the past accumulation of metals in the sediments of the River.
- The advice of the Greater Blue Mountains World Heritage Area Advisory Committee to Centennial Coal dated 2 December 2015.

A copy of the Revised EMP, (dated 5 April 2016) is attached as **Appendix A** to this report. Further detail regarding the implementation of the EMP is included as a Pollution Reduction Program (PRP) within the Clarence Colliery Environment Protection Licence 726 (EPL726), as outlined below:

U1 Wollangambe Environmental Monitoring Program

U1.1 The Licensee must implement the Revised Wollangambe River Environmental Monitoring Program (5 April 2016).

U1.2 The Licensee must commence implementation of the Program in August 2016.

U1.3 The Licensee must provide interim reports in accordance with the Program. The reports must be;

- provided every seven (7) months from 31 August 2016; and
- received by the EPA's Central West (Bathurst) office on the last day of the month each report is due e.g. the first report is to be received on 31 March 2017.

U1.4 The Licensee must provide to the EPA's Central West (Bathurst) office a final report in accordance with the requirements of the Program within two (2) months of the completion of the Program.

This is the fourth interim report as required under PRP condition U1.3 (due by 31st December 2018) on the implementation and progress of the EMP, and reports on additional monitoring undertaken and completed between March 2018 and August 2018.

2. SAMPLING PROGRAM

The revised EMP requires seven sampling locations, two sites upstream of the coal fines spill entry to the river (one upstream and one downstream of the Clarence Colliery LDP2 discharge entry to the river), and five sites downstream of the spill entry site - to include three sites within the section of river where coal fines were found, one site sufficiently further downstream assumed not to be impacted by the spill plus an intermediary site. Additional site selection criteria included the following:

- Utilise existing river monitoring sites where possible.
- Match site locations to increasing river stream order where possible.

Figure 1 shows the adopted sampling locations along the Wollangambe River. The sites are described as follows:

- *US1 Background upper catchment site (1st order stream).* This site is located at the existing OEH W1 site. It is upstream of the LDP aquatic ecology monitoring site WGRup but it is the LDP WQ1 site and following two seasons of parallel monitoring at sites US1 and WGRup, the US1 site has now been adopted for both this EMP and the LDP aquatic ecology monitoring programs.
- *US2 Between LDP2 entry and spill entry (upper end of 3rd Order stream section).* Located at the existing LDP aquatic ecology monitoring site WGRdown.
- *DS1 1km downstream of spill entry point (half way through 3rd Order stream section).* Located at the LDP aquatic ecology monitoring site WGRXdown.
- *DS2 About 3.5km downstream of spill entry point (at the upper end of the 4th Order stream section).*
- *DS2 About 5km downstream of spill entry point (about one quarter way into the 4th Order stream section).*
- *DS4 About 10.6km downstream of spill point (about three- quarter way through the 4th Order stream section above the Bells Creek confluence at Mount Wilson).*
- *DS5 Around 19km downstream of spill entry point, 5km into the 5th order stream section, and located just below the 3rd order Bell Ck confluence at Mt Wilson.*

The EMP specifies that for each of the above sites, sediment and water quality, macro-invertebrates and vertebrates (fish and frog) sampling are to be undertaken, and that in addition visual inspections for any remaining and accumulated coal fines must be undertaken. The details for each of these monitoring elements are described further in the report sections below.

The EMP also specifies a sampling schedule over a two and half year period that includes monthly sampling for six months for some sites followed by bi-monthly sampling for the remainder of the EMP, plus a mix of quarterly, biannual and yearly requirements for other sites and study elements. **Table 1** identifies the relevant sampling periods for all sites, and the study elements that are included in this report are shown hatched in grey.

Marine Pollution Research Pty Ltd (MPR) was commissioned to undertake the aquatic ecology component of the sampling program and Clarence Colliery undertook the initial six month's water and sediment sampling plus production of the first six-month data EMP report. Following completion of the first EMP report by Clarence Colliery, MPR was commissioned to undertake the remaining water and sediment sampling and prepare the remaining EMP six-month data reports. Australian Laboratory Services (ALS) were commissioned by Clarence Colliery to provide water and sediment quality analysis plus provide Microscopic Analysis reports.

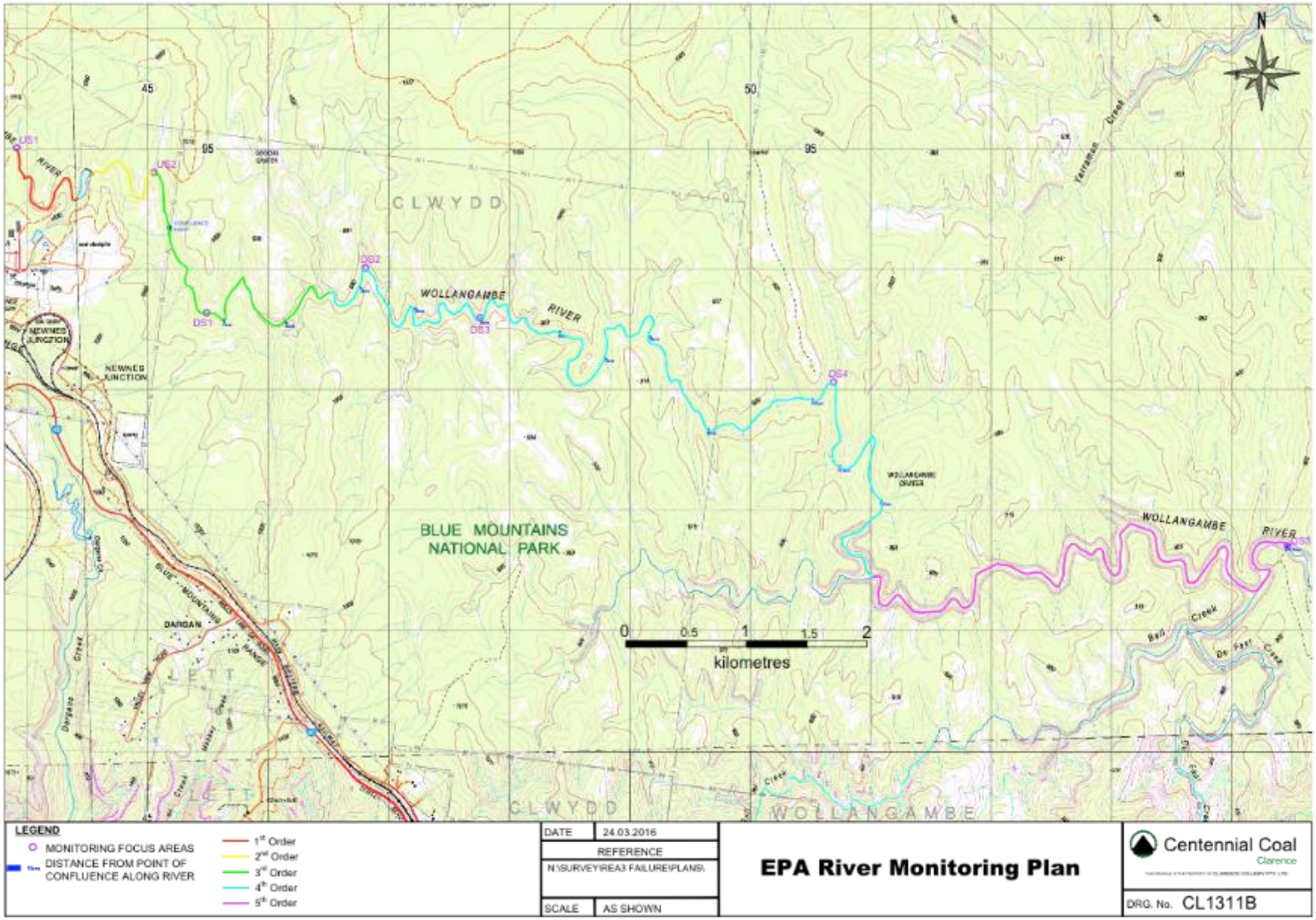


Figure 1. Wollangambe Monitoring Locations US1 through to DS5, in relation to Clarence Colliery

Table 1. Wollangambe River EMP Sampling Schedule*

Calendar Year	Study Month	Calendar Month	Petrographic Analysis		Sediment Metals		Water Quality		Macro-Inverts	Fish & Frogs	Coal Fines Visual Inspections			Reports
			US1, US2, DS4	DS1, DS2, DS3	US1, US2, DS4	DS1, DS2, DS3	US1, US2, DS4	DS1, DS2, DS3	US1 to DS4	US1 to DS4	US1, US2, DS4	DS5	DS1, DS2, DS3	
2016	1	Sep							Sp 16					
2016	2	Oct												
2016	3	Nov												
2016	4	Dec												
2017	5	Jan												
2017	6	Feb												
2017	7	Mar							Au 17					No 1
2017	8	Apr												
2017	9	May												
2017	10	Jun												
2017	11	Jul												
2017	12	Aug												
2017	13	Sep							Sp 17					No 2
2017	14	Oct												
2017	15	Nov												
2017	16	Dec												
2018	17	Jan												
2018	18	Feb												
2018	19	Mar							Au 18					No 3
2018	20	Apr												
2018	21	May												
2018	22	Jun												
2018	23	Jul												
2018	24	Aug												
2018	25	Sep							Sp 18					No 4
2018	26	Oct												
2018	27	Nov												
2018	28	Dec												
2019	29	Jan												
2019	30	Feb												
2019	31	Mar												Final
Note*			Gray fill means sampling completed and data included in reports to date											

2.1 Report Layout

The data for this summary report is contained in the following appendices:

- **Appendix B** provides the ALS laboratory reports for all the EMP water and sediment analysis surveys undertaken for this reporting period (March 2018 to August 2018).
- **Appendix C** provides the available ALS Microscope and Petrography data reports.
- **Appendix D** provides the MPR Autumn 2018 Aquatic Ecology report undertaken during this reporting period.

Data summary results are presented in the four following sections,

- **Section 2.2** Rainfall and Mine Discharge Data,
- **Section 3** Water Quality Monitoring Data,
- **Section 4** Sediment Metals, Petrography Analysis & Coal Fines Inspections, and
- **Section 5** Aquatic Ecology Monitoring Results.

Each Section provides a short outline of sampling methods, an explanation of how the data have been presented and a summary of analytes that are found at *below detection* concentrations.

2.2 Rainfall & Mine Discharge Data

Daily rainfall measurements are recorded at Clarence Colliery Meteorological Station located at Clarence Colliery pit top and operated on the Collier's behalf by ALS Global. Note that rainfall is recorded for the actual calendar day from midnight to midnight.

Background long-term mean monthly rainfall totals are acquired from Bureau of Meteorology Newnes Forest Centre Station (means based on data recorded from 1938 to 1999).

Clarence Colliery LDP 2 mine discharge data are collected by automatic flow monitors operated by ALS Global and both the site weather data and discharge flow are provided via a web link.

Daily rainfall and discharge volumes for 2015 to 2018 are shown graphically in **Figures 2-5. Table 2** shows daily rainfall for the present reporting period.

Table 2 Daily Rainfall March 2018 to August 2018 (yellow highlights = sampling days)						
Day	March	April	May	June	July	August
1	0	0	0.2	0	0	0
2	0	0	0.2	0	0	0
3	0.4	0	0	1	9.2	0
4	0	0.8	0	0	0.2	8.8
5	2.4	0.2	0	0.8	0.2	0
6	15	0	0	1.6	0	0
7	6.6	0	0	3.6	0.8	11.4
8	1	0	0	0.2	2.2	0
9	0	0	0	6.6	0	0
10	0	0	0	2.6	0	0
11	0	0	0	0.8	0	0
12	0.2	0	1.6	0	0	0.8
13	0	0	0.6	0	0.2	0.4
14	2.6	1.4	0	0	0	0
15	0.6	2.4	0	0	0.2	0
16	0.2	0	0.2	2.8	0	0
17	0	0	0	0.4	0	0
18	0	0.4	0	1.2	0	0
19	0	0	0	2.8	0	1.6
20	0	12.4	0	3	0	0
21	3.6	0.4	0	0.4	0	0
22	10.4	0	0	0.2	0	0
23	8.8	0	0	0.2	0	0
24	7.4	0	0	0	0	0
25	9	0	0	0	0	0
26	13.4	0	0	0	0	1.4
27	0.6	0	0	0	0	13
28	0	0	0	0.6	0	0.4
29	0	1.4	0	18.4	0	0.2
30	0	3.2	9.4	0.2	0.4	0
31	0		0.6		0	0
Monthly Total (mm)	82.2	22.6	12.8	47.4	13.4	38
Long-term Monthly Mean	74.6	57.6	51.2	73.1	60.3	57.4

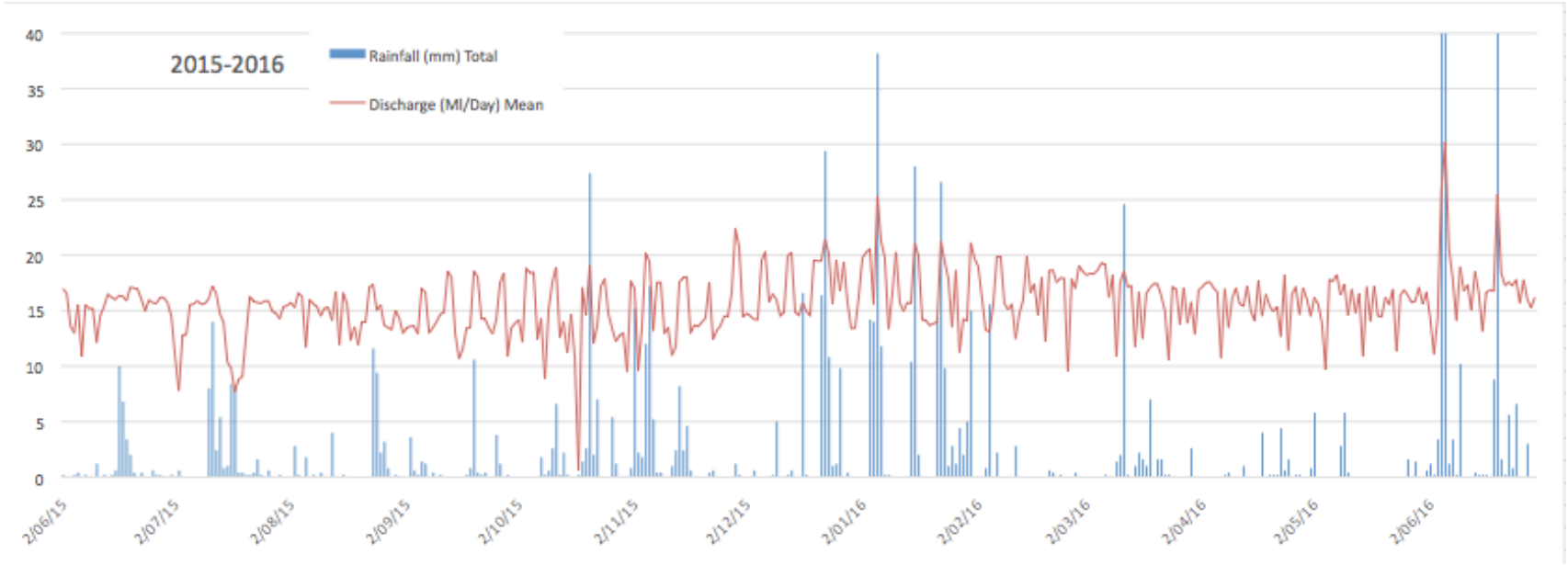


Figure 2.

Daily Rainfall & LDP Discharge

Flow 2015 to 2016

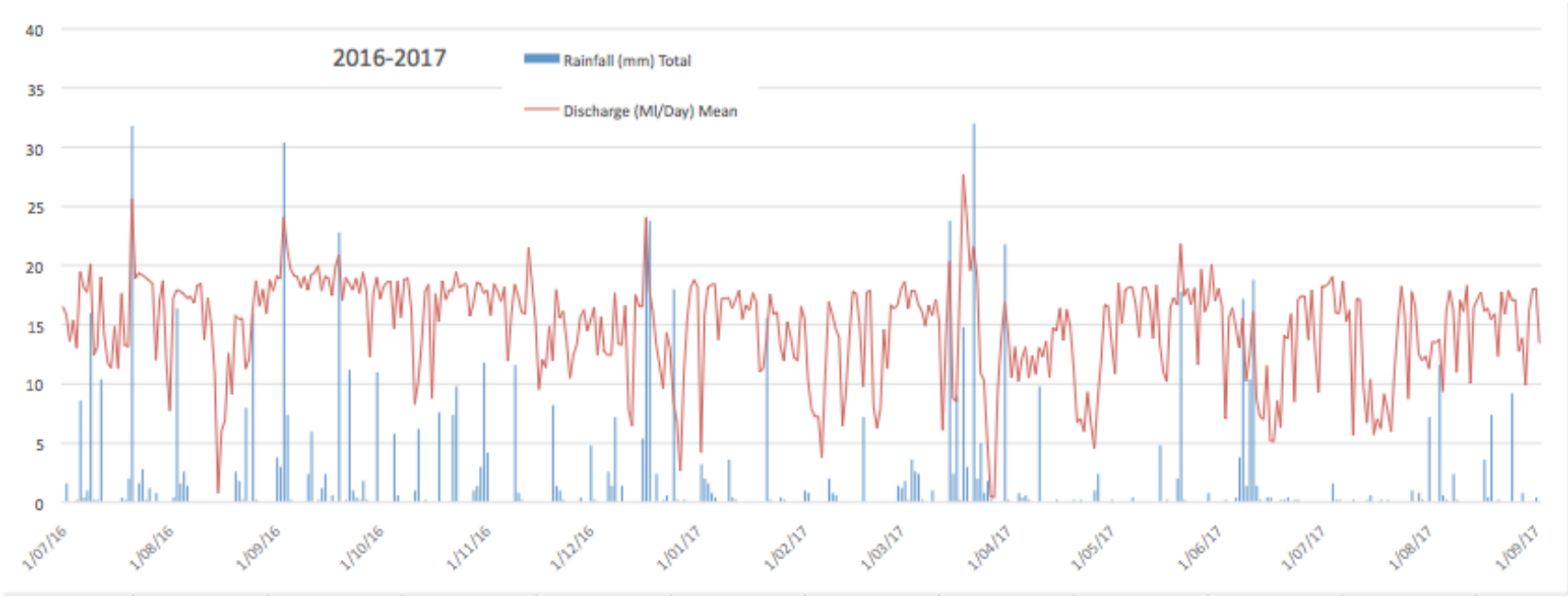


Figure 3.

Daily Rainfall & LDP Discharge

Flow 2016 to 2017

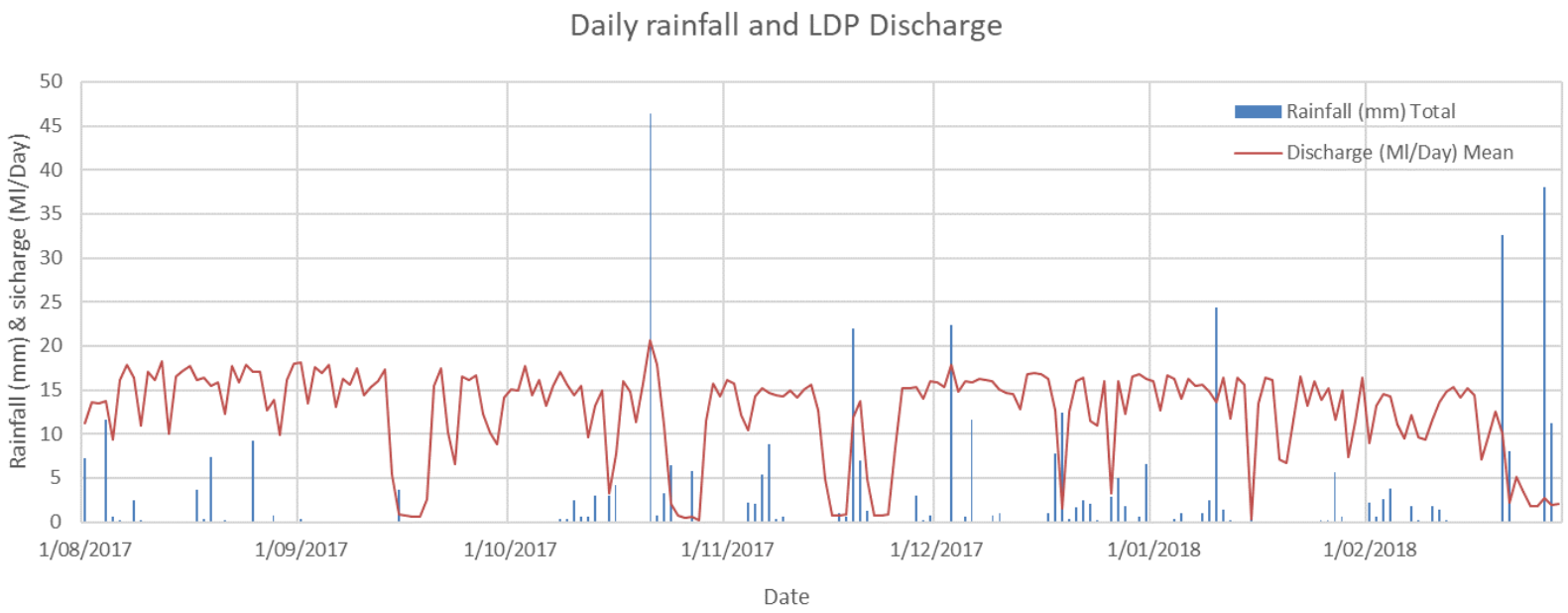


Figure 4.

Daily Rainfall & LDP Discharge

Flow Aug 2017 to Feb 2018

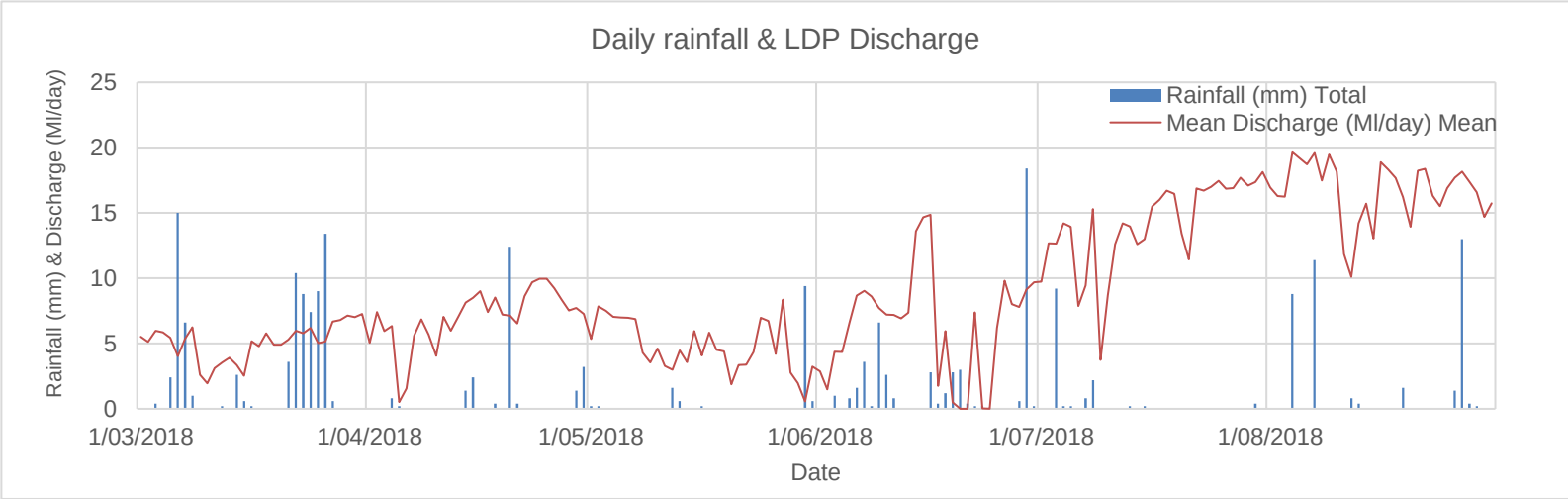


Figure 5.

Daily Rainfall & LDP Discharge

Flow Mar 2018 to Aug 2018

3 WATER QUALITY MONITORING RESULTS

Section 3.1 provides a summary of water quality monitoring methodology and outlines how the data are presented. Water quality monitoring results are provided in **Sections 3.2** (Physical and Mineral), **3.3** (Nutrients and Organics) and **3.4** (Metals and Metalloids).

3.1 Methods and Data Presentation

Field Methods:

Water quality sampling is undertaken using a combination of metered water quality measurements and collection of water samples for subsequent laboratory analysis:

- A submersible Yeo-Kal 915 water quality data logger is used to record water temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity at all sampling sites. The meter is calibrated daily before commencing field work and calibration is checked at the completion of each day's field work.
- Water samples are collected into suitable containers supplied by the NATA registered laboratory, and kept chilled in back-packs, then in a chilled esky for delivery to the laboratory on the same day.
- Due to the time taken to access Downstream sites and the requirement to deliver the samples to the laboratory on the same day where possible, water samples for dissolved metal analysis are not field-filtered.
- For some of the remote sites where samplers were unable to exit the site in time to deliver the samples on the same day, samples were kept chilled in a refrigerator overnight for delivery to the laboratory in the morning.

Data Presentation:

For each section the results are presented in a **Summary Table**, and are shown graphically in **Control Charts** and **Box-plots**:

- The **Summary Table** presents the analyte detection limit (DL), sample size, the number of sample values above DL, minimum, median, mean, standard deviation (SD) of the mean, 80th percentile and maximum value for each analyte over all sampling events to date. **Note that all results are expressed as mg/L.**
- Results for analytes that have all or most analytic results below detection are shaded in grey with no (or reduced) sample statistics calculated and no bar charts or box plots produced.
- Depending on sample size the following general rules apply to calculation of site statistics:
    - If no values >DL, <DL indicated in all statistical cells (the min, max, mean cells etc).
    - if one value >DL, then maximum value only shown,
    - if two values >DL, then maximum and minimum values shown only,
    - If three values >DL (for sample size of 5 through to 10), then use half DL values for calculation of statistics, and show the DL as the minimum value.
    - For analytes with 3 or more values above DL, median, mean, SD and 80th percentile statistics are calculated using halve DL values.
- The **Control Charts** provide results for the concentrations of each analyte over time for all six sites, from the first sample run in the first monitoring period (August 2016) to the most recent sample for this current monitoring period (August 2018). Most are shown in line graph mode.

- Where analyte values are similar across sites making discrimination of site differences difficult to see in line graph mode, the control graphs are shown in the form of clustered bar charts.
- Given the variation in sampling frequency between sites for the period August 2016 to August 2018 (see **Table 1**), the control graph quarterly data for sites US1, US2 and DS4 are shown as isolated data points, whereas the monthly data for sites DS1, DS2 and DS3 appear as continuous lines. Based on the inter-monthly variation observed in analyte values for DS1, DS2 and DS3, lines connecting quarterly data points for sites US1, US2 and DS4 over this period would be misleading.
- **Box Plots** compare the summary statistical results for each analyte per site over the complete sampling program to date:
    - The upper and lower sides of the main box show the quartile (75 and 25 percentile) values for the data. The range between these values is called the interquartile range (IQR).
    - The line through the box shows the median (50 percentile) for the data and the cross (X) shows the mean value for the data.
    - The box 'whiskers' generally show the maximum and minimum values provided the data are all within 1.5 IQRs either side of the IQR.
    - If there are outlier data (i.e. values outside this range), they are shown as small circles located on both sides or on one side of the whiskers (depending whether the outliers are very low or very high value) and the whiskers on the side that have outliers then shows the 1.5 IQR limits for the data. Outliers will then indicate the relevant minimum or maximum value.

3.2 Physical & Mineral Water Quality Monitoring Data

The physical and mineral water quality results for each sampling location and event are provided below in Site Summary **Tables 3 to 8**, Control Charts, and Box Plots:

- Results for water pH, Electrical Conductivity and Turbidity for the first six months of sampling were intermittent and are a mix of laboratory measurements and field measurements - where available, and field Temperature results were only available when water sampling coincided with aquatic ecology sampling. Whilst the field and laboratory results are generally compatible, the laboratory EC results are always calculated as EC at 25°C and field conductivity is measured at field ambient water temperature.
- Electrical Conductivity, water temperature, pH and turbidity results for the next six-monthly reporting period are based on both field and laboratory measurements.
- Metered dissolved oxygen sampling during water sampling only commenced in May 2017.
- TSS (<5mg/L), Hydroxide and Carbonate Alkalinity (< 1mg/L) concentrations were all <DL for all sites and for all sampling times to date, and are not shown in Control Graphs or Box Plots.
- Dissolved Sulphur, Magnesium and Potassium were all <DL (of 1mg/L) for Site US1 over all sample times and are shown in Control Graphs and Box Plots as Detection Limit value.

Table 3 US1 Physical and Mineral Water Quality Summary Statistics

	Temp	Dissolved Oxygen	EC	pH	Turbidity	TSS	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Total Hardness as CaCO3	Chloride	Dissolved Sulfur as S	Total Sulfur as S	Sulfate as SO4 - Turbidimetric	Calcium	Magnesium	Sodium	Potassium	Total Anions	Total Cations
	°C	% sat	µS/cm	pH Units	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L
Detection limit (DL)	NA	NA	NA	NA	NA	5	1	1	1	1	1	1	1	1	1	1	1	1	1	0.01	0.01
Sample size (n)	6	4	4	5	1	6	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
n > DL	6	4	4	5	1	0	0	0	3	3	1	9	0	2	5	1	0	9	0	9	9
Min	6.41	79.8	25	5.14	-	<DL	<DL	<DL	1	1	-	5	<DL	1	1	-	<DL	3	<DL	0.16	0.13
Median	14.3	86.3	31.0	5.8	-	<DL	<DL	<DL	0.5	0.5	-	6.0	<DL	-	1.0	-	<DL	4.0	<DL	0.19	0.17
Mean	14.0	84.9	30.0	6.0	-	<DL	<DL	<DL	1.0	1.0	-	5.9	<DL	-	0.9	-	<DL	3.8	<DL	0.19	0.17
SD	5.5	3.4	3.6	0.8	-	<DL	<DL	<DL	0.9	0.9	-	1.1	<DL	-	0.5	-	<DL	0.8	<DL	0.03	0.04
80th percentile	17.8	86.8	32.4	6.4	-	<DL	<DL	<DL	1.4	1.4	-	6.4	<DL	-	1.0	-	<DL	4.4	<DL	0.22	0.22
Max	21.5	87.2	33.0	7.2	8.5	<DL	<DL	<DL	3.0	3.0	2.0	8.0	<DL	1.0	2.0	1.0	<DL	5.0	<DL	0.23	0.22

Table 4 US2 Physical and Mineral Water Quality Summary Statistics

	Temp	Dissolved Oxygen	EC	pH	Turbidity	TSS	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Total Hardness as CaCO3	Chloride	Dissolved Sulfur as S	Total Sulfur as S	Sulfate as SO4 - Turbidimetric	Calcium	Magnesium	Sodium	Potassium	Total Anions	Total Cations
	°C	% sat	µS/cm	pH Units	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L
Detection limit (DL)	NA	NA	NA	NA	NA	5	1	1	1	1	1	1	1	1	1	1	1	1	1	0.01	0.01
Sample size (n)	6	4	5	5	1	6	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
n > DL	6	4	5	5	1	0	0	0	9	9	9	9	9	9	9	9	9	9	9	9	9
Min	12.3	83.8	283	5.48	-	<DL	<DL	<DL	14	14	90	3	30	27	82	26	6	2	3	2.27	2.00
Median	16.8	85.9	286.0	6.70	-	<DL	<DL	<DL	18.0	18.0	123.0	4.0	35.0	35.0	106.0	33.0	10.0	3.0	4.0	2.78	2.68
Mean	16.5	86.8	301.2	6.54	-	<DL	<DL	<DL	20.3	20.3	122.0	3.9	34.7	33.4	108.8	33.2	9.4	3.3	3.7	2.78	2.67
SD	3.3	3.4	23.6	0.65	-	<DL	<DL	<DL	7.2	7.2	13.8	0.6	2.7	3.5	18.2	4.6	2.5	0.7	0.5	0.35	0.29
80th percentile	17.9	88.9	322.6	6.93	-	<DL	<DL	<DL	24.8	24.8	132.8	4.0	37.0	36.4	125.2	36.8	12.0	4.0	4.0	3.06	2.92
Max	21.7	91.4	333	7.20	18.8	<DL	<DL	<DL	36	36	135	5	38	37	135	41	12	4	4	3.28	2.96

Table 5 DS1 Physical and Mineral Water Quality Summary Statistics

	Temp	Dissolved Oxygen	EC	pH	Turbidity	TSS	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Total Hardness as CaCO3	Chloride	Dissolved Sulfur as S	Total Sulfur as S	Sulfate as SO4 - Turbidimetric	Calcium	Magnesium	Sodium	Potassium	Total Anions	Total Cations
	°C	% sat	µS/cm	pH Units	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L
Detection limit (DL)	NA	NA	NA	NA	NA	5	1	1	1	1	1	1	1	1	1	1	1	1	1	0.01	0.01
Sample size (n)	11	6	10	10	1	12	16	16	16	16	15	16	16	15	16	16	16	16	16	16	16
n > DL	11	6	10	10	1	2	0	0	16	16	15	16	16	15	16	16	16	16	16	16	16
Min	9.9	82.5	263	5.54	-	6	<DL	<DL	7	7	50	3	13	14	39	15	3	3	2	1.12	1.18
Median	16.8	87.9	293.5	6.74	-	-	<DL	<DL	19.0	19.0	114.0	4.0	31.5	31.0	94.5	29.5	10.0	3.5	3.0	2.53	2.52
Mean	16.2	89.3	297.0	6.66	-	-	<DL	<DL	19.6	19.6	104.2	4.1	29.0	29.0	87.0	28.0	8.7	3.5	3.2	2.32	2.35
SD	3.5	7.0	27.7	0.44	-	-	<DL	<DL	7.9	7.9	26.4	1.2	7.8	7.7	24.3	7.1	3.0	0.5	0.8	0.58	0.55
80th percentile	19.6	92.0	309.6	6.97	-	-	<DL	<DL	26.0	26.0	127.2	4.0	35.0	34.2	108.0	33.0	11.0	4.0	4.0	2.79	2.80
Max	20.9	101.6	358	7.13	12.5	11	<DL	<DL	37	37	129	8	38	42	119	40	13	4	4	2.90	2.86

Table 6 DS2 Physical and Mineral Water Quality Summary Statistics

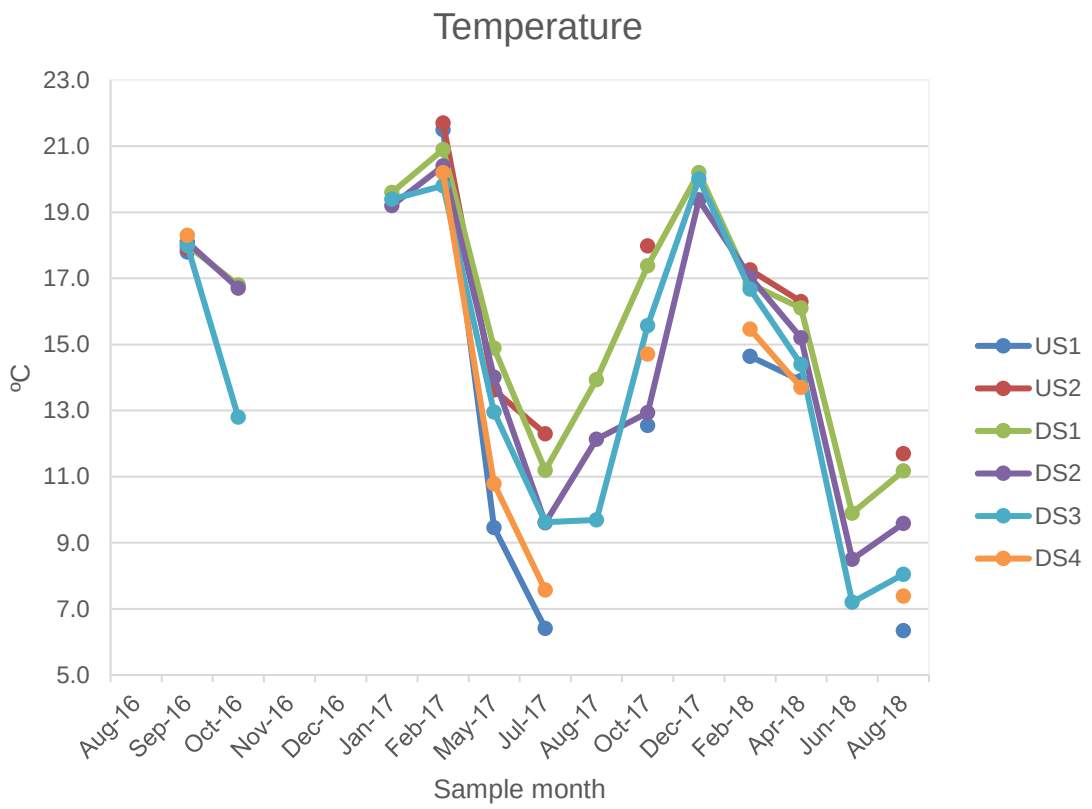
	Temp	Dissolved Oxygen	EC	pH	Turbidity	TSS	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Total Hardness as CaCO3	Chloride	Dissolved Sulfur as S	Total Sulfur as S	Sulfate as SO4 - Turbidimetric	Calcium	Magnesium	Sodium	Potassium	Total Anions	Total Cations
	°C	% sat	µS/cm	pH Units	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L
Detection limit (DL)	NA	NA	NA	NA	NA	5	1	1	1	1	1	1	1	1	1	1	1	1	1	0.01	0.01
Sample size (n)	11	6	10	10	1	12	16	16	16	16	15	16	16	15	16	16	16	16	16	16	16
n > DL	11	6	10	10	1	1	0	0	16	16	15	16	16	15	16	16	16	16	16	16	16
Min	8.5	79.8	197	5.60	-	-	<DL	<DL	7	7	40	3	7	11	28	11	3	2	1	0.86	0.93
Median	16.7	87.3	276.0	6.84	-	-	<DL	<DL	16.0	16.0	104.0	4.0	29.0	28.0	86.0	28.0	9.0	3.0	3.0	2.36	2.36
Mean	15.5	88.3	268.6	6.71	-	-	<DL	<DL	17.3	17.3	95.2	4.1	26.3	26.5	79.2	25.3	8.1	3.1	2.9	2.11	2.13
SD	4.0	7.1	32.4	0.43	-	-	<DL	<DL	7.6	7.6	29.5	1.2	8.5	8.2	25.7	7.5	3.0	0.6	1.0	0.60	0.60
80th percentile	19.2	92.3	288.0	6.99	-	-	<DL	<DL	23.0	23.0	119.2	4.0	33.0	32.2	100.0	30.0	10.0	4.0	4.0	2.55	2.66
Max	20.4	99.8	312	7.06	3.9	6	<DL	<DL	35	35	124	8	35	40	111	37	12	4	4	2.70	2.69

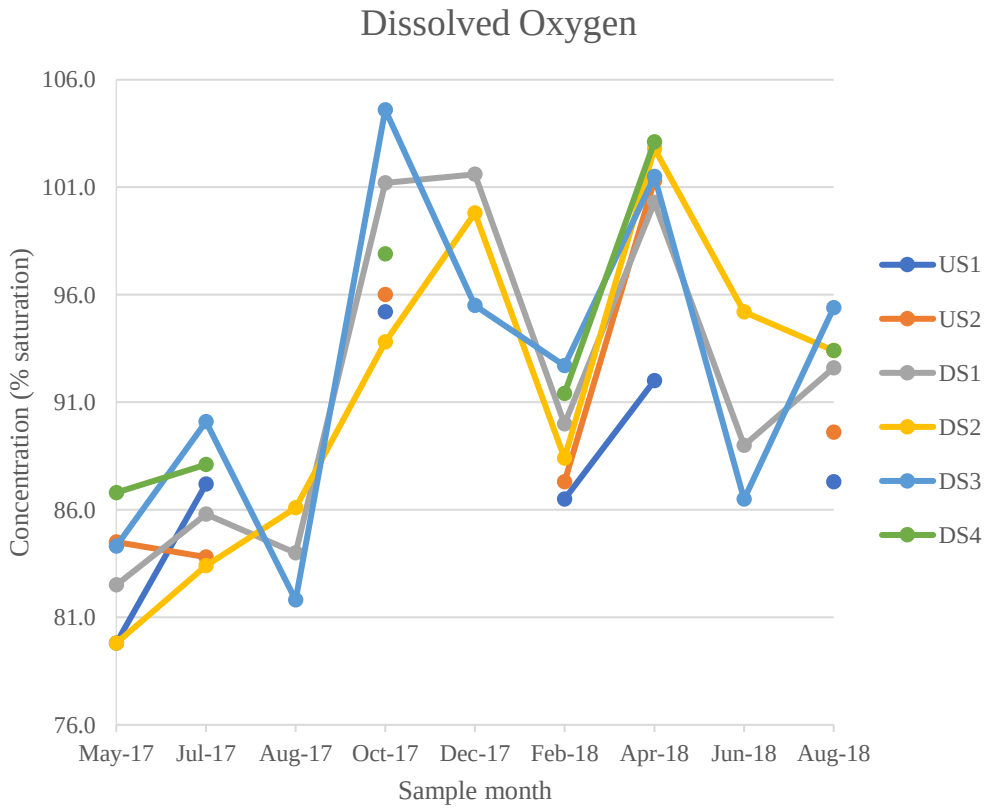
Table 7 DS3 Physical and Mineral Water Quality Summary Statistics

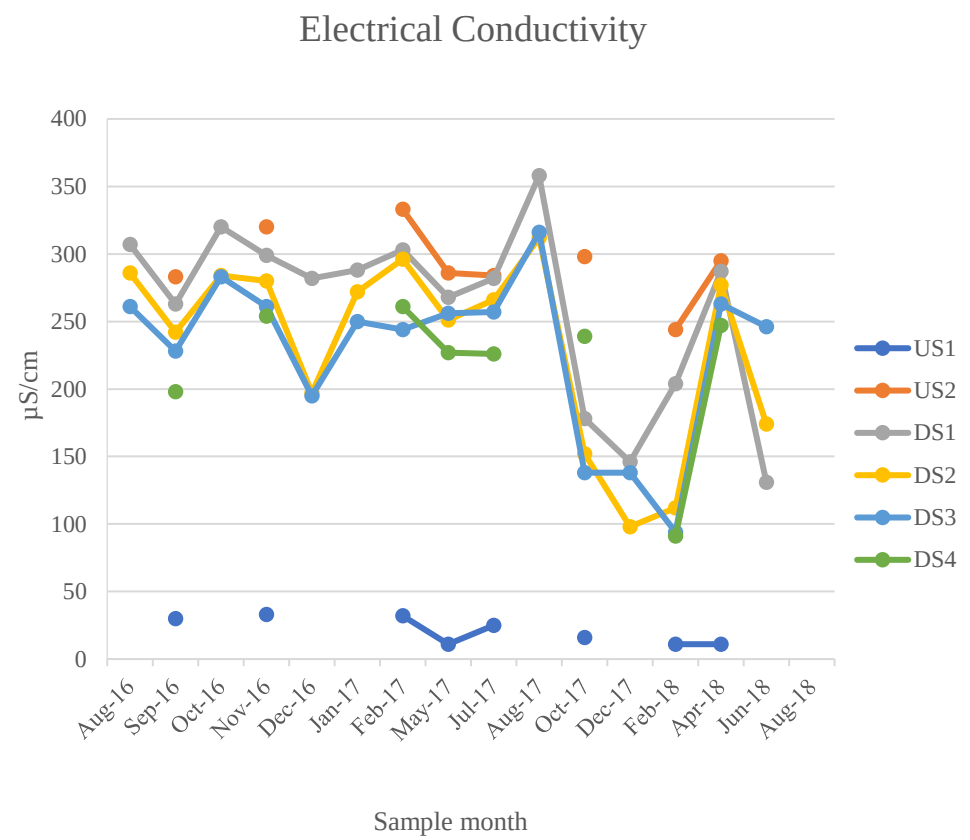
	Temp	Dissolved Oxygen	EC	pH	Turbidity	TSS	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Total Hardness as CaCO3	Chloride	Dissolved Sulfur as S	Total Sulfur as S	Sulfate as SO4 - Turbidimetric	Calcium	Magnesium	Sodium	Potassium	Total Anions	Total Cations
	°C	% sat	µS/cm	pH Units	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L
Detection limit (DL)	NA	NA	NA	NA	NA	5	1	1	1	1	1	1	1	1	1	1	1	1	1	0.01	0.01
Sample size (n)	11	6	10	10	1	12	16	16	16	16	15	16	16	15	16	16	16	16	16	16	16
n > DL	11	6	10	10	1	1	0	0	16	16	15	16	16	15	16	16	16	16	16	16	16
Min	7.2	81.8	195	5.69	-	-	<DL	<DL	6	6	31	3	10	10	28	9	2	2	1	0.87	0.77
Median	14.4	91.4	256.5	6.82	-	-	<DL	<DL	15.5	15.5	100.0	4.0	28.5	28.0	82.0	26.0	8.5	3.0	3.0	2.26	2.20
Mean	14.6	89.5	255.1	6.73	-	-	<DL	<DL	16.9	16.9	91.4	4.1	25.7	26.7	77.8	24.4	7.6	3.1	2.7	2.07	2.05
SD	4.5	5.4	31.7	0.45	-	-	<DL	<DL	7.1	7.1	24.9	1.3	7.4	6.9	23.2	6.3	2.8	0.6	0.7	0.51	0.51
80th percentile	19.4	92.7	265.4	7.00	-	-	<DL	<DL	22.0	22.0	108.4	4.0	30.0	31.0	98.0	30.0	10.0	4.0	3.0	2.43	2.41
Max	20.0	95.5	316	7.37	5.2	9	<DL	<DL	33	33	118	8	34	40	112	31	11	4	4	2.68	2.62

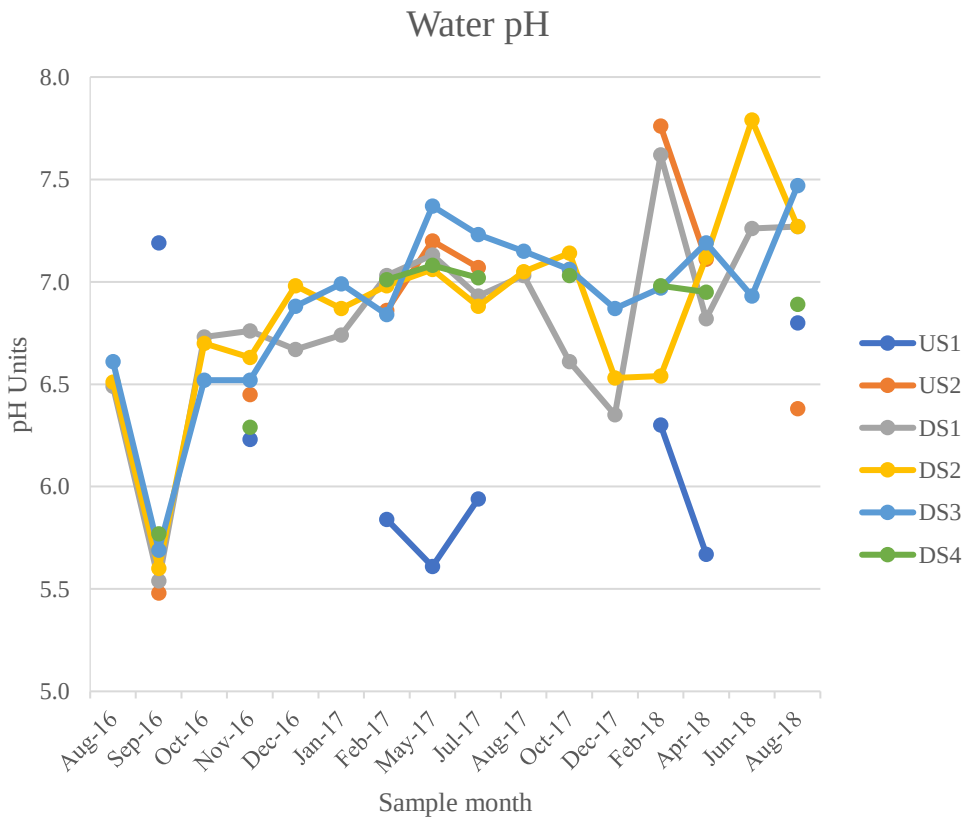
Table 8 DS4 Physical and Mineral Water Quality Summary Statistics

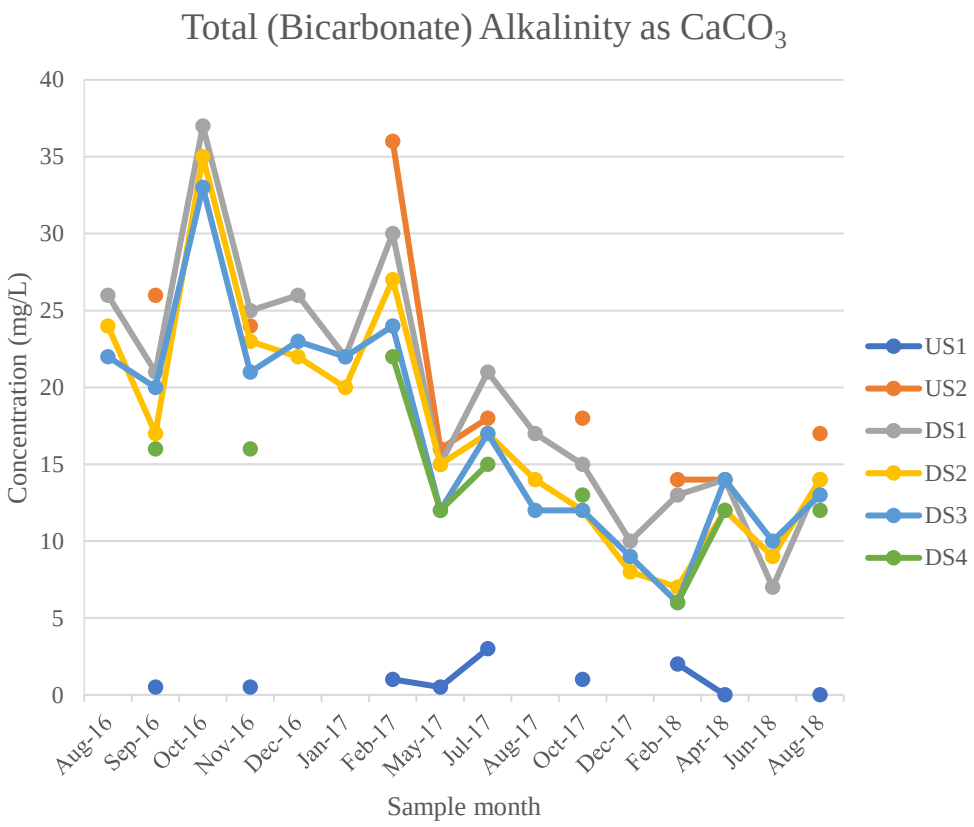
	Temp	Dissolved Oxygen	EC	pH	Turbidity	TSS	Hydroxide Alkalinity as CaCO3	Carbonate Alkalinity as CaCO3	Bicarbonate Alkalinity as CaCO3	Total Alkalinity as CaCO3	Total Hardness as CaCO3	Chloride	Dissolved Sulfur as S	Total Sulfur as S	Sulfate as SO4 - Turbidimetric	Calcium	Magnesium	Sodium	Potassium	Total Anions	Total Cations
	°C	% sat	µS/cm	pH Units	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L
Detection limit (DL)	NA	NA	NA	NA	NA	5	1	1	1	1	1	1	1	1	1	1	1	1	1	0.01	0.01
Sample size (n)	6	4	5	5	1	6	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
n > DL	6	4	5	5	1	0	0	0	9	9	9	9	9	9	9	9	9	9	9	9	9
Min	7.6	86.8	198	5.77	-	<DL	<DL	<DL	6	6	28	3	10	10	29	8	2	2	1	0.89	0.72
Median	14.6	89.8	227.0	7.01	-	<DL	<DL	<DL	13.0	13.0	91.0	4.0	27.0	27.0	79.0	25.0	8.0	3.0	3.0	2.07	1.99
Mean	14.3	91.3	233.2	6.64	-	<DL	<DL	<DL	13.8	13.8	85.3	4.0	24.4	24.6	74.1	23.0	6.8	2.9	2.7	1.93	1.90
SD	4.7	5.4	25.2	0.58	-	<DL	<DL	<DL	4.3	4.3	22.2	0.9	6.0	6.4	19.8	6.1	2.2	0.8	0.9	0.43	0.47
80th percentile	18.3	94.4	255.4	7.04	-	<DL	<DL	<DL	16.0	16.0	98.4	4.0	27.4	28.4	88.4	25.4	8.0	3.4	3.0	2.17	2.21
Max	20.2	98.9	261	7.08	3.4	<DL	<DL	<DL	22	22	100	6	30	30	94	30	9	4	4	2.31	2.24

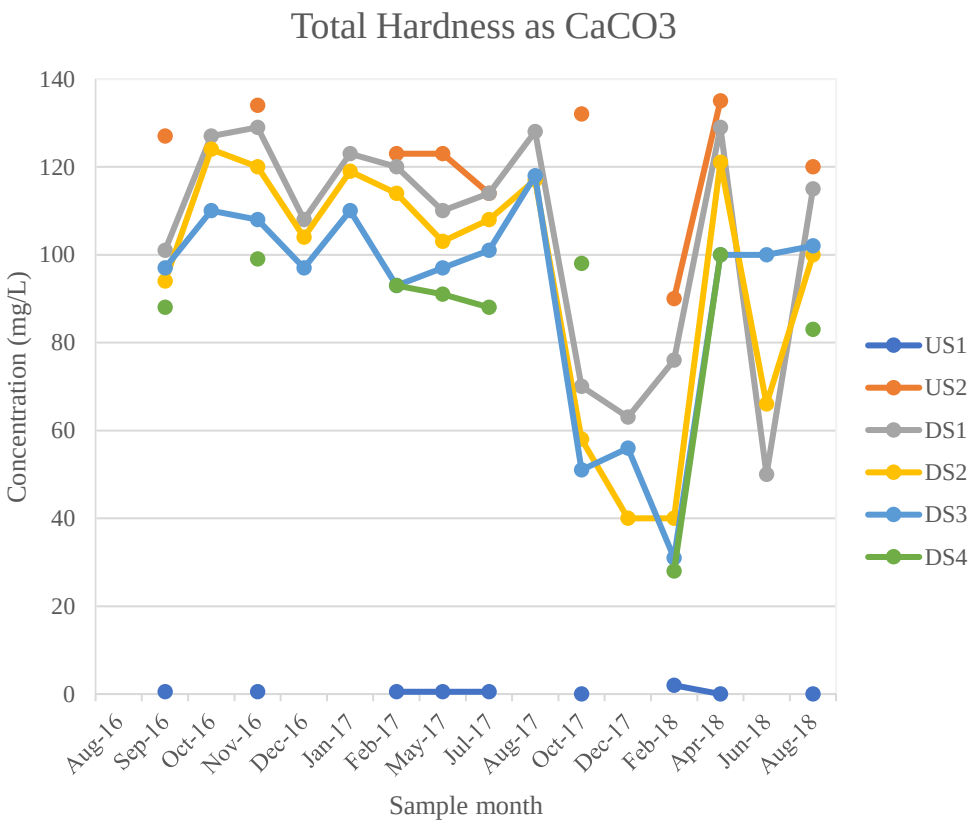

Temperature
23.0
21.0
19.0
17.0
15.0
13.0
11.0
9.0
7.0
5.0
°C
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

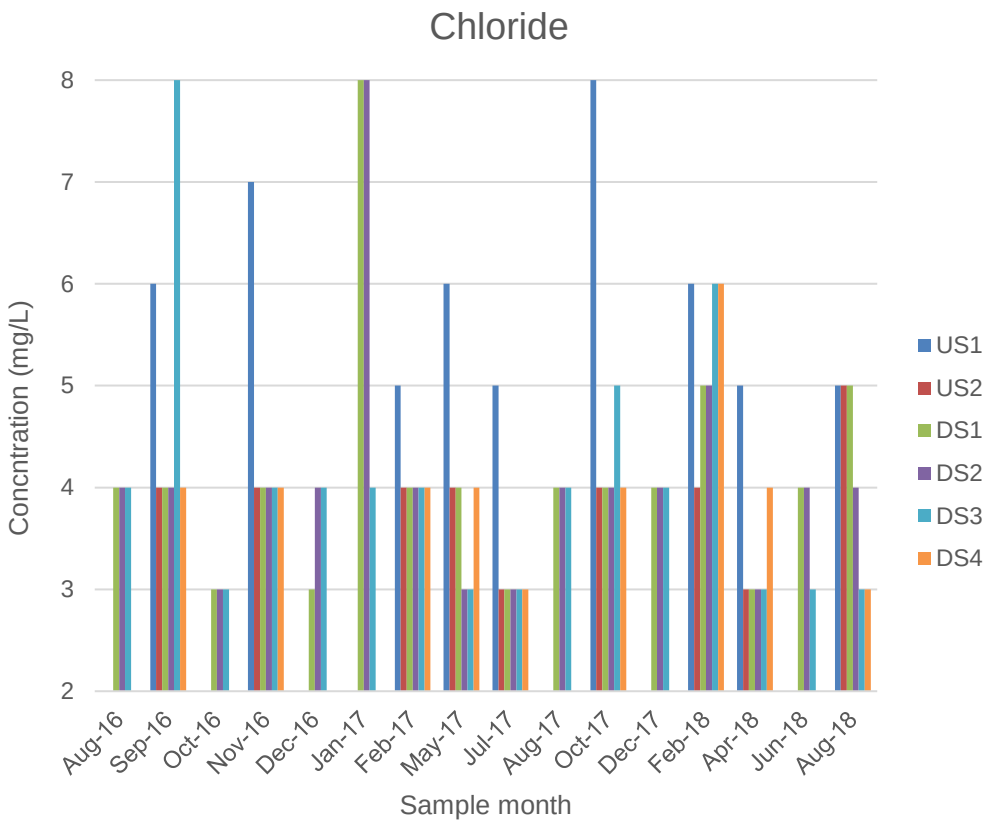

Dissolved Oxygen
106.0
101.0
96.0
91.0
86.0
81.0
76.0
Concentration (% saturation)
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

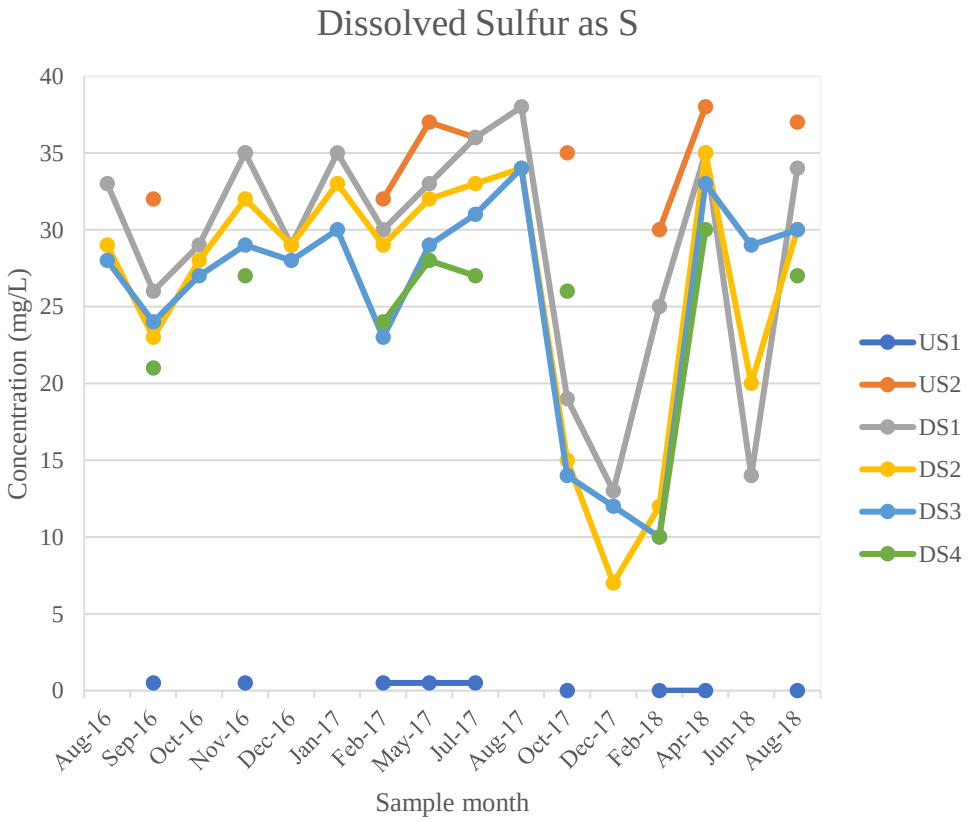

Electrical Conductivity
µS/cm
400
350
300
250
200
150
100
50
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

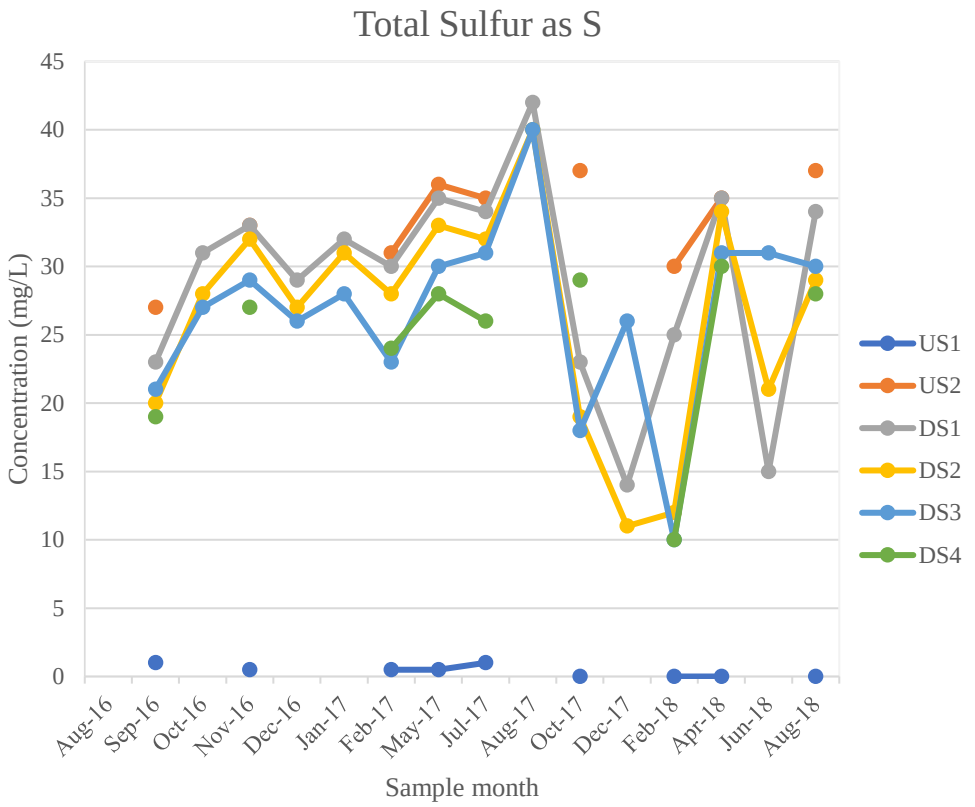

Water pH
pH Units
8.0
7.5
7.0
6.5
6.0
5.5
5.0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

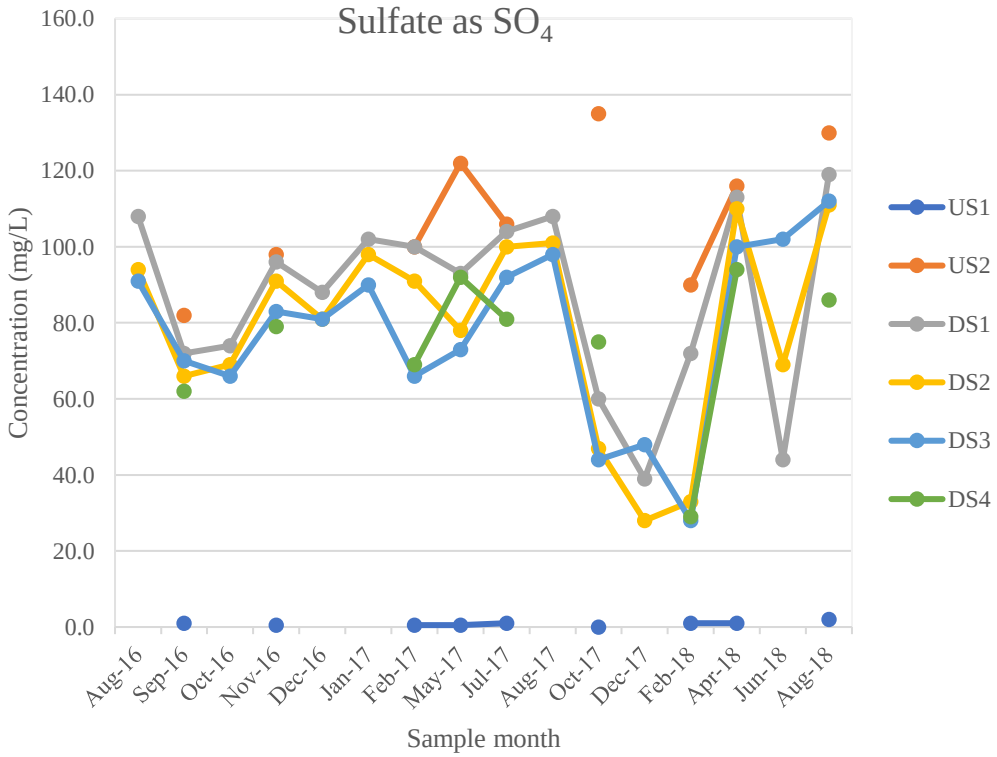

Total (Bicarbonate) Alkalinity as $CaCO_3$
Concentration (mg/L)
40
35
30
25
20
15
10
5
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

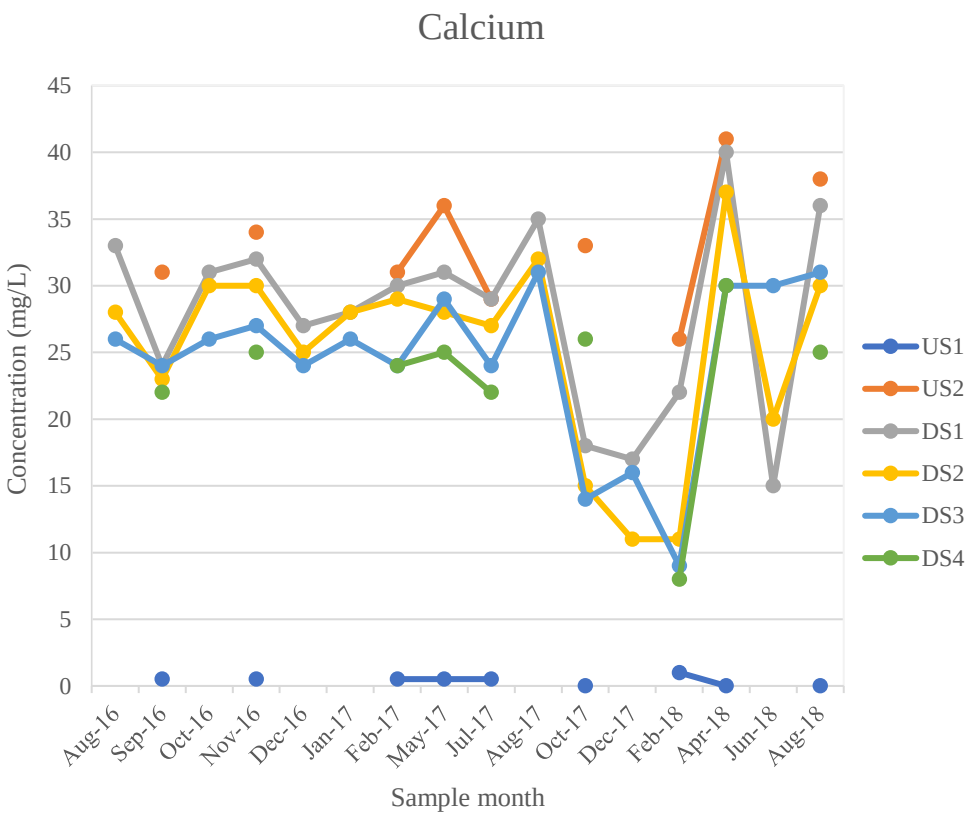

Total Hardness as CaCO3
Concentration (mg/L)
140
120
100
80
60
40
20
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

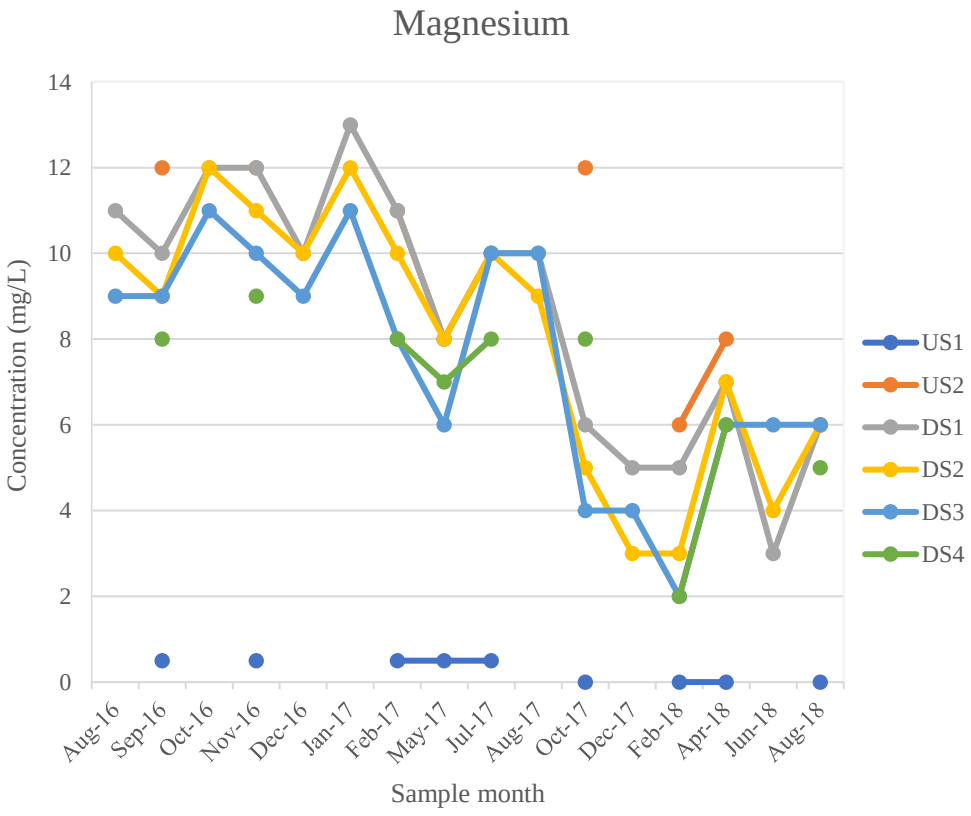

Chloride
Concntration (mg/L)
8
7
6
5
4
3
2
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

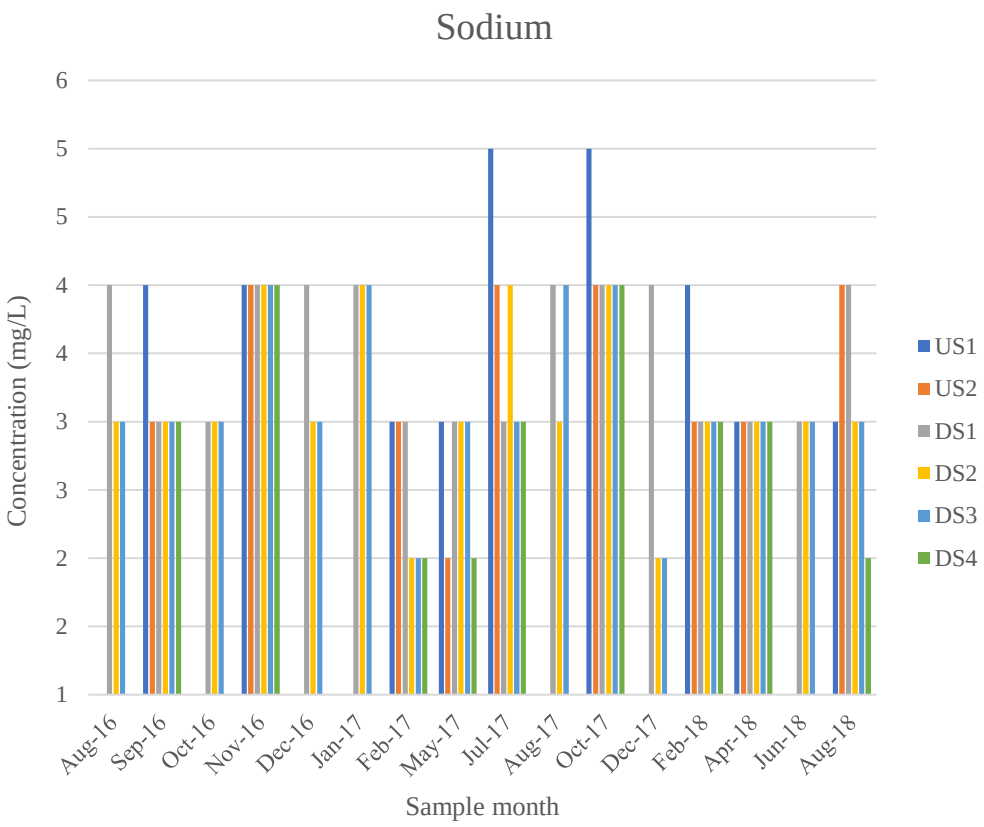

Dissolved Sulfur as S
Concentration (mg/L)
40
35
30
25
20
15
10
5
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

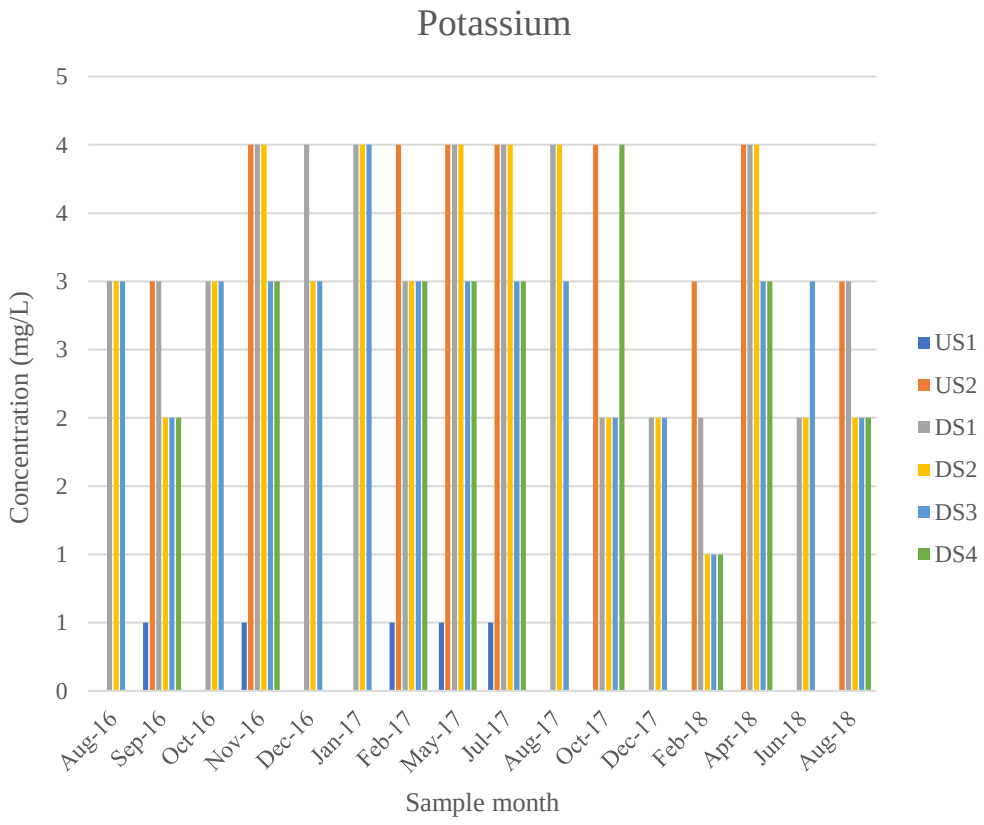

Total Sulfur as S
Concentration (mg/L)
45
40
35
30
25
20
15
10
5
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

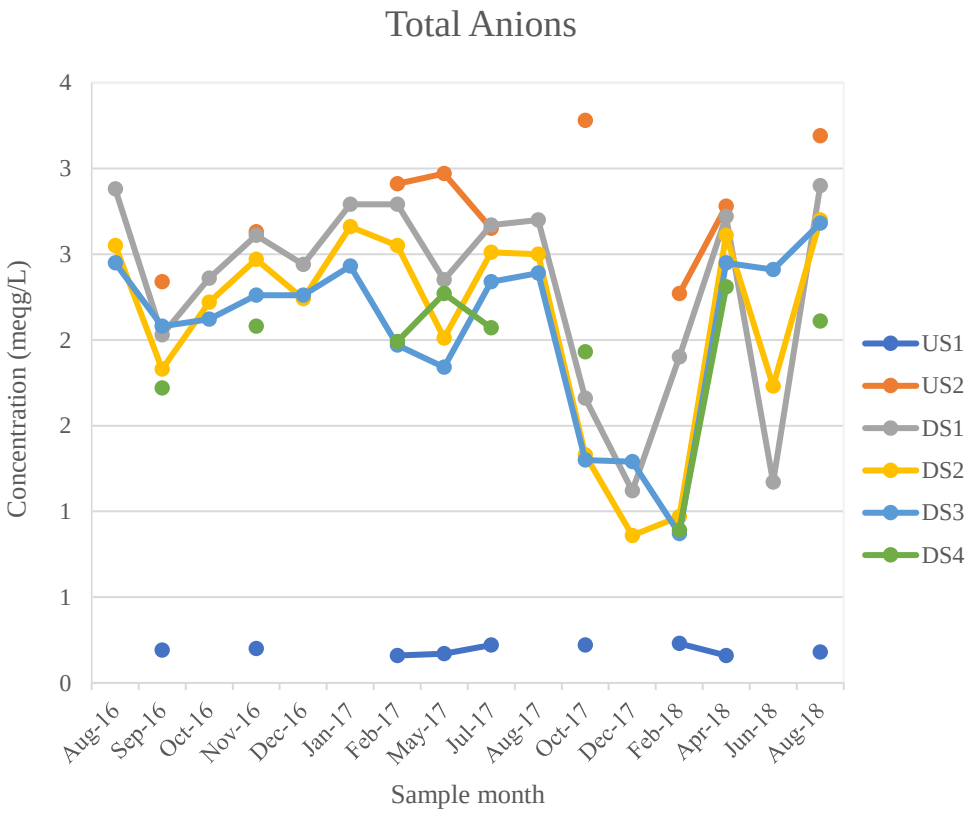

Sulfate as SO4
Concentration (mg/L)
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

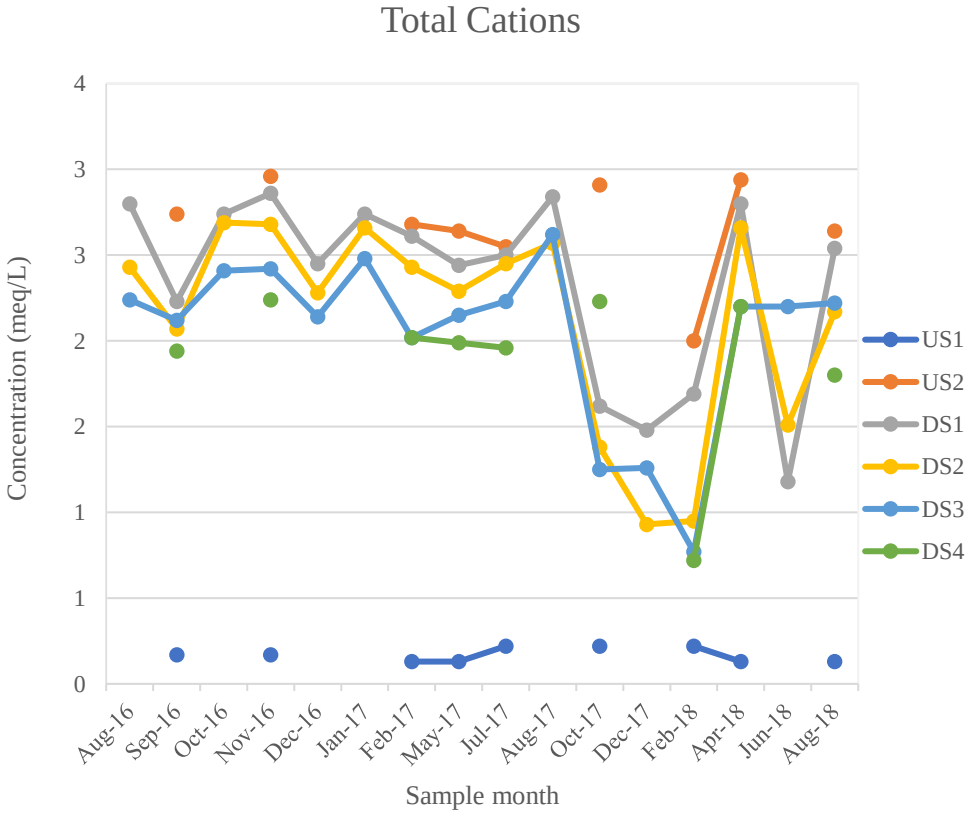

Calcium
Concentration (mg/L)
45
40
35
30
25
20
15
10
5
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

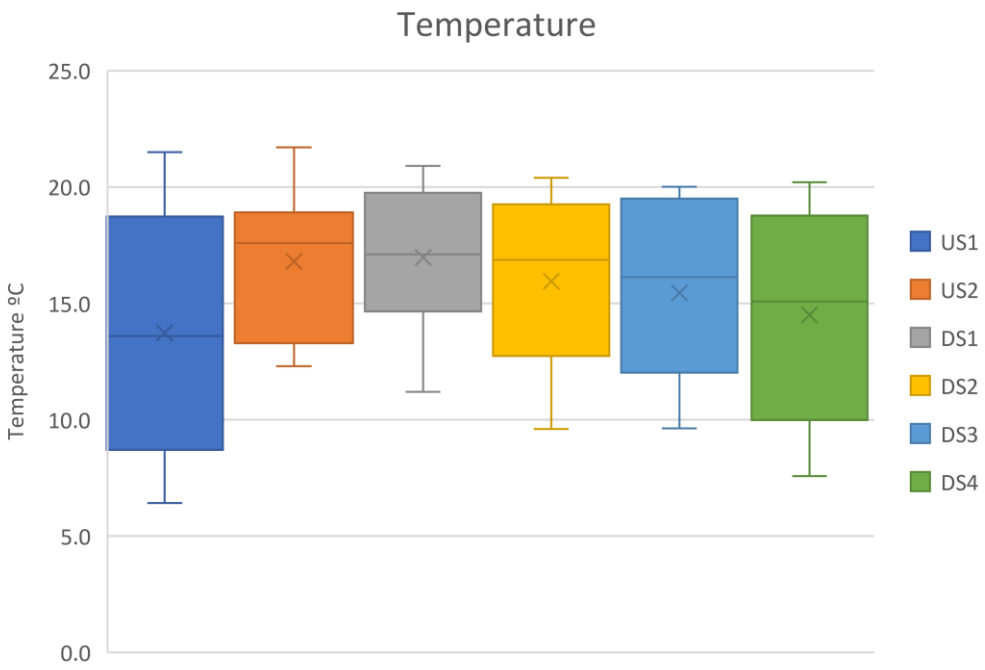

Magnesium
Concentration (mg/L)
14
12
10
8
6
4
2
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

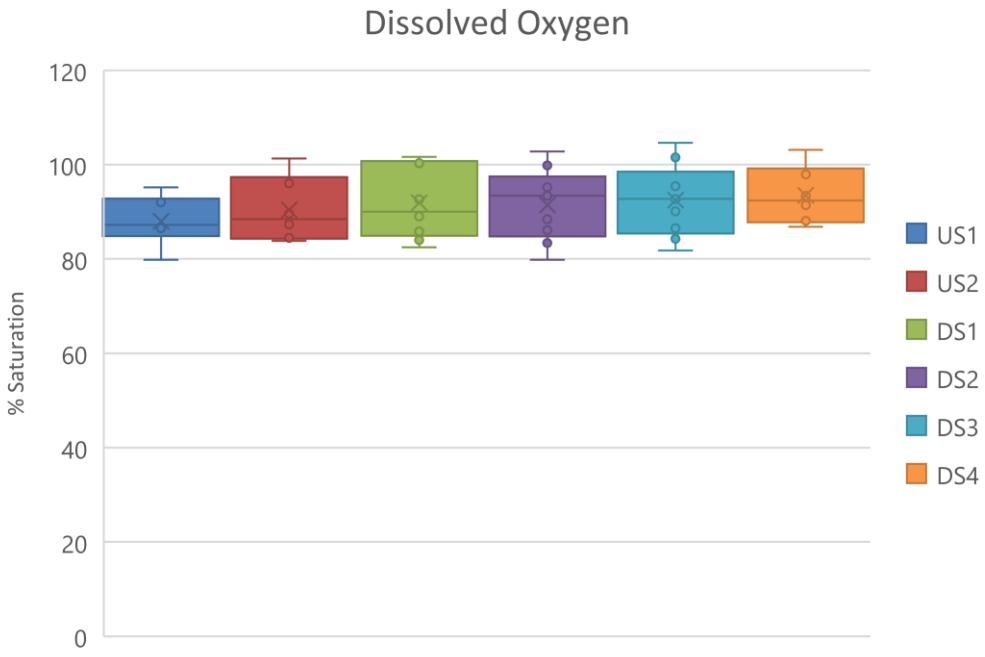

Sodium
Concentration (mg/L)
6
5
5
4
4
3
3
2
2
1
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

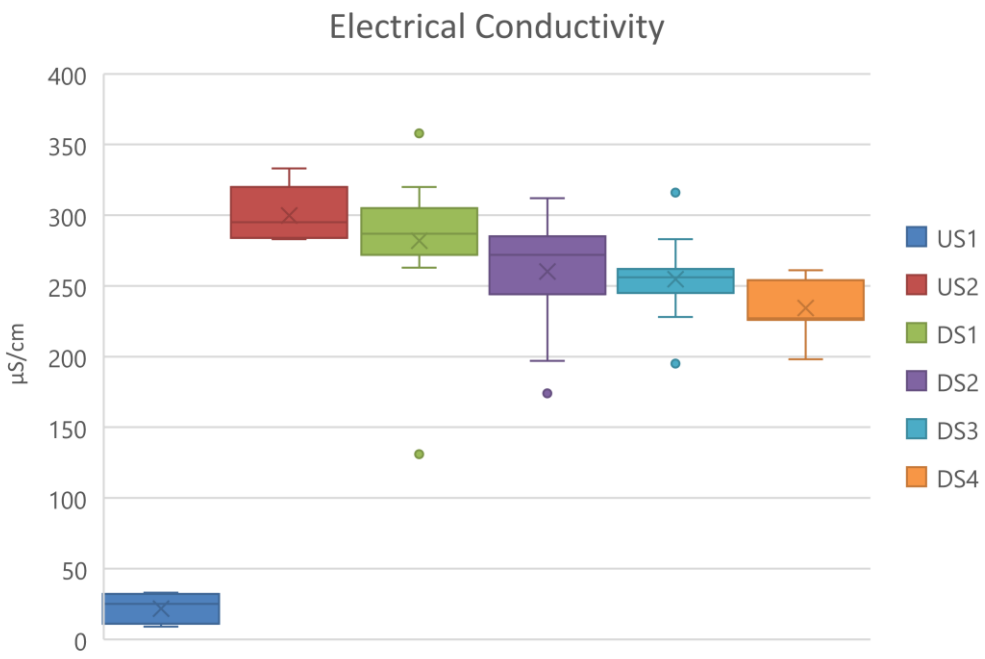

Potassium
Concentration (mg/L)
5
4
4
3
3
2
2
1
1
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

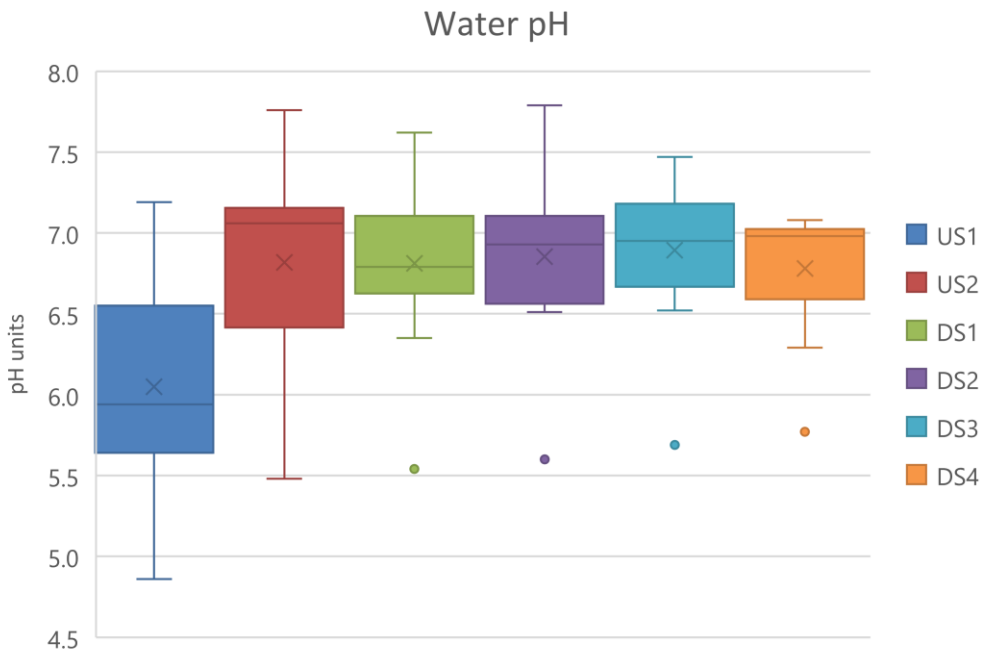

Total Anions
Concentration (meqg/L)
4
3
3
2
2
1
1
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

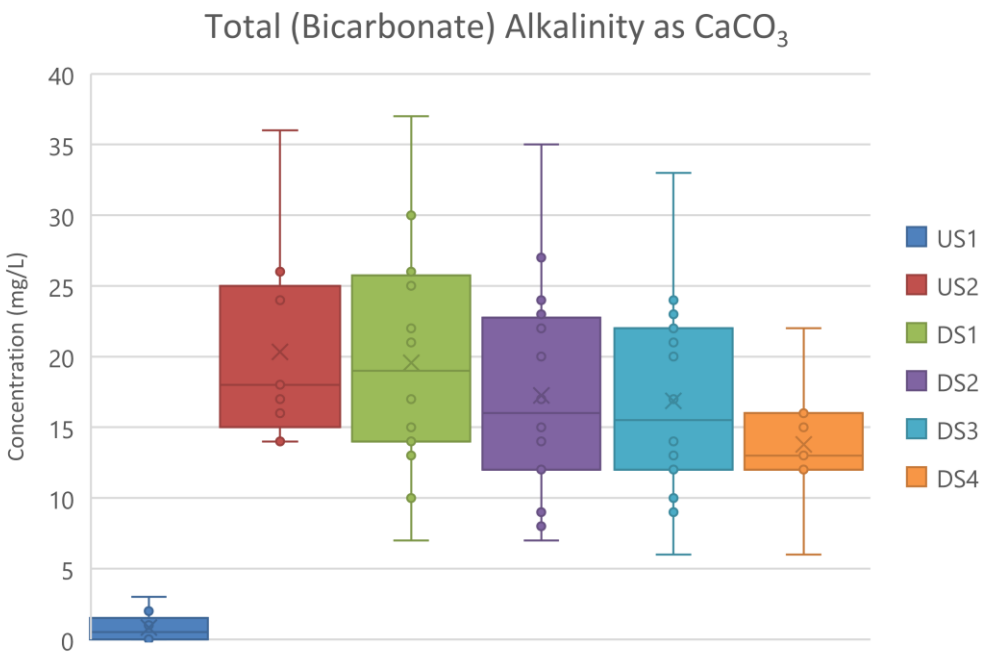

Total Cations
Concentration (meq/L)
4
3
3
2
2
1
1
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

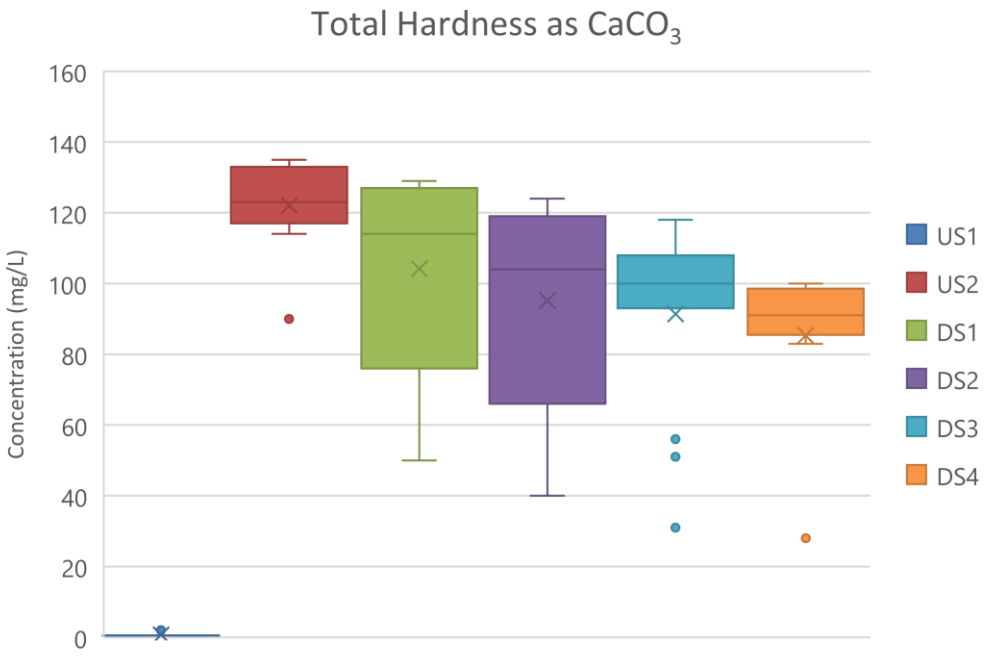

Temperature
25.0
20.0
15.0
10.0
5.0
0.0
Temperature ºC
US1
US2
DS1
DS2
DS3
DS4

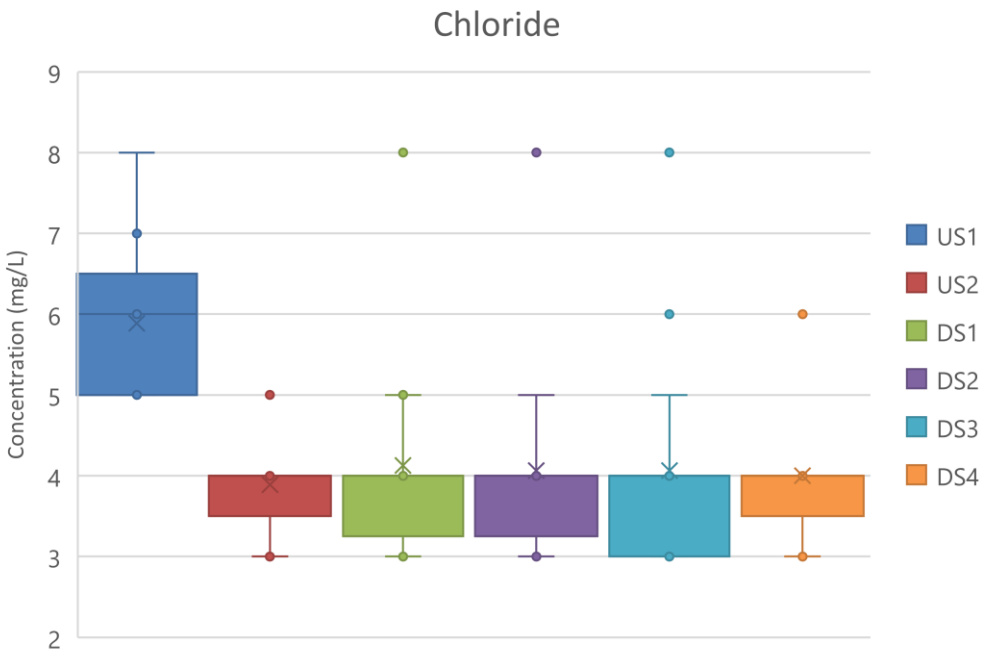

Dissolved Oxygen
120
100
80
60
40
20
0
% Saturation
US1
US2
DS1
DS2
DS3
DS4

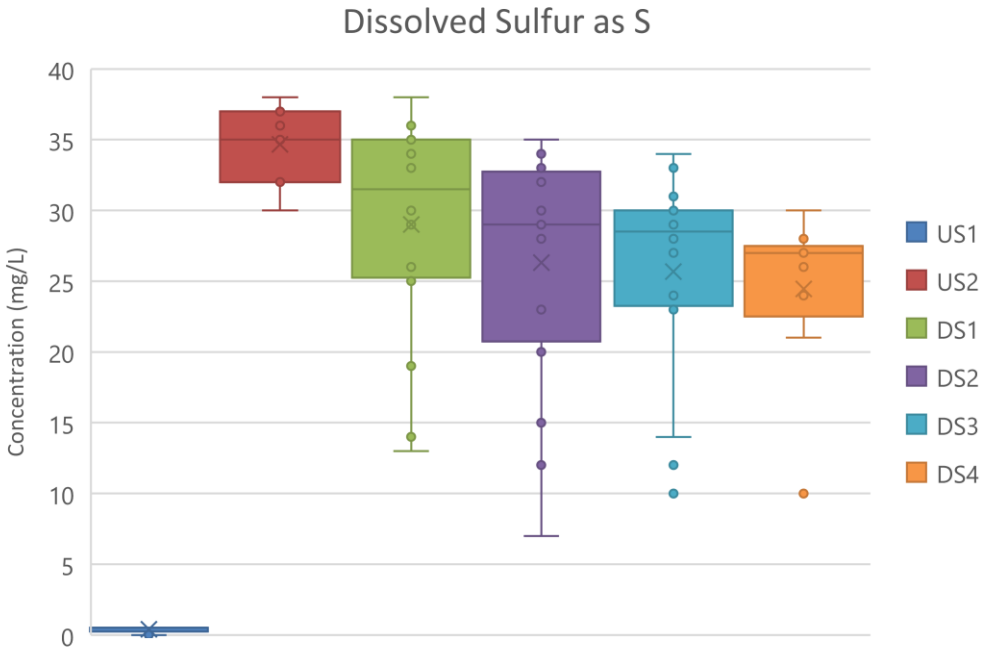

Electrical Conductivity
400
350
300
250
200
150
100
50
0
µS/cm
US1
US2
DS1
DS2
DS3
DS4

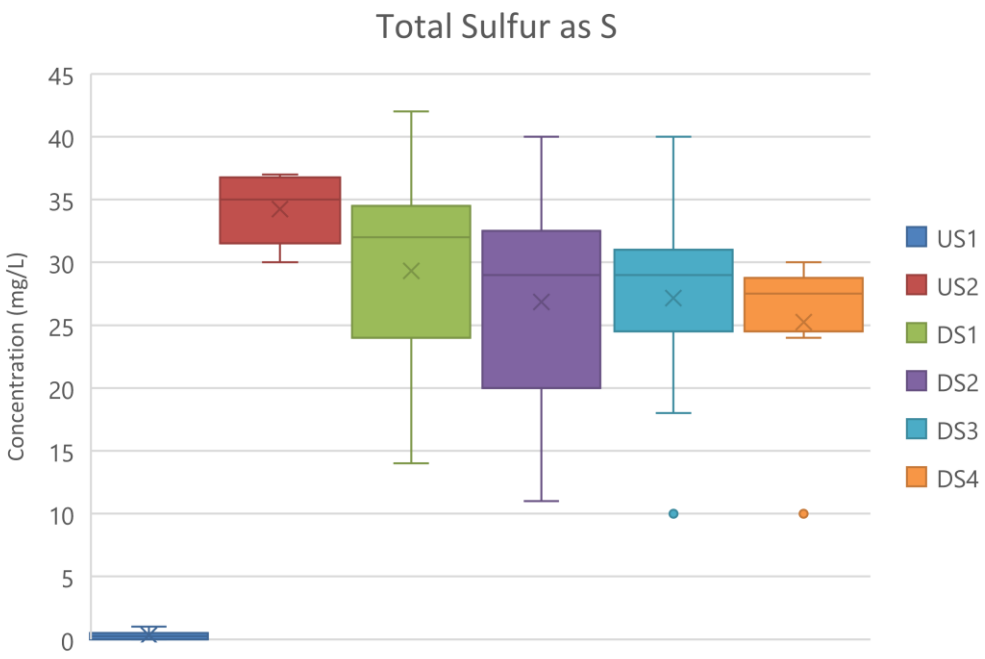

Water pH
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
pH units
US1
US2
DS1
DS2
DS3
DS4

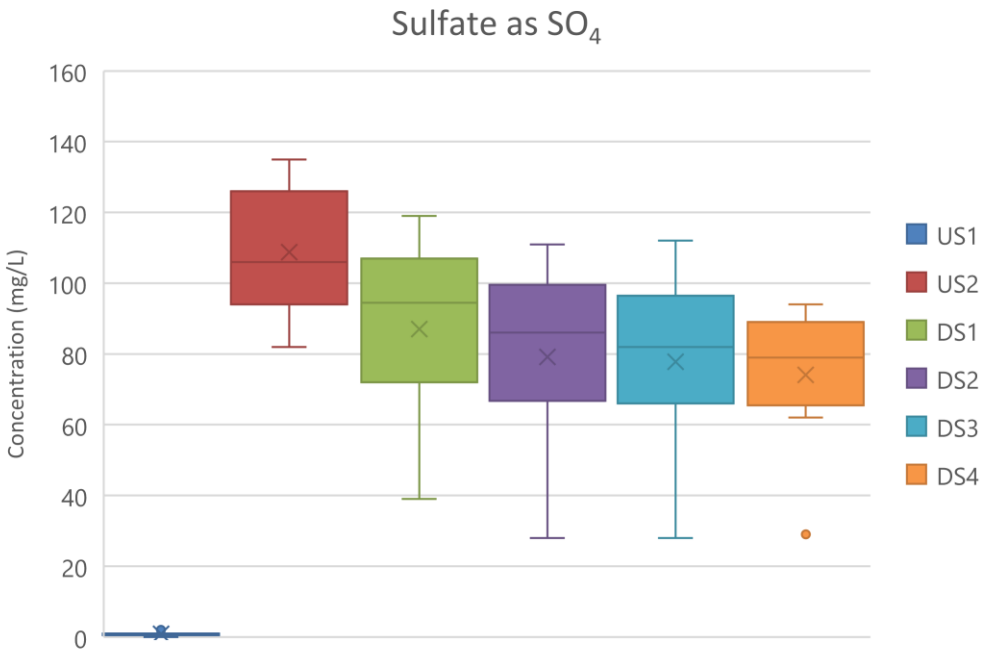

Total (Bicarbonate) Alkalinity as $CaCO_3$
Concentration (mg/L)
40
35
30
25
20
15
10
5
0
US1
US2
DS1
DS2
DS3
DS4

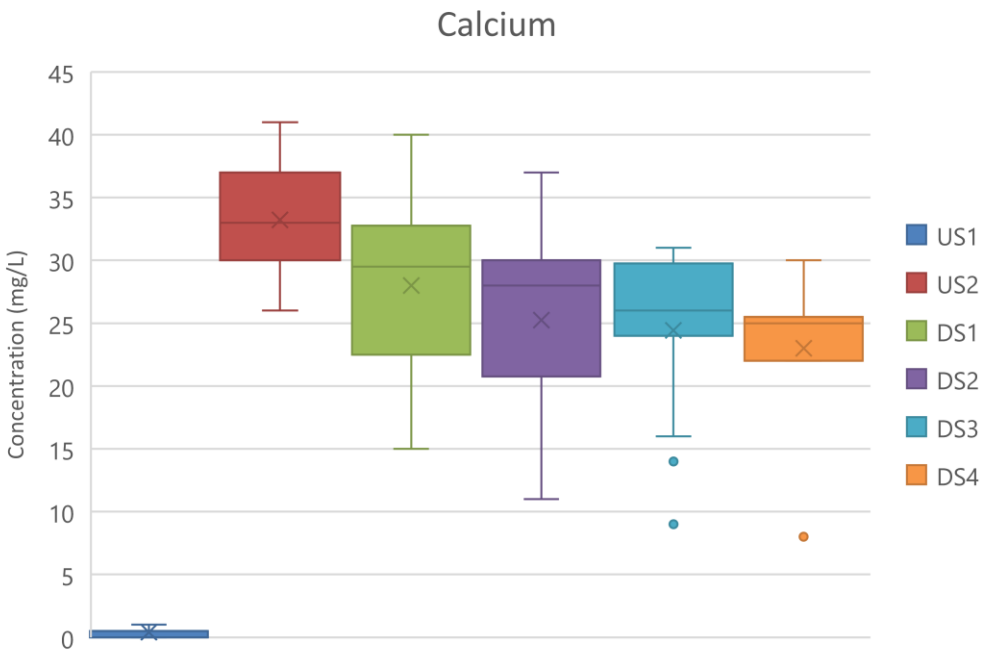

Total Hardness as $CaCO_3$
Concentration (mg/L)
160
140
120
100
80
60
40
20
0
US1
US2
DS1
DS2
DS3
DS4

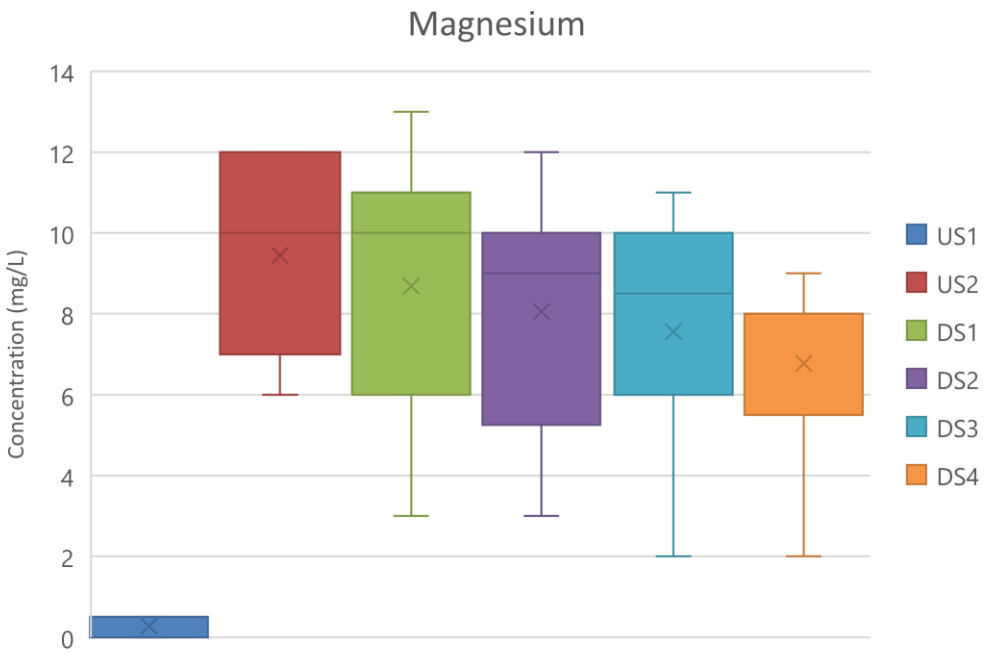

Chloride
Concentration (mg/L)
9
8
7
6
5
4
3
2
US1
US2
DS1
DS2
DS3
DS4

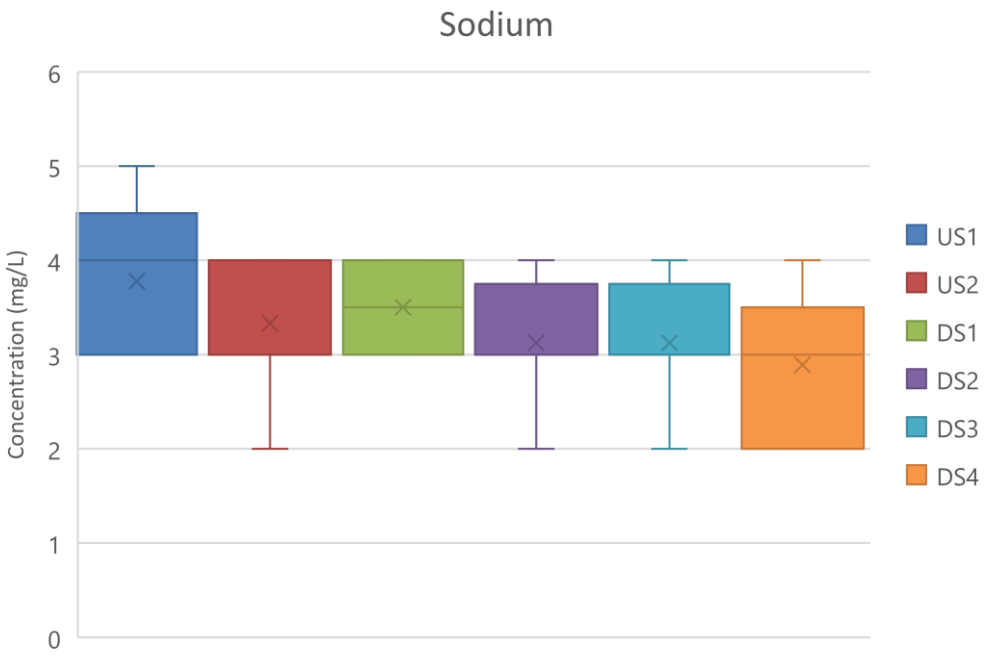

Dissolved Sulfur as S
Concentration (mg/L)
40
35
30
25
20
15
10
5
0
US1
US2
DS1
DS2
DS3
DS4

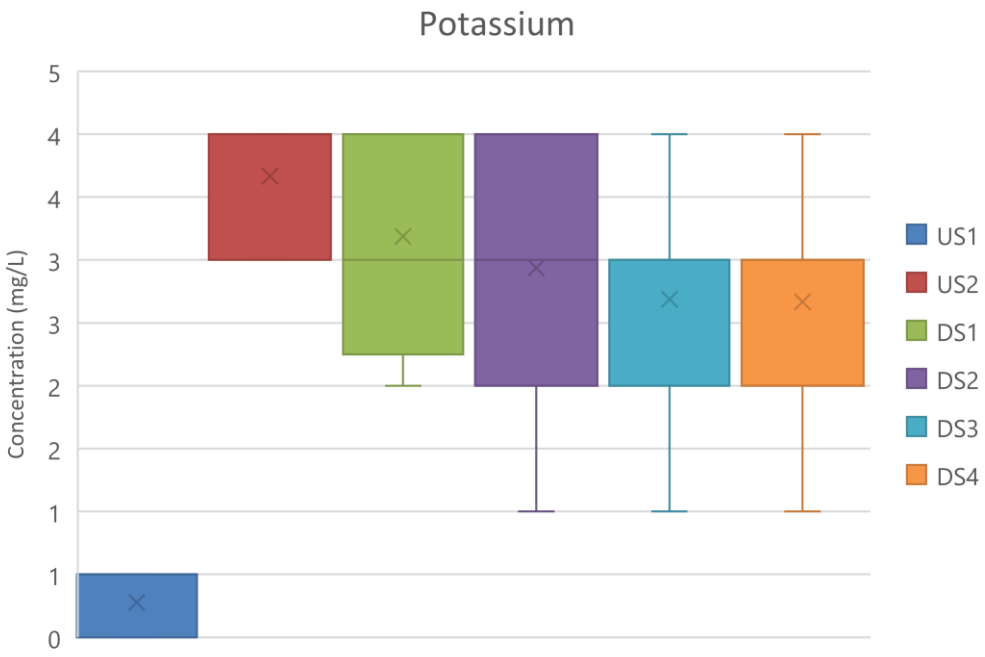

Total Sulfur as S
Concentration (mg/L)
45
40
35
30
25
20
15
10
5
0
US1
US2
DS1
DS2
DS3
DS4

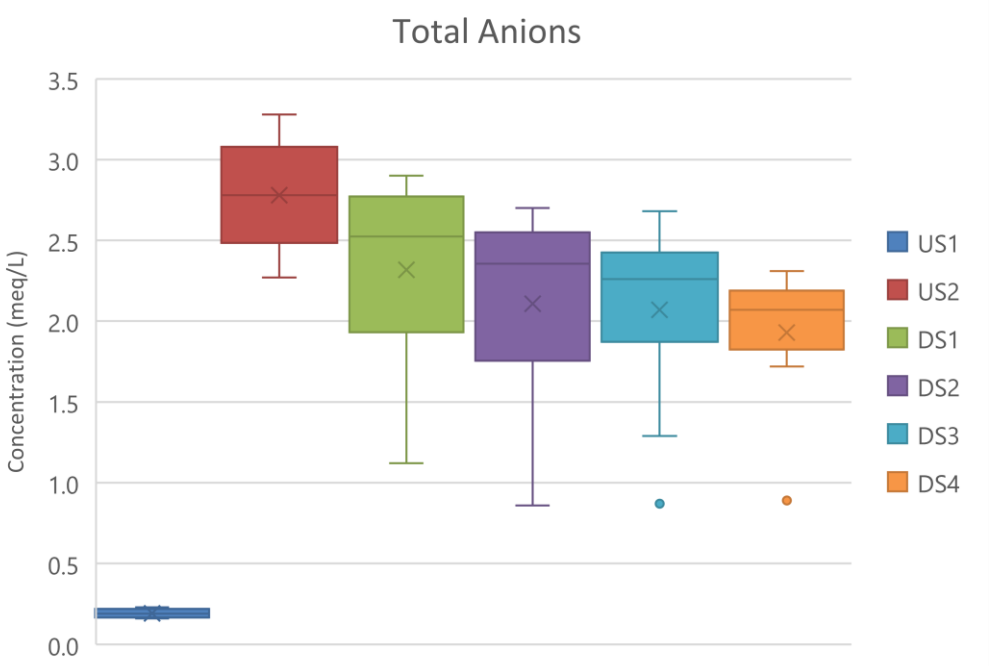

Sulfate as SO4
Concentration (mg/L)
160
140
120
100
80
60
40
20
0
US1
US2
DS1
DS2
DS3
DS4

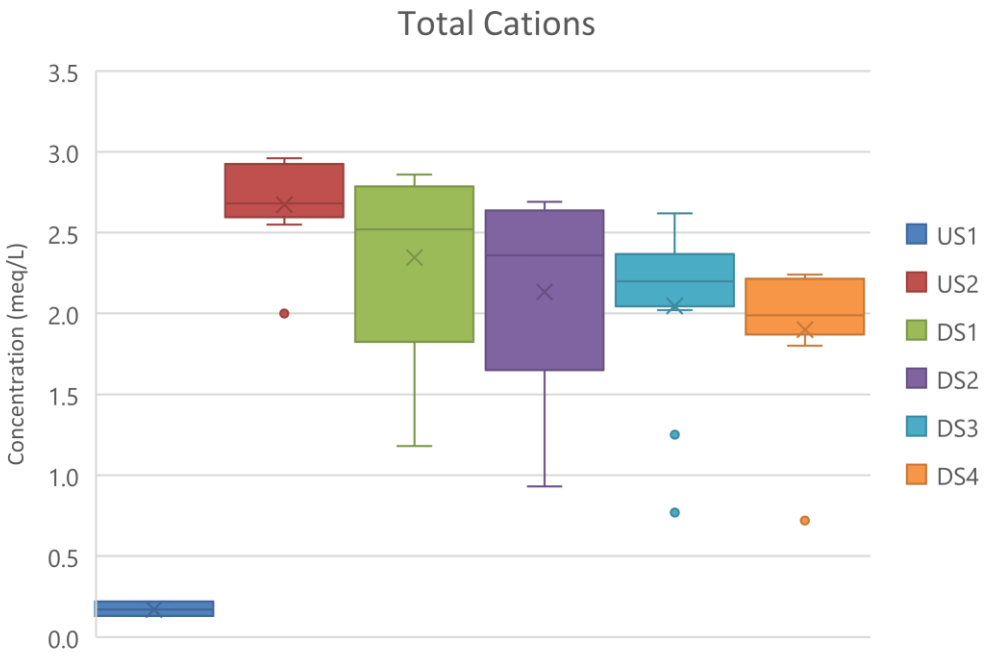

Calcium
Concentration (mg/L)
45
40
35
30
25
20
15
10
5
0
US1
US2
DS1
DS2
DS3
DS4


Magnesium
Concentration (mg/L)
14
12
10
8
6
4
2
0
US1
US2
DS1
DS2
DS3
DS4


Sodium
Concentration (mg/L)
6
5
4
3
2
1
0
US1
US2
DS1
DS2
DS3
DS4


Potassium
Concentration (mg/L)
5
4
4
3
3
2
2
1
1
0
US1
US2
DS1
DS2
DS3
DS4


Total Anions
Concentration (meq/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
US1
US2
DS1
DS2
DS3
DS4


Total Cations
Concentration (meq/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
US1
US2
DS1
DS2
DS3
DS4

3.3 Nutrients & Organics Water Quality Monitoring Data

The nutrients and organics water quality results for each sampling location and event are provided below in Site Summary **Tables 9 to 14**, Control Charts, and Box Plots:

- Nitrite Detection Limit (DL < 0.01mg/L), Oil and Grease (DL < 5 mg/L), Total Phenol (DL < 0.05mg/L) and Total Cyanide (DL < 0.004mg/L) concentrations were all below DL for all sites and for all sampling times to date, and are not plotted as Control Graphs or Box Plots.
- Fluoride concentrations at all sites were below Detection Limit of 0.1mg/L apart from site DS2.
- Total Phosphorus (TP) concentrations at sites US2 and DS3 were below detection.
- TKN was below detection for all surveys at sites DS2 and DS4.
- Total Nitrogen (TN) was below detection for all surveys at sites DS2 and DS4.
- TP, TKN, and TN at the sites nominated above are graphed at half Detection Limit values in the Control Graphs and Box Plots.

Table 9 US1 Nutrient and Organic Water Quality Summary Statistics

	Nutrients								Dissolved		Total			Organics		Misc	
	Ammonia	Nitrite	Nitrate	Nitrogen Oxides	Organic Nitrogen	Total Kjeldahl Nitrogen	Total Nitrogen	Total Phosphorus	Silicon as SiO2	Silicon	Silicon as SiO2	Silicon	Total Organic Carbon	Oil & Grease	Phenols	Total Cyanide	Fluoride
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.01	0.01	0.01	0.1	0.1	0.1	0.01	0.1	0.05	0.1	0.05	1	5	0.05	0.004	0.1
Sample size (n)	9	9	9	9	0	9	9	9	9	9	9	9	9	9	9	9	9
n > DL	4	0	4	4	0	3	3	1	9	9	9	9	8	0	0	0	0
Min	0.01	<DL	0.01	0.01	<DL	0.10	0.10	-	3.9	1.82	3.9	1.82	1.0	<DL	<DL	<DL	<DL
Median	0.01	<DL	0.01	0.01	<DL	0.05	0.05	-	4.7	2.19	4.9	2.26	2.0	<DL	<DL	<DL	<DL
Mean	0.01	<DL	0.01	0.01	<DL	0.08	0.08	-	5.0	2.32	5.0	2.32	1.6	<DL	<DL	<DL	<DL
SD	0.01	<DL	0.01	0.01	<DL	0.05	0.05	-	1.0	0.46	0.9	0.39	0.6	<DL	<DL	<DL	<DL
80th percentile	0.02	<DL	0.02	0.02	<DL	0.10	0.10	-	5.6	2.62	5.2	2.40	2.0	<DL	<DL	<DL	<DL
Max	0.03	<DL	0.03	0.03	<DL	0.20	0.20	0.02	6.6	3.11	6.9	3.21	2.0	<DL	<DL	<DL	<DL

Table 10 US2 Nutrient and Organic Water Quality Summary Statistics

	Nutrients								Dissolved		Total			Organics		Misc	
	Ammonia	Nitrite	Nitrate	Nitrogen Oxides	Organic Nitrogen	Total Kjeldahl Nitrogen	Total Nitrogen	Total Phosphorus	Silicon as SiO2	Silicon	Silicon as SiO2	Silicon	Total Organic Carbon	Oil & Grease	Phenols	Total Cyanide	Fluoride
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.01	0.01	0.01	0.1	0.1	0.1	0.01	0.1	0.05	0.1	0.05	1	5	0.05	0.004	0.1
Sample size (n)	9	9	9	9	0	9	9	9	9	9	9	9	9	9	9	9	9
n > DL	4	0	2	2	0	2	2	0	9	9	9	9	3	0	0	0	0
Min	0.01	<DL	0.01	0.01	<DL	0.20	0.20	<DL	5.0	2.34	4.8	2.24	1.0	<DL	<DL	<DL	<DL
Median	0.01	<DL	-	-	<DL	-	-	<DL	5.7	2.68	5.8	2.64	0.5	<DL	<DL	<DL	<DL
Mean	0.02	<DL	-	-	<DL	-	-	<DL	5.8	2.70	5.7	2.63	0.8	<DL	<DL	<DL	<DL
SD	0.03	<DL	-	-	<DL	-	-	<DL	0.7	0.33	0.4	0.19	0.5	<DL	<DL	<DL	<DL
80th percentile	0.02	<DL	-	-	<DL	-	-	<DL	6.2	2.89	5.9	2.78	1.0	<DL	<DL	<DL	<DL
Max	0.11	<DL	0.04	0.04	<DL	0.20	0.20	<DL	7.1	3.32	6.4	2.84	2.0	<DL	<DL	<DL	<DL

Table 11 DS1 Nutrient and Organic Water Quality Summary Statistics

	Nutrients								Dissolved		Total			Organics		Misc	
	Ammonia	Nitrite	Nitrate	Nitrogen Oxides	Organic Nitrogen	Total Kjeldahl Nitrogen	Total Nitrogen	Total Phosphorus	Silicon as SiO2	Silicon	Silicon as SiO2	Silicon	Total Organic Carbon	Oil & Grease	Phenols	Total Cyanide	Fluoride
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.01	0.01	0.01	0.1	0.1	0.1	0.01	0.1	0.05	0.1	0.05	1	5	0.05	0.004	0.1
Sample size (n)	16	16	16	16	1	16	16	16	16	16	15	15	16	16	16	16	16
n > DL	4	0	7	7	0	3	3	1	16	16	15	15	7	0	0	0	0
Min	0.01	<DL	0.01	0.01	<DL	0.10	0.10	-	5.2	2.42	5.0	2.35	1.0	<DL	<DL	<DL	<DL
Median	0.01	<DL	0.01	0.01	<DL	0.05	0.05	-	5.7	2.66	5.8	2.69	0.5	<DL	<DL	<DL	<DL
Mean	0.02	<DL	0.02	0.02	<DL	0.09	0.09	-	5.8	2.73	6.2	2.88	0.9	<DL	<DL	<DL	<DL
SD	0.02	<DL	0.03	0.03	<DL	0.09	0.09	-	0.6	0.28	1.7	0.80	0.6	<DL	<DL	<DL	<DL
80th percentile	0.03	<DL	0.02	0.02	<DL	0.05	0.05	-	6.4	2.99	6.1	2.80	1.0	<DL	<DL	<DL	<DL
Max	0.07	<DL	0.09	0.09	<DL	0.30	0.30	0.1	7.1	3.33	12.2	5.69	2.0	<DL	<DL	<DL	<DL

Table 12 DS2 Nutrient and Organic Water Quality Summary Statistics

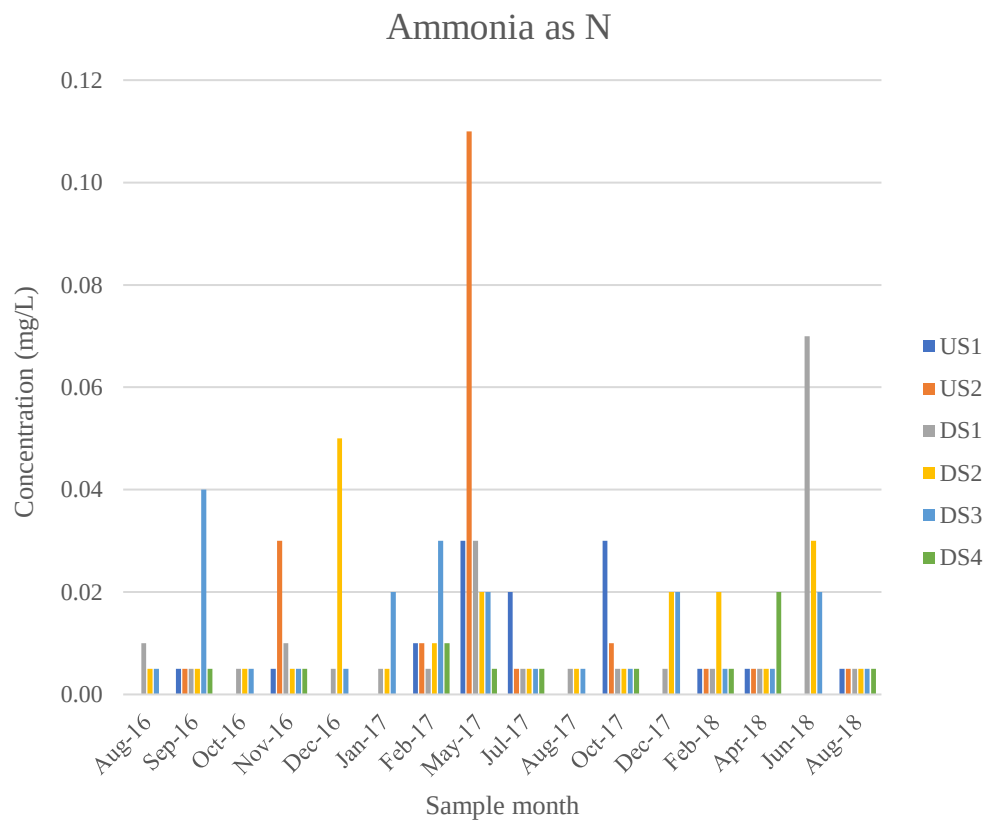
	Nutrients								Dissolved		Total			Organics		Misc	
	Ammonia	Nitrite	Nitrate	Nitrogen Oxides	Organic Nitrogen	Total Kjeldahl Nitrogen	Total Nitrogen	Total Phosphorus	Silicon as SiO2	Silicon	Silicon as SiO2	Silicon	Total Organic Carbon	Oil & Grease	Phenols	Total Cyanide	Fluoride
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.01	0.01	0.01	0.1	0.1	0.1	0.01	0.1	0.05	0.1	0.05	1	5	0.05	0.004	0.1
Sample size (n)	16	16	16	16	1	16	16	16	16	16	15	15	16	16	16	16	16
n > DL	6	0	9	9	0	1	1	2	16	16	15	15	4	0	0	0	1
Min	0.01	<DL	0.01	0.01	<DL	-	-	0.03	4.6	2.17	4.7	2.20	1.0	<DL	<DL	<DL	-
Median	0.01	<DL	0.02	0.02	<DL	-	-	-	5.5	2.57	5.7	2.64	0.5	<DL	<DL	<DL	-
Mean	0.01	<DL	0.02	0.02	<DL	-	-	-	5.7	2.65	5.7	2.63	0.8	<DL	<DL	<DL	-
SD	0.01	<DL	0.01	0.01	<DL	-	-	-	0.7	0.30	0.4	0.19	0.6	<DL	<DL	<DL	-
80th percentile	0.02	<DL	0.02	0.02	<DL	-	-	-	6.0	2.82	5.9	2.77	1.0	<DL	<DL	<DL	-
Max	0.05	<DL	0.03	0.03	<DL	0.20	0.20	0.04	7.0	3.25	6.4	2.91	2.0	<DL	<DL	<DL	0.2

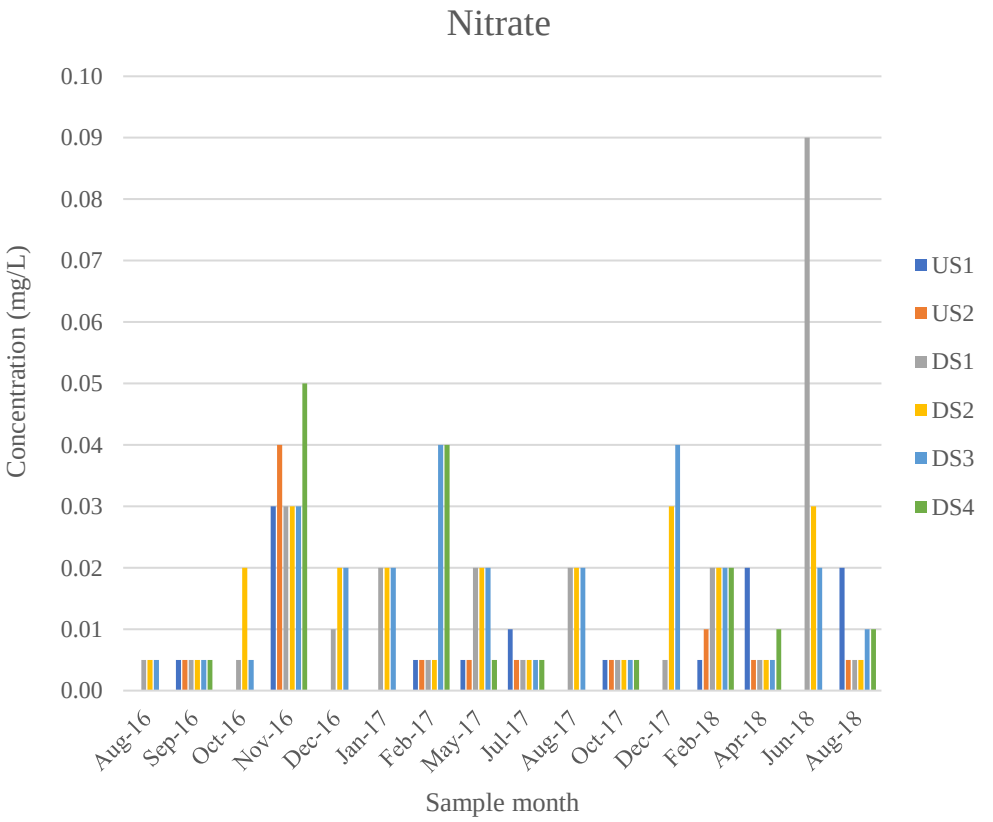
Table 13 DS3 Nutrient and Organic Water Quality Summary Statistics

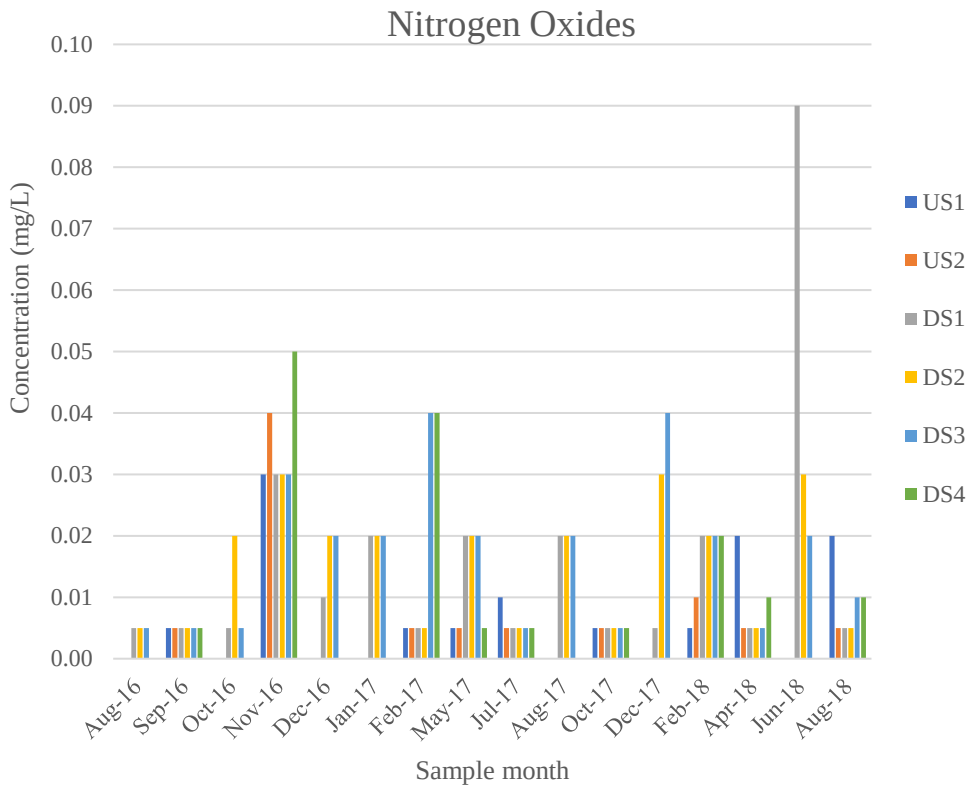
	Nutrients								Dissolved		Total			Organics		Misc	
	Ammonia	Nitrite	Nitrate	Nitrogen Oxides	Organic Nitrogen	Total Kjeldahl Nitrogen	Total Nitrogen	Total Phosphorus	Silicon as SiO2	Silicon	Silicon as SiO2	Silicon	Total Organic Carbon	Oil & Grease	Phenols	Total Cyanide	Fluoride
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.01	0.01	0.01	0.1	0.1	0.1	0.01	0.1	0.05	0.1	0.05	1	5	0.05	0.004	0.1
Sample size (n)	14	14	14	14	1	14	14	14	14	14	13	13	14	14	14	14	14
n > DL	5	0	8	8	0	1	1	0	14	14	13	13	3	0	0	0	0
Min	0.01	<DL	0.01	0.01	<DL	-	-	<DL	4.6	2.17	4.7	2.20	1.0	<DL	<DL	<DL	<DL
Median	0.01	<DL	0.02	0.02	<DL	-	-	<DL	5.3	2.49	5.6	2.57	0.5	<DL	<DL	<DL	<DL
Mean	0.01	<DL	0.02	0.02	<DL	-	-	<DL	5.4	2.53	5.7	2.66	0.9	<DL	<DL	<DL	<DL
SD	0.01	<DL	0.01	0.01	<DL	-	-	<DL	0.6	0.26	1.0	0.48	0.8	<DL	<DL	<DL	<DL
80th percentile	0.02	<DL	0.02	0.02	<DL	-	-	<DL	5.6	2.60	5.9	2.75	1.1	<DL	<DL	<DL	<DL
Max	0.04	<DL	0.04	0.04	<DL	0.10	0.10	<DL	6.8	3.20	8.8	4.12	3.0	<DL	<DL	<DL	<DL

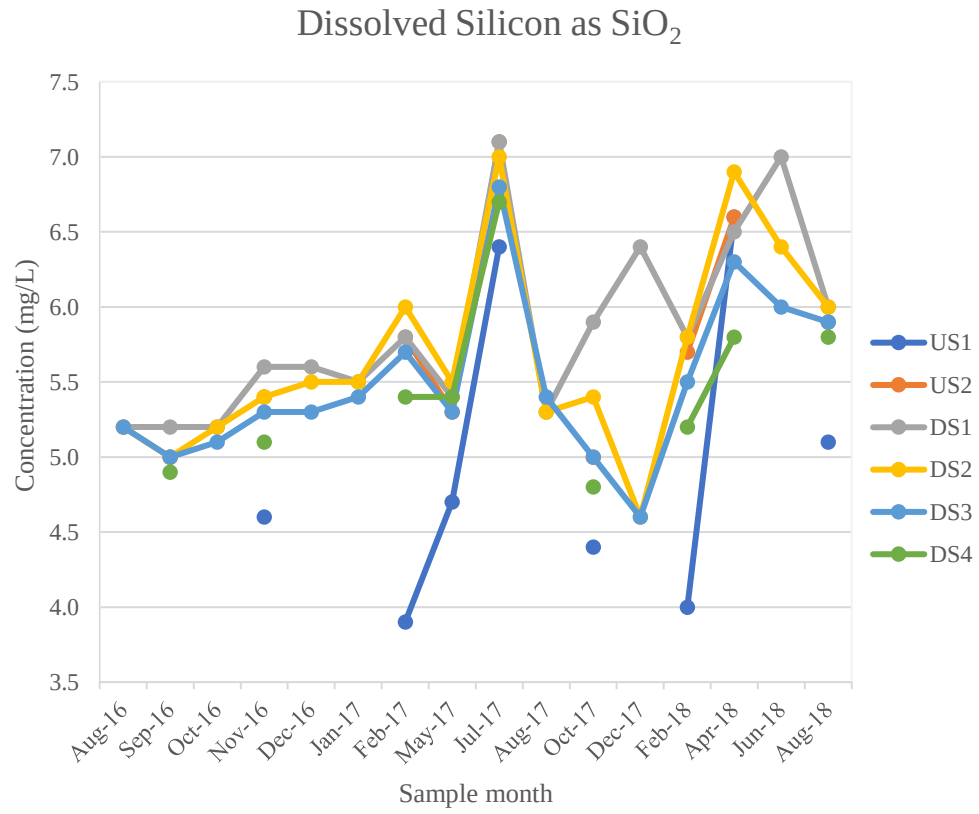
Table 14 DS4 Nutrient and Organic Water Quality Summary Statistics

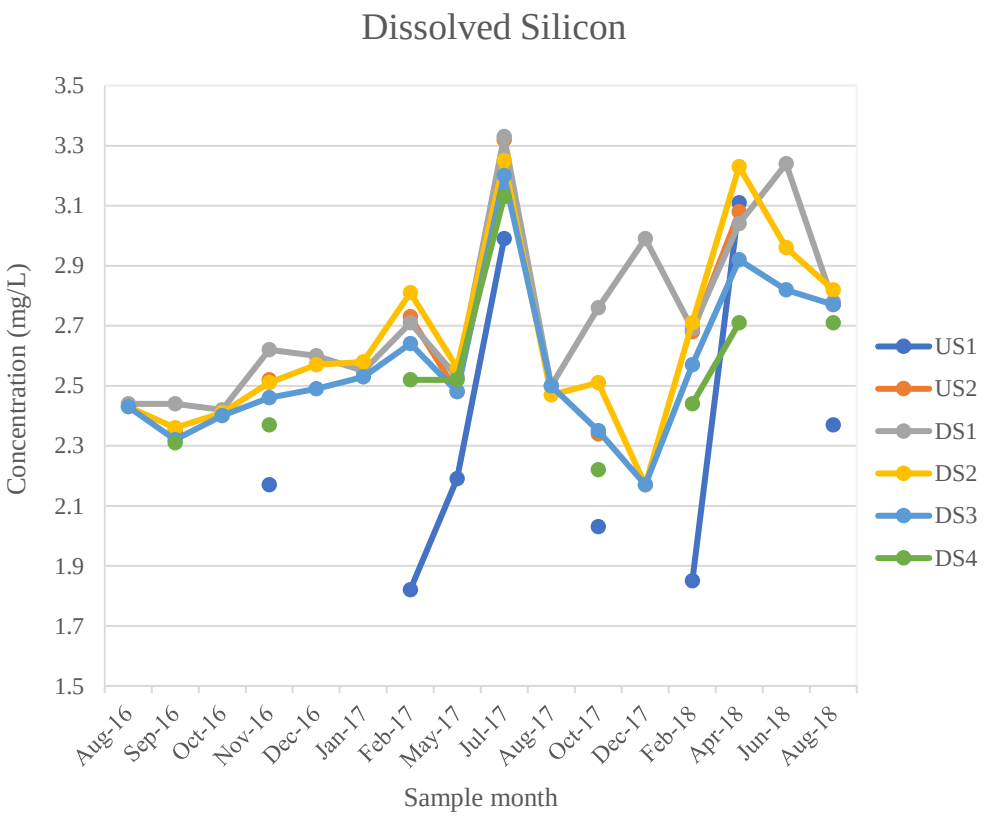
	Nutrients								Dissolved		Total			Organics		Misc	
	Ammonia	Nitrite	Nitrate	Nitrogen Oxides	Organic Nitrogen	Total Kjeldahl Nitrogen	Total Nitrogen	Total Phosphorus	Silicon as SiO2	Silicon	Silicon as SiO2	Silicon	Total Organic Carbon	Oil & Grease	Phenols	Total Cyanide	Fluoride
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.01	0.01	0.01	0.1	0.1	0.1	0.01	0.1	0.05	0.1	0.05	1	5	0.05	0.004	0.1
Sample size (n)	9	9	9	9	0	9	9	9	9	9	9	9	9	9	9	9	9
n > DL	2	0	5	5	0	0	0	2	9	9	9	9	2	0	0	0	0
Min	0.01	<DL	0.01	0.01	<DL	<DL	<DL	0.02	4.8	2.22	4.6	2.16	2.0	<DL	<DL	<DL	<DL
Median	-	<DL	0.01	0.01	<DL	<DL	<DL	-	5.4	2.52	5.5	2.55	-	<DL	<DL	<DL	<DL
Mean	-	<DL	0.02	0.02	<DL	<DL	<DL	-	5.5	2.55	5.5	2.55	-	<DL	<DL	<DL	<DL
SD	-	<DL	0.02	0.02	<DL	<DL	<DL	-	0.6	0.27	0.6	0.26	-	<DL	<DL	<DL	<DL
80th percentile	-	<DL	0.03	0.03	<DL	<DL	<DL	-	5.8	2.71	5.8	2.66	-	<DL	<DL	<DL	<DL
Max	0.02	<DL	0.05	0.05	<DL	<DL	<DL	0.3	6.7	3.13	6.6	3.09	3.0	<DL	<DL	<DL	<DL

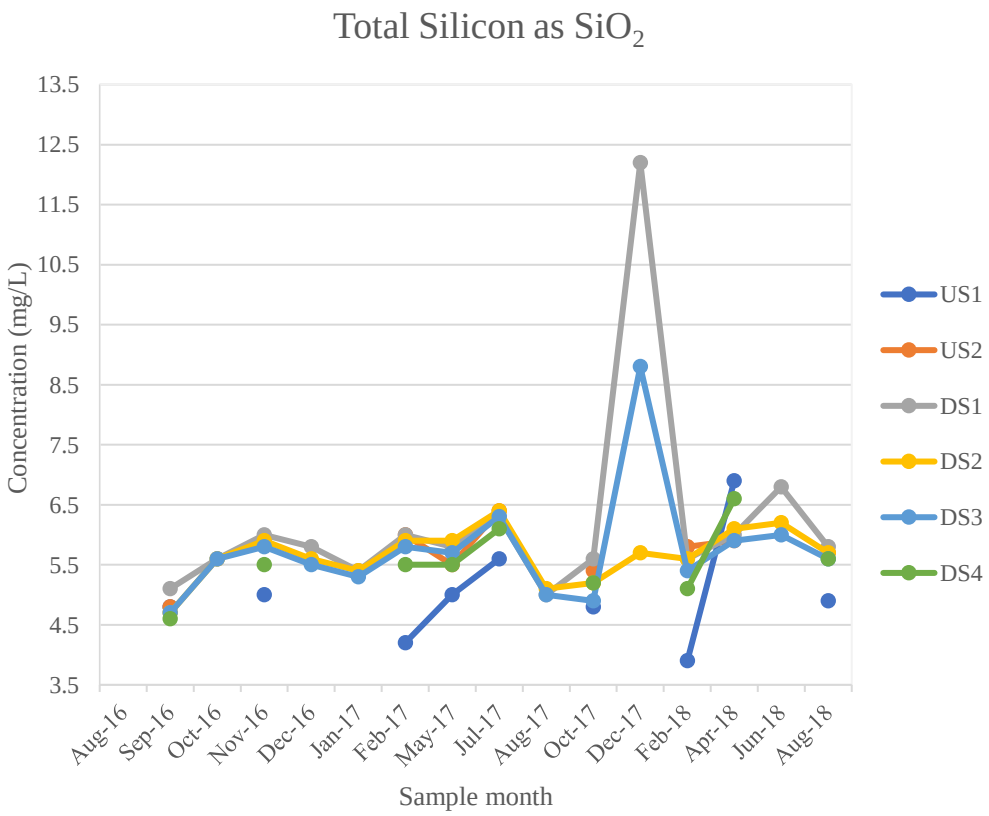

Ammonia as N
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Concentration (mg/L)
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

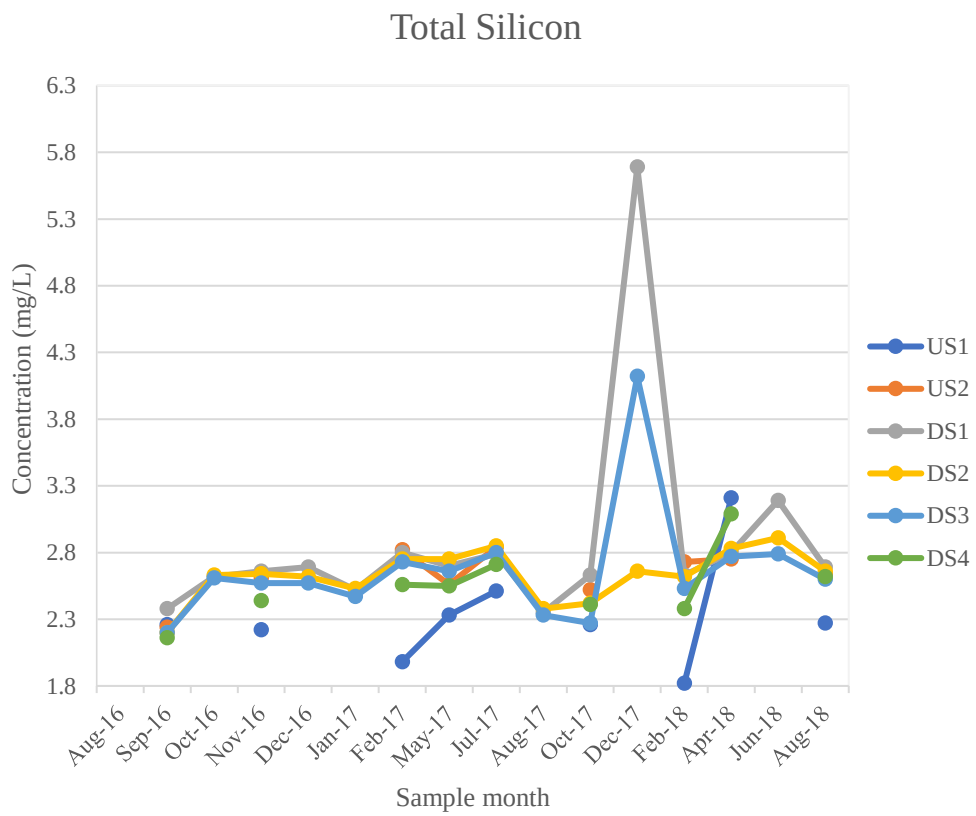

Nitrate
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Concentration (mg/L)
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

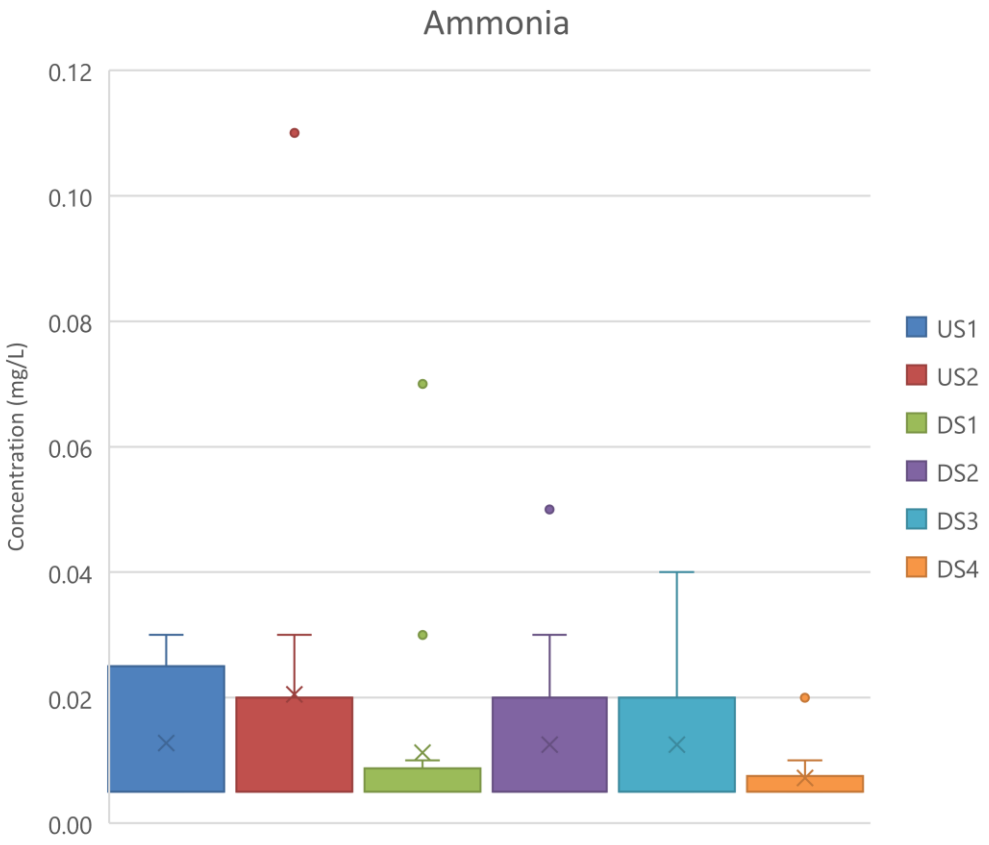

Nitrogen Oxides
Concentration (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

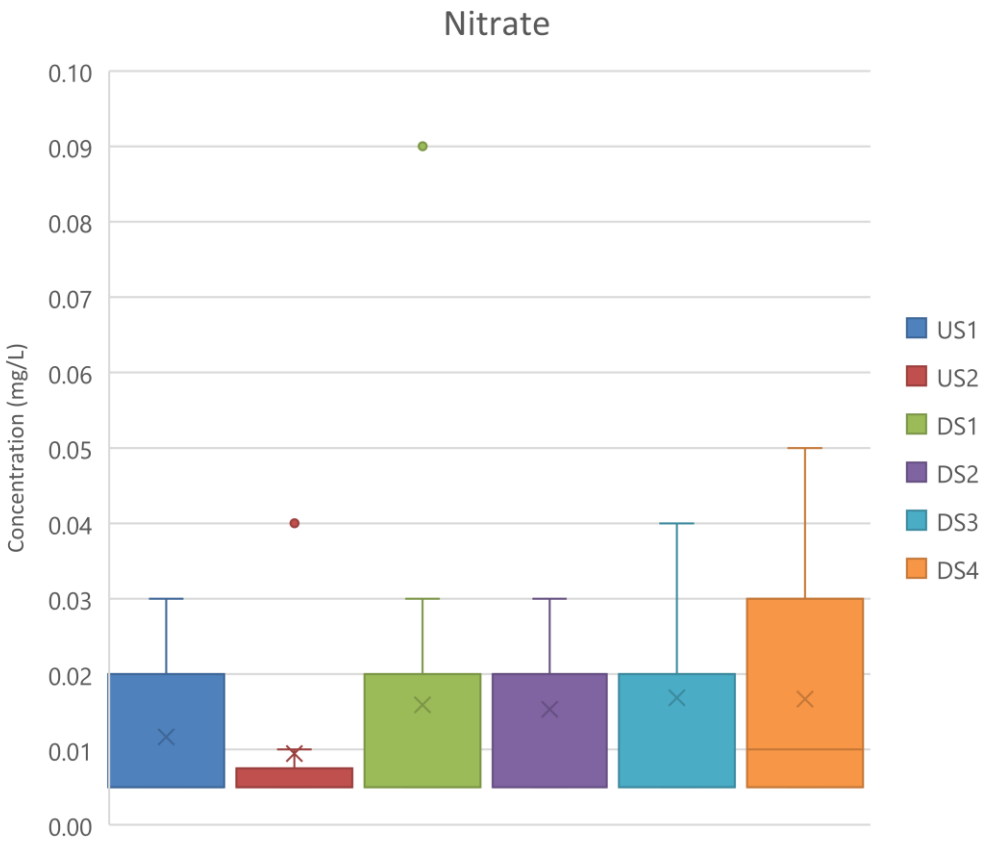

Dissolved Silicon as SiO2
Concentration (mg/L)
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

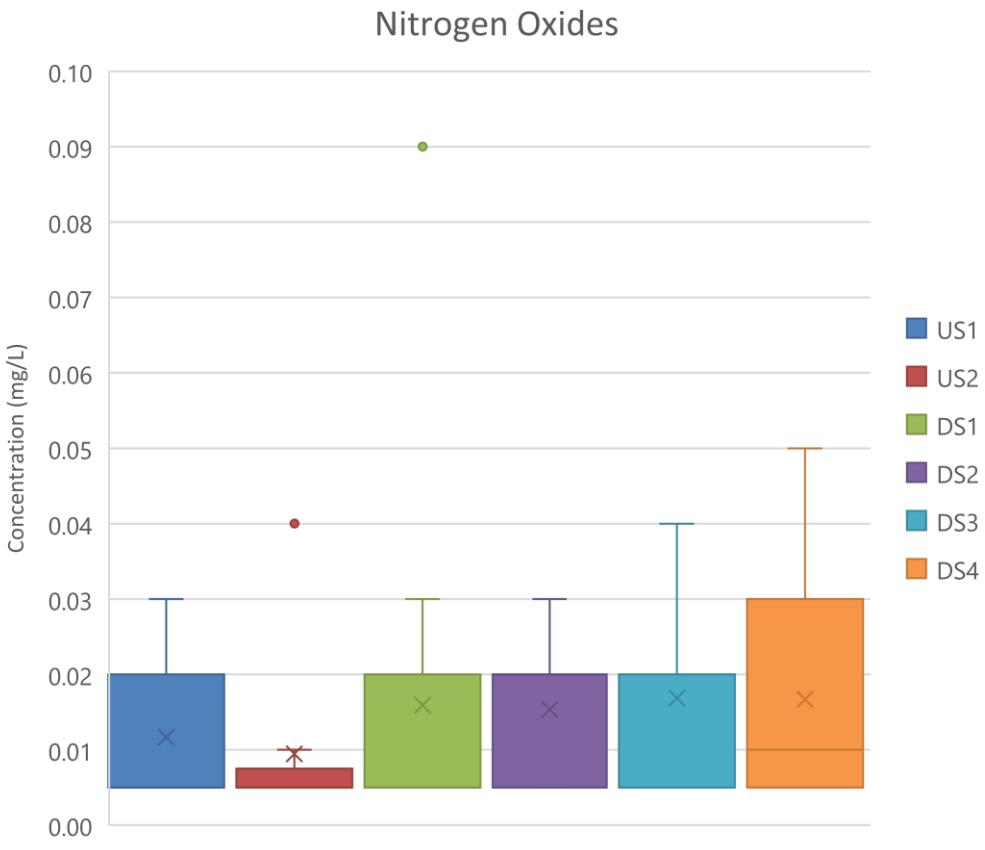

Dissolved Silicon
Concentration (mg/L)
3.5
3.3
3.1
2.9
2.7
2.5
2.3
2.1
1.9
1.7
1.5
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

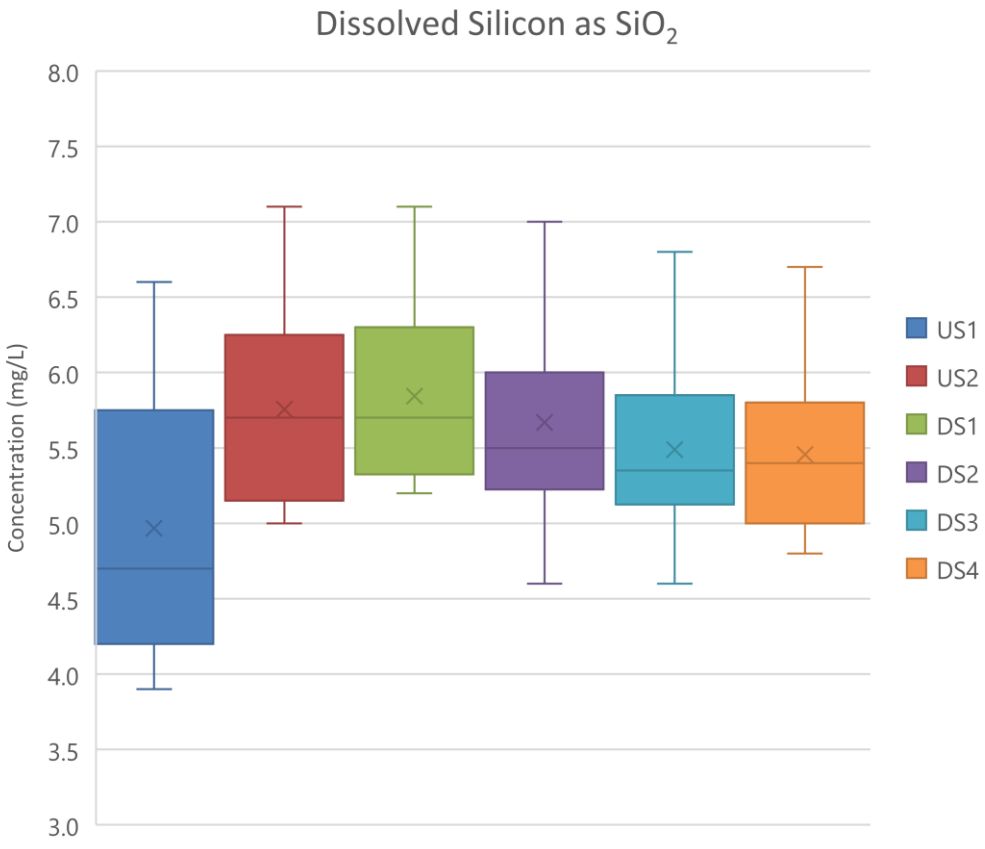

Total Silicon as SiO2
Concentration (mg/L)
13.5
12.5
11.5
10.5
9.5
8.5
7.5
6.5
5.5
4.5
3.5
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

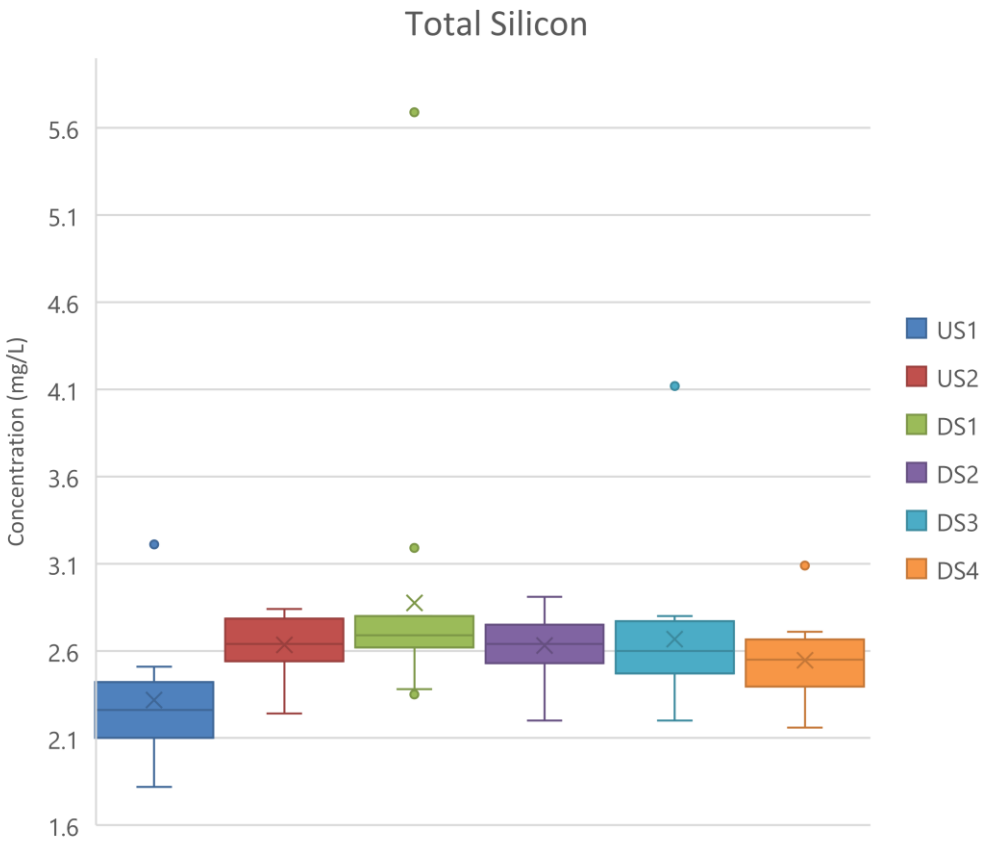

Total Silicon
Concentration (mg/L)
6.3
5.8
5.3
4.8
4.3
3.8
3.3
2.8
2.3
1.8
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

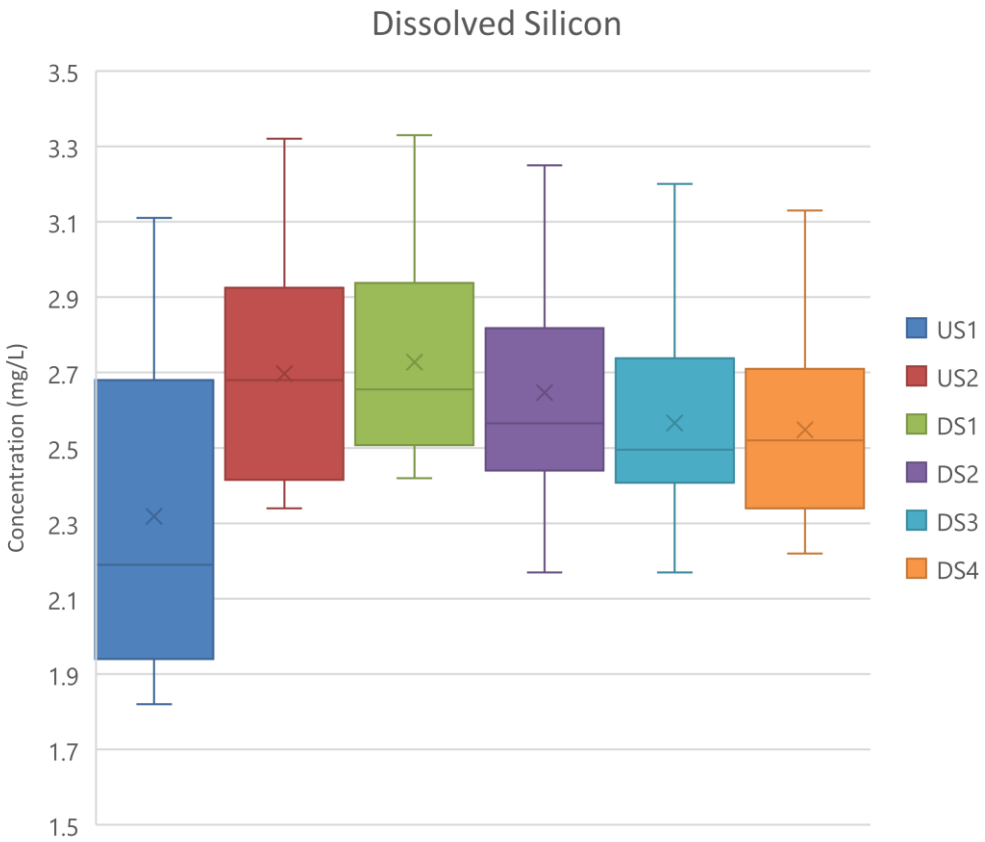

Ammonia
Concentration (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
US1
US2
DS1
DS2
DS3
DS4


Nitrate
Concentration (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
US1
US2
DS1
DS2
DS3
DS4


Nitrogen Oxides
Concentration (mg/L)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
US1
US2
DS1
DS2
DS3
DS4


Dissolved Silicon as SiO_2
Concentration (mg/L)
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
US1
US2
DS1
DS2
DS3
DS4


Total Silicon
Concentration (mg/L)
5.6
5.1
4.6
4.1
3.6
3.1
2.6
2.1
1.6
US1
US2
DS1
DS2
DS3
DS4


Dissolved Silicon
Concentration (mg/L)
3.5
3.3
3.1
2.9
2.7
2.5
2.3
2.1
1.9
1.7
1.5
US1
US2
DS1
DS2
DS3
DS4

3.4 Metals and Metalloids Water Quality Monitoring Data

The metal and metalloid water quality results for each sampling location and event are provided below in Site Summary **Tables 15 to 20** and associated Control Charts and Box Plots:

- Of the 21 analytes only Aluminium, Barium, Cobalt, Iron, Lithium, Manganese, Nickel, Rubidium, Strontium and Zinc had total and/or dissolved concentrations above detection limits for a meaningful number of samples and sites, and Molybdenum concentrations were above detection at a few replicate samples for sites US2, DS1 and DS2. The results for these sites are graphed in the Control Graphs and Box Plots below.
- Of the remaining analytes, Selenium concentrations were all below the detection limit of 0.01mg/L for all samples. Whilst the ANZECC (2000) Total Selenium Default Trigger Level for 95% protection of biota (DTV95) is 0.011mg/L, Table 3.4.1 recommended that the 99% protection DTV (0.005mg/L) be applied for typical slightly to moderately disturbed systems.
- The remaining analytes (Antimony, Arsenic, Beryllium, Boron, Cadmium, Chromium, Copper, Lead and Uranium) had no or a very few samples above Detection.

Table 15 US1 Metal and Metalloid Water Quality Summary Statistics

	Total Metals																				
	Aluminium	Antimony	Arsenic	Beryllium	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Uranium	Zinc	Boron	Iron
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.001	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.05	0.05
Sample size (n)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
n > DL	9	0	0	1	9	0	0	0	0	0	1	9	0	1	0	0	8	0	1	1	9
Min	0.02	<DL	<DL	-	0.004	<DL	<DL	<DL	<DL	<DL	-	0.012	<DL	-	<DL	<DL	0.001	<DL	-	-	0.14
Median	0.07	<DL	<DL	-	0.008	<DL	<DL	<DL	<DL	<DL	-	0.046	<DL	-	<DL	<DL	0.003	<DL	-	-	0.42
Mean	0.07	<DL	<DL	-	0.008	<DL	<DL	<DL	<DL	<DL	-	0.043	<DL	-	<DL	<DL	0.003	<DL	-	-	0.53
SD	0.04	<DL	<DL	-	0.003	<DL	<DL	<DL	<DL	<DL	-	0.025	<DL	-	<DL	<DL	0.002	<DL	-	-	0.27
80th percentile	0.09	<DL	<DL	-	0.009	<DL	<DL	<DL	<DL	<DL	-	0.064	<DL	-	<DL	<DL	0.004	<DL	-	-	0.83
Max	0.16	<DL	<DL	0.001	0.013	<DL	<DL	<DL	<DL	<DL	0.004	0.082	<DL	0.048	<DL	<DL	0.005	<DL	0.009	0.06	0.86
	Dissolved Metals																				
	Aluminium	Antimony	Arsenic	Beryllium	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Uranium	Zinc	Boron	Iron
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.001	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.05	0.05
Sample size (n)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
n > DL	9	0	0	0	9	0	0	0	0	1	2	9	0	1	0	0	9	0	0	1	9
Min	0.02	<DL	<DL	<DL	0.004	<DL	<DL	<DL	<DL	-	0.001	0.010	<DL	-	<DL	<DL	0.001	<DL	<DL	-	0.1
Median	0.03	<DL	<DL	<DL	0.006	<DL	<DL	<DL	<DL	-	-	0.033	<DL	-	<DL	<DL	0.004	<DL	<DL	-	0.26
Mean	0.038888889	<DL	<DL	<DL	0.006	<DL	<DL	<DL	<DL	-	-	0.036	<DL	-	<DL	<DL	0.003	<DL	<DL	-	0.3088889
SD	0.01964971	<DL	<DL	<DL	0.002	<DL	<DL	<DL	<DL	-	-	0.023	<DL	-	<DL	<DL	0.001	<DL	<DL	-	0.1958599
80th percentile	0.06	<DL	<DL	<DL	0.008	<DL	<DL	<DL	<DL	-	-	0.056	<DL	-	<DL	<DL	0.004	<DL	<DL	-	0.464
Max	0.07	<DL	<DL	<DL	0.009	<DL	<DL	<DL	<DL	0.010	0.010	0.076	<DL	0.002	<DL	<DL	0.005	<DL	<DL	0.06	0.68

Table 16 US2 Metal and Metalloid Water Quality Summary Statistics

	Total Metals																				
	Aluminium	Antimony	Arsenic	Beryllium	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Uranium	Zinc	Boron	Iron
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.001	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.05	0.05
Sample size (n)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
n > DL	8	1	0	0	9	0	1	9	0	0	9	9	1	8	9	0	9	0	9	0	6
Min	0.01	-	<DL	<DL	0.017	<DL	-	0.003	<DL	<DL	0.016	0.044	-	0.001	0.011	<DL	0.044	<DL	0.025	<DL	0.05
Median	0.02	-	<DL	<DL	0.021	<DL	-	0.007	<DL	<DL	0.019	0.094	-	0.029	0.015	<DL	0.059	<DL	0.039	<DL	0.08
Mean	0.11	-	<DL	<DL	0.021	<DL	-	0.008	<DL	<DL	0.019	0.112	-	0.029	0.015	<DL	0.057	<DL	0.038	<DL	0.07
SD	0.25	-	<DL	<DL	0.003	<DL	-	0.005	<DL	<DL	0.002	0.064	-	0.016	0.002	<DL	0.006	<DL	0.014	<DL	0.04
80th percentile	0.07	-	<DL	<DL	0.022	<DL	-	0.009	<DL	<DL	0.020	0.141	-	0.037	0.016	<DL	0.061	<DL	0.045	<DL	0.09
Max	0.77	0.001	<DL	<DL	0.026	<DL	0.002	0.018	<DL	<DL	0.022	0.257	0.002	0.056	0.016	<DL	0.064	<DL	0.068	<DL	0.14
	Dissolved Metals																				
	Aluminium	Antimony	Arsenic	Beryllium	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Uranium	Zinc	Boron	Iron
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.001	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.05	0.05
Sample size (n)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
n > DL	2	0	1	0	9	0	0	9	0	0	9	9	1	9	7	0	9	0	9	0	3
Min	0.03	<DL	-	<DL	0.006	<DL	<DL	0.003	<DL	<DL	0.014	0.040	-	0.019	0.001	<DL	0.045	<DL	0.021	<DL	0.05
Median	-	<DL	-	<DL	0.019	<DL	<DL	0.006	<DL	<DL	0.018	0.086	-	0.031	0.014	<DL	0.056	<DL	0.030	<DL	0.025
Mean	-	<DL	-	<DL	0.018	<DL	<DL	0.007	<DL	<DL	0.018	0.103	-	0.031	0.011	<DL	0.055	<DL	0.035	<DL	0.0377778
SD	-	<DL	-	<DL	0.005	<DL	<DL	0.004	<DL	<DL	0.002	0.056	-	0.010	0.006	<DL	0.005	<DL	0.013	<DL	0.0206324
80th percentile	-	<DL	-	<DL	0.021	<DL	<DL	0.008	<DL	<DL	0.018	0.135	-	0.039	0.014	<DL	0.058	<DL	0.042	<DL	0.054
Max	0.1	<DL	0.004	<DL	0.023	<DL	<DL	0.015	<DL	<DL	0.020	0.224	0.001	0.046	0.015	<DL	0.061	<DL	0.063	<DL	0.08

Table 17 DS1 Metal and Metalloid Water Quality Summary Statistics

	Total Metals																				
	Aluminium	Antimony	Arsenic	Beryllium	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Uranium	Zinc	Boron	Iron
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.001	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.05	0.05
Sample size (n)	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
n > DL	12	0	0	0	16	0	0	16	0	0	16	16	3	16	16	0	16	0	16	0	5
Min	0.01	<DL	<DL	<DL	0.013	<DL	<DL	0.002	<DL	<DL	0.008	0.043	0.001	0.021	0.006	<DL	0.023	<DL	0.018	<DL	0.05
Median	0.02	<DL	<DL	<DL	0.019	<DL	<DL	0.005	<DL	<DL	0.016	0.062	0.001	0.031	0.014	<DL	0.055	<DL	0.038	<DL	0.025
Mean	0.025	<DL	<DL	<DL	0.019	<DL	<DL	0.007	<DL	<DL	0.015	0.084	0.001	0.037	0.012	<DL	0.048	<DL	0.046	<DL	0.0384375
SD	0.030659419	<DL	<DL	<DL	0.003	<DL	<DL	0.006	<DL	<DL	0.004	0.062	0.000	0.022	0.003	<DL	0.013	<DL	0.029	<DL	0.0219635
80th percentile	0.02	<DL	<DL	<DL	0.022	<DL	<DL	0.008	<DL	<DL	0.018	0.088	0.001	0.041	0.014	<DL	0.059	<DL	0.050	<DL	0.06
Max	0.13	<DL	<DL	<DL	0.023	<DL	<DL	0.026	<DL	<DL	0.019	0.293	0.001	0.105	0.015	<DL	0.060	<DL	0.142	<DL	0.09
	Dissolved Metals																				
	Aluminium	Antimony	Arsenic	Beryllium	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Uranium	Zinc	Boron	Iron
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.001	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.05	0.05
Sample size (n)	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
n > DL	4	0	0	0	15	0	0	15	1	0	15	15	2	15	14	0	15	0	15	0	1
Min	0.01	<DL	<DL	<DL	0.013	<DL	<DL	0.002	-	<DL	0.009	0.039	0.001	0.017	0.001	<DL	0.022	<DL	0.013	<DL	-
Median	0.005	<DL	<DL	<DL	0.020	<DL	<DL	0.004	-	<DL	0.015	0.054	-	0.028	0.013	<DL	0.052	<DL	0.035	<DL	-
Mean	0.016333333	<DL	<DL	<DL	0.019	<DL	<DL	0.006	-	<DL	0.015	0.080	-	0.034	0.011	<DL	0.078	<DL	0.042	<DL	-
SD	0.032703575	<DL	<DL	<DL	0.003	<DL	<DL	0.006	-	<DL	0.003	0.068	-	0.022	0.004	<DL	0.117	<DL	0.030	<DL	-
80th percentile	0.01	<DL	<DL	<DL	0.020	<DL	<DL	0.007	-	<DL	0.017	0.084	-	0.039	0.014	<DL	0.059	<DL	0.049	<DL	-
Max	0.13	<DL	<DL	<DL	0.023	<DL	<DL	0.024	0.002	<DL	0.018	0.304	0.002	0.101	0.015	<DL	0.500	<DL	0.143	<DL	0.06

Table 18 DS2 Metal and Metalloid Water Quality Summary Statistics

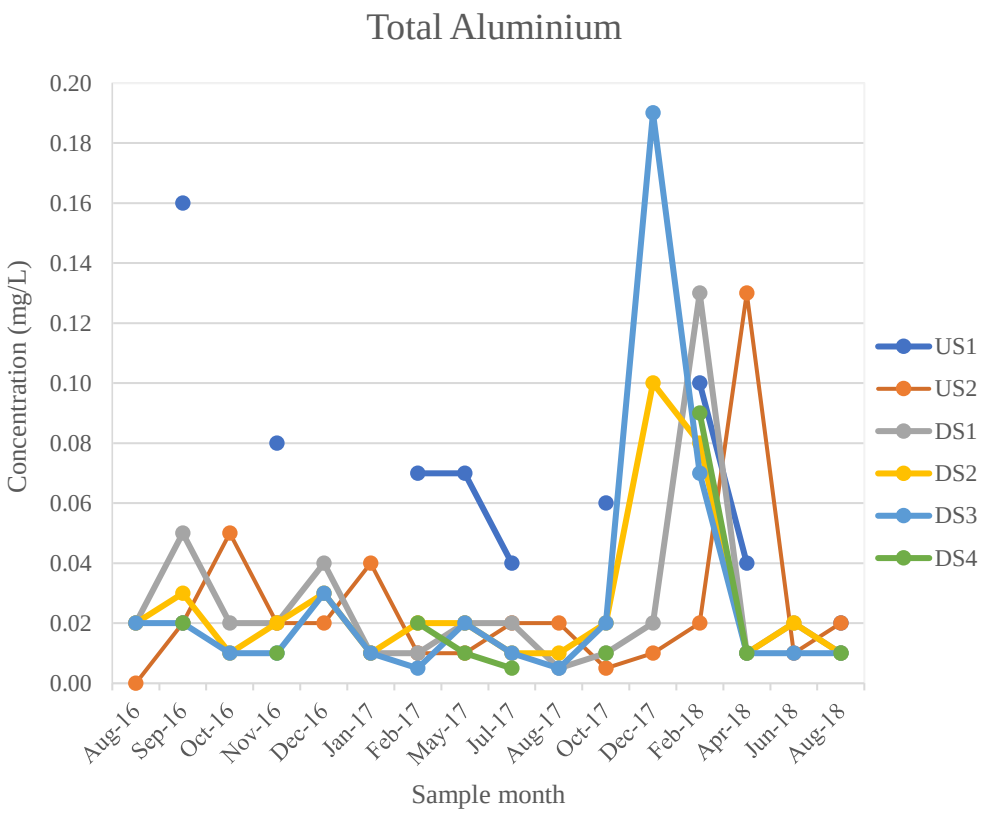
	Total Metals																				
	Aluminium	Antimony	Arsenic	Beryllium	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Uranium	Zinc	Boron	Iron
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.001	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.05	0.05
Sample size (n)	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
n > DL	15	2	0	0	16	0	1	15	0	0	16	16	1	16	16	0	16	0	16	0	9
Min	0.01	0.001	<DL	<DL	0.013	<DL	-	0.001	<DL	<DL	0.008	0.026	-	0.015	0.005	<DL	0.021	<DL	0.014	<DL	0.05
Median	0.02	-	<DL	<DL	0.018	<DL	-	0.003	<DL	<DL	0.016	0.045	-	0.024	0.013	<DL	0.051	<DL	0.035	<DL	0.06
Mean	0.03	-	<DL	<DL	0.018	<DL	-	0.004	<DL	<DL	0.014	0.060	-	0.025	0.011	<DL	0.047	<DL	0.036	<DL	0.06
SD	0.03	-	<DL	<DL	0.002	<DL	-	0.002	<DL	<DL	0.003	0.041	-	0.008	0.003	<DL	0.012	<DL	0.015	<DL	0.05
80th percentile	0.03	-	<DL	<DL	0.020	<DL	-	0.005	<DL	<DL	0.016	0.071	-	0.030	0.014	<DL	0.056	<DL	0.045	<DL	0.08
Max	0.10	0.002	<DL	<DL	0.022	<DL	0.003	0.008	<DL	<DL	0.018	0.192	0.001	0.042	0.015	<DL	0.059	<DL	0.080	<DL	0.21
	Dissolved Metals																				
	Aluminium	Antimony	Arsenic	Beryllium	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Uranium	Zinc	Boron	Iron
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.001	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.05	0.05
Sample size (n)	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
n > DL	5	0	0	0	15	0	0	15	1	0	15	15	1	15	14	0	15	0	15	0	2
Min	0.01	<DL	<DL	<DL	0.011	<DL	<DL	0.001	-	<DL	0.006	0.025	-	0.013	0.001	<DL	0.019	<DL	0.014	<DL	0.06
Median	0.005	<DL	<DL	<DL	0.018	<DL	<DL	0.002	-	<DL	0.013	0.046	-	0.021	0.012	<DL	0.050	<DL	0.030	<DL	-
Mean	0.011333333	<DL	<DL	<DL	0.017	<DL	<DL	0.003	-	<DL	0.013	0.054	-	0.022	0.010	<DL	0.044	<DL	0.029	<DL	-
SD	0.016740313	<DL	<DL	<DL	0.003	<DL	<DL	0.002	-	<DL	0.003	0.042	-	0.008	0.004	<DL	0.013	<DL	0.008	<DL	-
80th percentile	0.01	<DL	<DL	<DL	0.019	<DL	<DL	0.003	-	<DL	0.016	0.053	-	0.029	0.013	<DL	0.054	<DL	0.032	<DL	-
Max	0.07	<DL	<DL	<DL	0.022	<DL	<DL	0.008	0.001	<DL	0.017	0.192	0.004	0.041	0.015	<DL	0.059	<DL	0.044	<DL	0.07

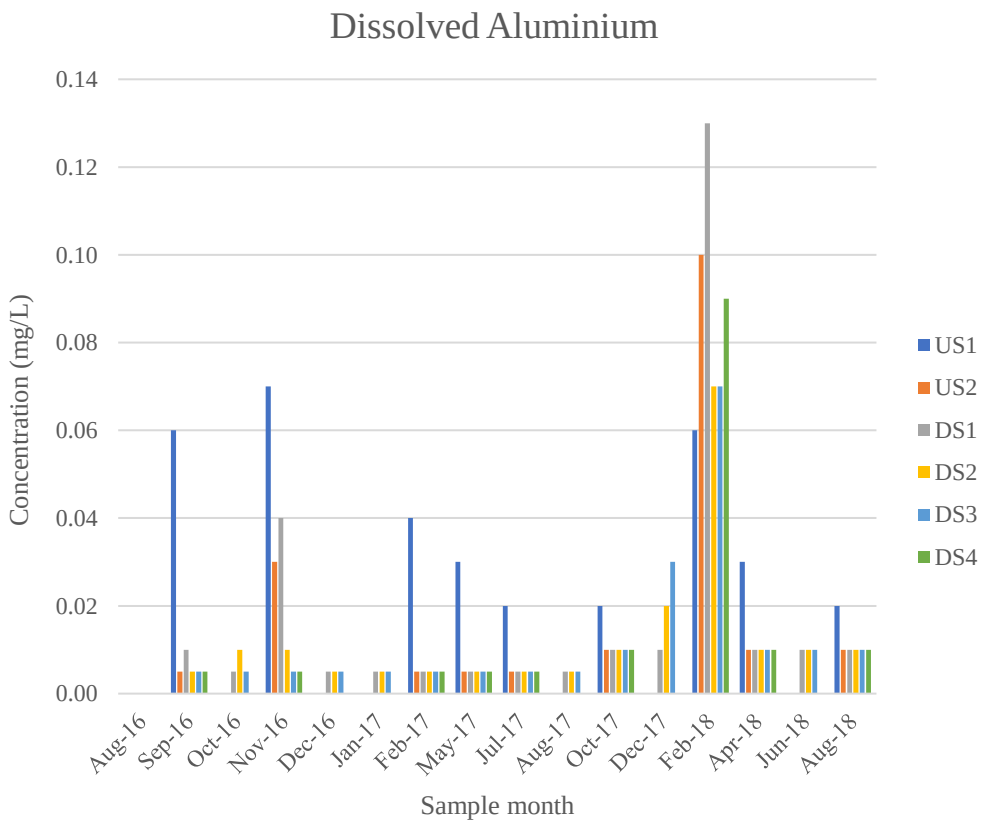
Table 19 DS3 Metal and Metalloid Water Quality Summary Statistics

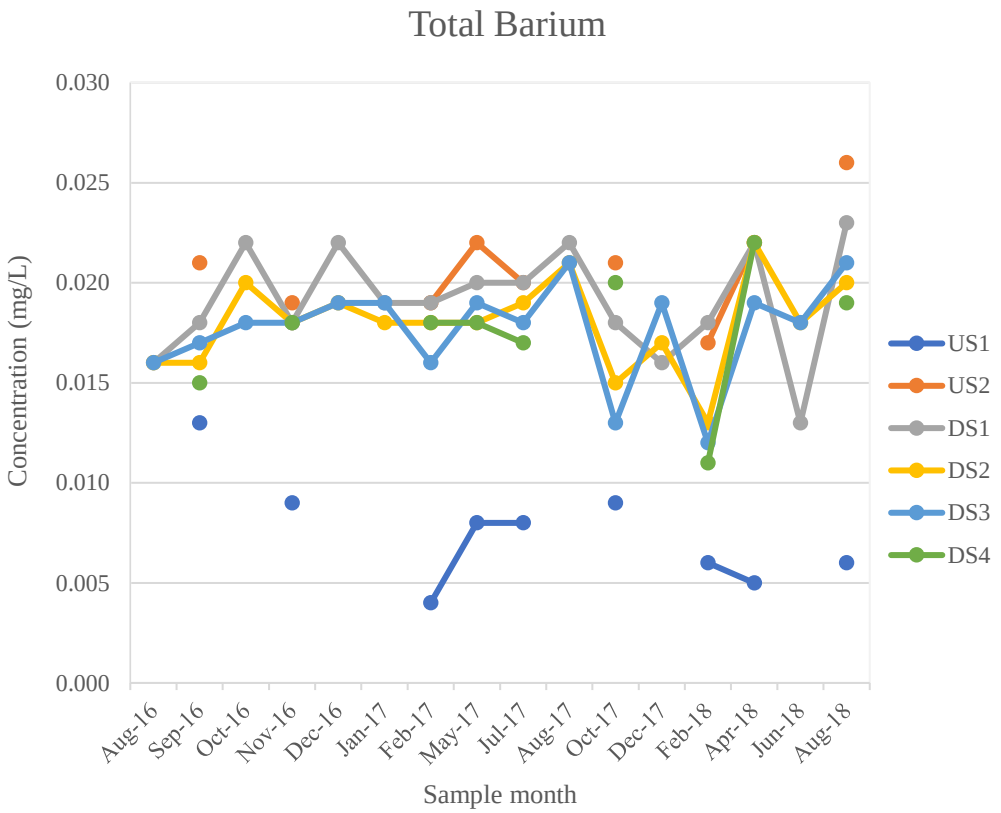
	Total Metals																				
	Aluminium	Antimony	Arsenic	Beryllium	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Uranium	Zinc	Boron	Iron
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.001	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.05	0.05
Sample size (n)	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
n > DL	11	0	0	0	16	2	2	11	1	0	16	16	0	16	16	0	16	0	16	0	2
Min	0.01	<DL	<DL	<DL	0.012	0.0001	0.001	0.001	-	<DL	0.007	0.018	<DL	0.013	0.004	<DL	0.018	<DL	0.012	<DL	0.08
Median	0.01	<DL	<DL	<DL	0.018	-	-	0.002	-	<DL	0.015	0.028	<DL	0.022	0.012	<DL	0.050	<DL	0.029	<DL	-
Mean	0.03	<DL	<DL	<DL	0.018	-	-	0.002	-	<DL	0.014	0.039	<DL	0.023	0.011	<DL	0.045	<DL	0.034	<DL	-
SD	0.05	<DL	<DL	<DL	0.002	-	-	0.002	-	<DL	0.003	0.028	<DL	0.008	0.003	<DL	0.010	<DL	0.028	<DL	-
80th percentile	0.02	<DL	<DL	<DL	0.019	-	-	0.003	-	<DL	0.015	0.046	<DL	0.028	0.013	<DL	0.051	<DL	0.033	<DL	-
Max	0.19	<DL	<DL	<DL	0.021	0.0003	0.001	0.006	0.003	<DL	0.017	0.119	<DL	0.039	0.014	<DL	0.054	<DL	0.134	<DL	0.20
	Dissolved Metals																				
	Aluminium	Antimony	Arsenic	Beryllium	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Uranium	Zinc	Boron	Iron
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.001	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.05	0.05
Sample size (n)	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
n > DL	2	0	0	0	15	0	0	8	0	0	15	15	0	15	14	0	15	0	15	0	0
Min	0.03	<DL	<DL	<DL	0.011	<DL	<DL	0.001	<DL	<DL	0.006	0.017	<DL	0.012	0.001	<DL	0.018	<DL	0.012	<DL	<DL
Median	-	<DL	<DL	<DL	0.017	<DL	<DL	0.001	<DL	<DL	0.013	0.027	<DL	0.018	0.011	<DL	0.045	<DL	0.025	<DL	<DL
Mean	-	<DL	<DL	<DL	0.016	<DL	<DL	0.002	<DL	<DL	0.013	0.035	<DL	0.020	0.010	<DL	0.042	<DL	0.024	<DL	<DL
SD	-	<DL	<DL	<DL	0.003	<DL	<DL	0.001	<DL	<DL	0.002	0.029	<DL	0.008	0.004	<DL	0.011	<DL	0.006	<DL	<DL
80th percentile	-	<DL	<DL	<DL	0.019	<DL	<DL	0.002	<DL	<DL	0.014	0.036	<DL	0.023	0.012	<DL	0.049	<DL	0.029	<DL	<DL
Max	0.07	<DL	<DL	<DL	0.020	<DL	<DL	0.005	<DL	<DL	0.015	0.126	<DL	0.039	0.013	<DL	0.054	<DL	0.033	<DL	<DL

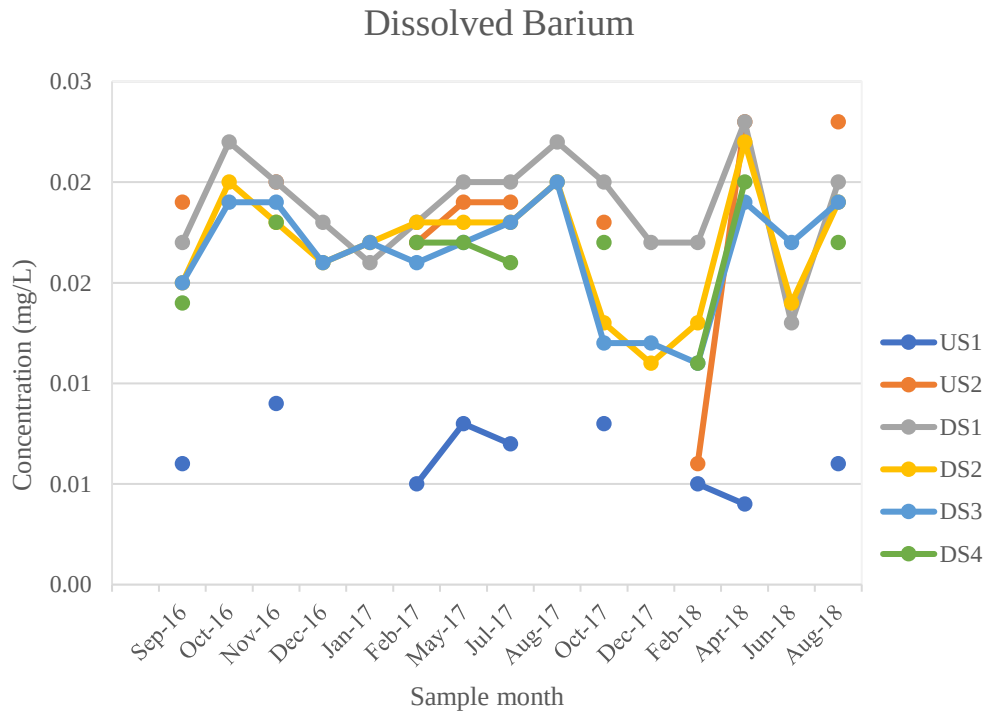
Table 20 DS4 Metal and Metalloid Water Quality Summary Statistics

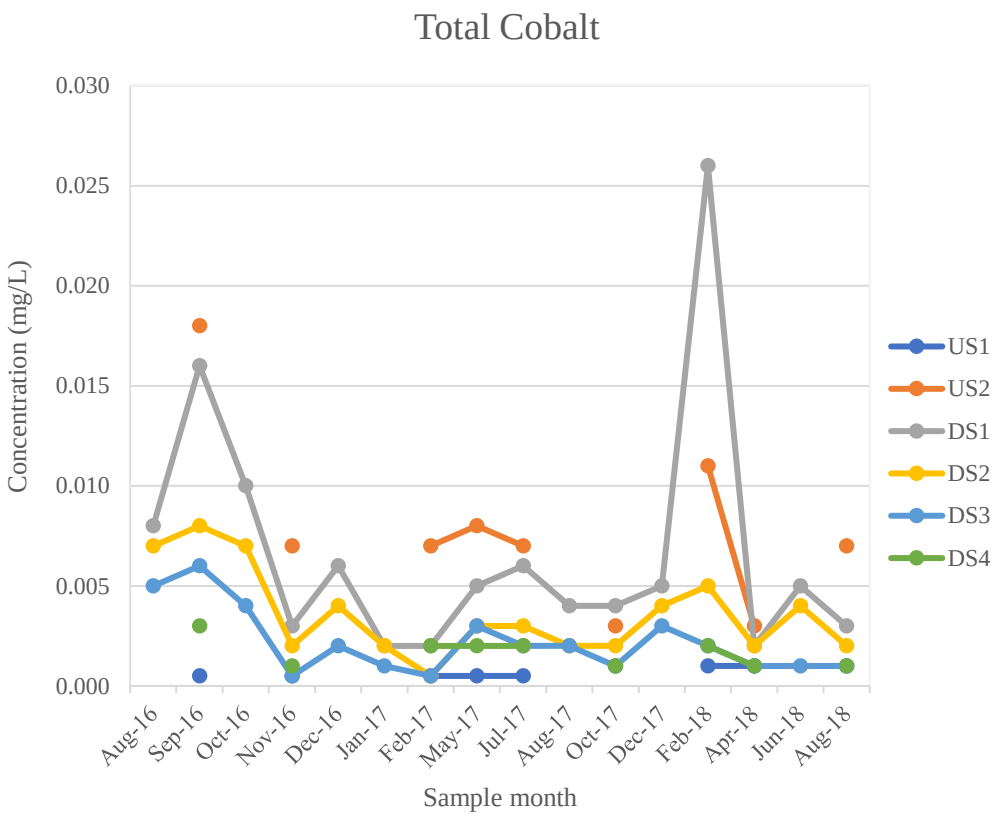
	Total Metals																				
	Aluminium	Antimony	Arsenic	Beryllium	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Uranium	Zinc	Boron	Iron
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.001	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.05	0.05
Sample size (n)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
n > DL	5	0	0	0	9	0	0	9	0	0	9	9	0	9	9	0	9	0	9	0	2
Min	0.01	<DL	<DL	<DL	0.011	<DL	<DL	0.001	<DL	<DL	0.006	0.024	<DL	0.012	0.004	<DL	0.017	<DL	0.012	<DL	0.06
Median	0.01	<DL	<DL	<DL	0.018	<DL	<DL	0.002	<DL	<DL	0.013	0.036	<DL	0.016	0.011	<DL	0.044	<DL	0.024	<DL	-
Mean	0.02	<DL	<DL	<DL	0.018	<DL	<DL	0.002	<DL	<DL	0.012	0.037	<DL	0.018	0.010	<DL	0.043	<DL	0.022	<DL	-
SD	0.03	<DL	<DL	<DL	0.003	<DL	<DL	0.001	<DL	<DL	0.002	0.013	<DL	0.005	0.003	<DL	0.011	<DL	0.006	<DL	-
80th percentile	0.02	<DL	<DL	<DL	0.019	<DL	<DL	0.002	<DL	<DL	0.014	0.048	<DL	0.019	0.011	<DL	0.049	<DL	0.026	<DL	-
Max	0.09	<DL	<DL	<DL	0.022	<DL	<DL	0.003	<DL	<DL	0.014	0.061	<DL	0.029	0.014	<DL	0.054	<DL	0.028	<DL	0.06
	Dissolved Metals																				
	Aluminium	Antimony	Arsenic	Beryllium	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Uranium	Zinc	Boron	Iron
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Detection limit (DL)	0.01	0.001	0.001	0.001	0.001	0.0001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.01	0.001	0.001	0.005	0.05	0.05
Sample size (n)	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
n > DL	1	0	0	0	9	0	0	9	0	0	9	9	0	9	9	0	9	0	9	0	1
Min	-	<DL	<DL	<DL	0.011	<DL	<DL	0.001	<DL	<DL	0.006	0.023	<DL	0.011	0.005	<DL	0.018	<DL	0.011	<DL	-
Median	-	<DL	<DL	<DL	0.017	<DL	<DL	0.002	<DL	<DL	0.011	0.034	<DL	0.015	0.010	<DL	0.042	<DL	0.021	<DL	-
Mean	-	<DL	<DL	<DL	0.016	<DL	<DL	0.002	<DL	<DL	0.011	0.034	<DL	0.016	0.010	<DL	0.040	<DL	0.022	<DL	-
SD	-	<DL	<DL	<DL	0.003	<DL	<DL	0.001	<DL	<DL	0.002	0.012	<DL	0.004	0.002	<DL	0.009	<DL	0.006	<DL	-
80th percentile	-	<DL	<DL	<DL	0.017	<DL	<DL	0.002	<DL	<DL	0.012	0.038	<DL	0.018	0.012	<DL	0.045	<DL	0.026	<DL	-
Max	0.09	<DL	<DL	<DL	0.020	<DL	<DL	0.002	<DL	<DL	0.014	0.062	<DL	0.025	0.013	<DL	0.046	<DL	0.033	<DL	0.06

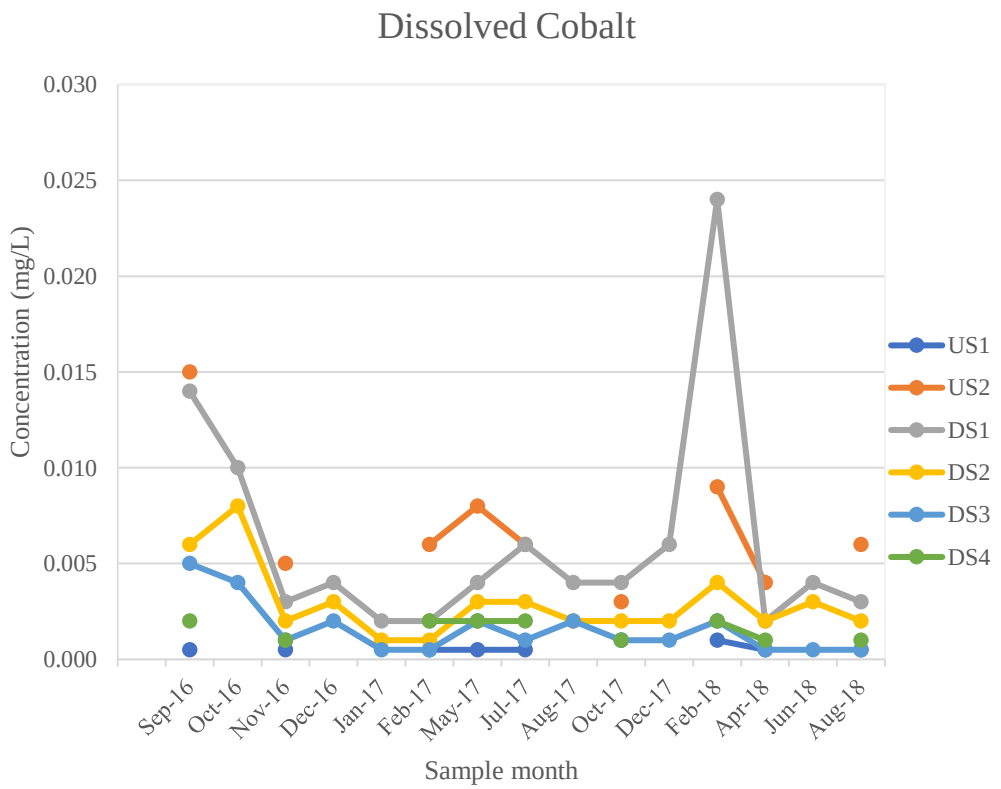

Total Aluminium
Concentration (mg/L)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

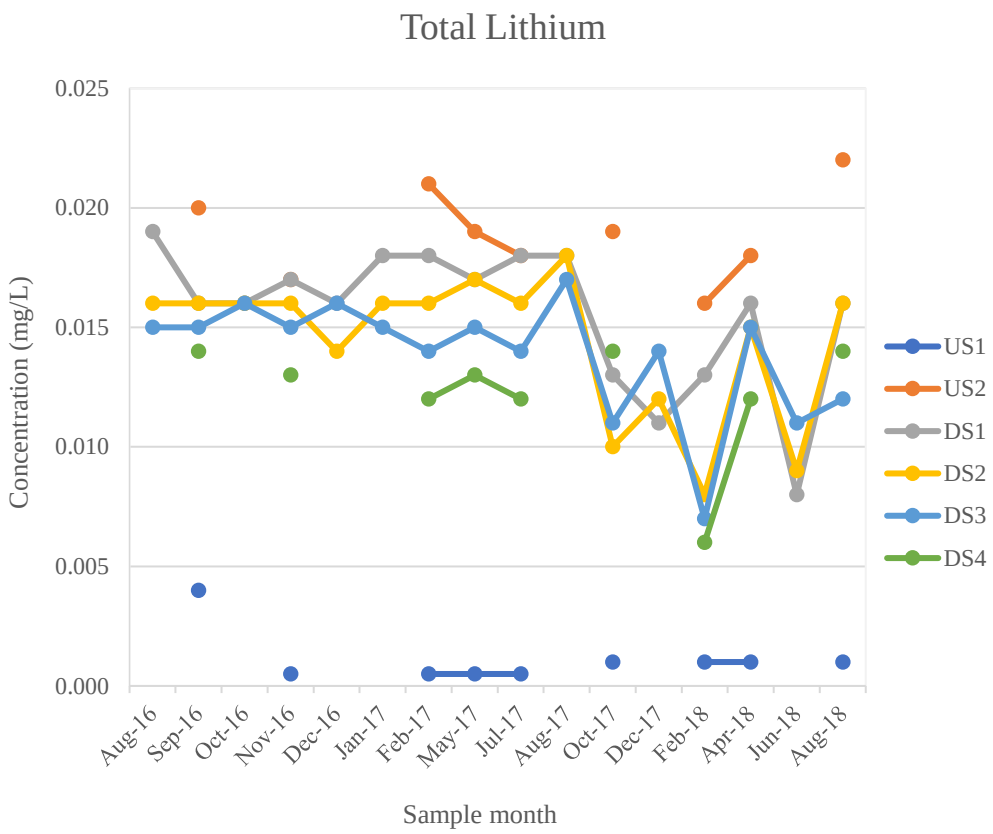

Dissolved Aluminium
Concentration (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

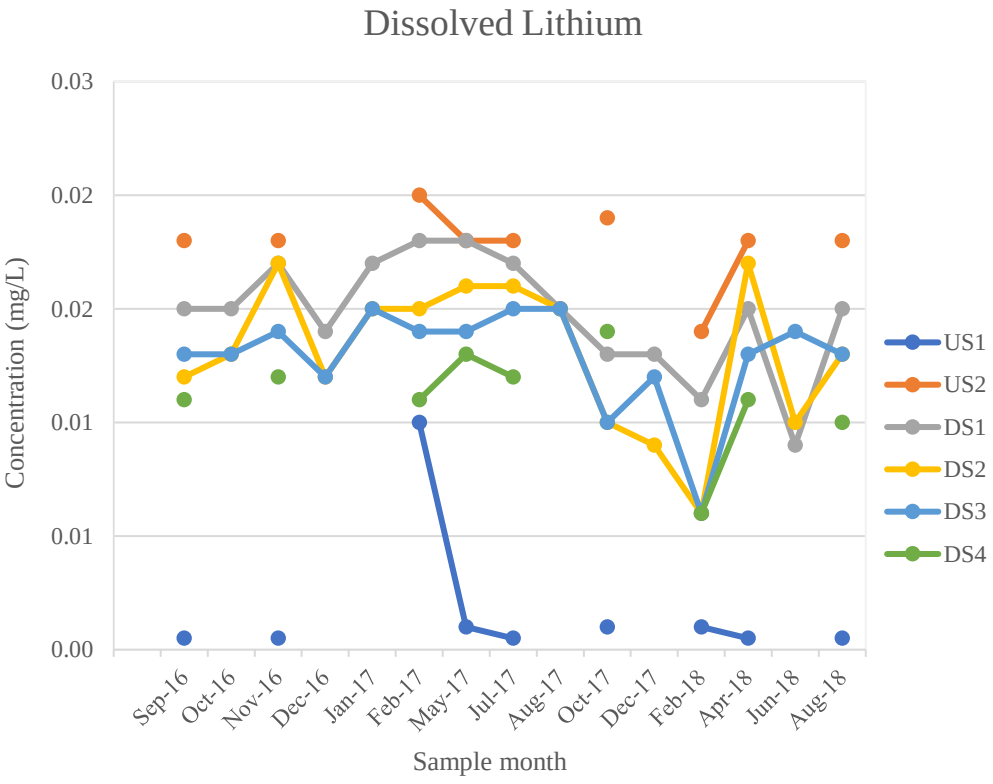

Total Barium
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Concentration (mg/L)
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

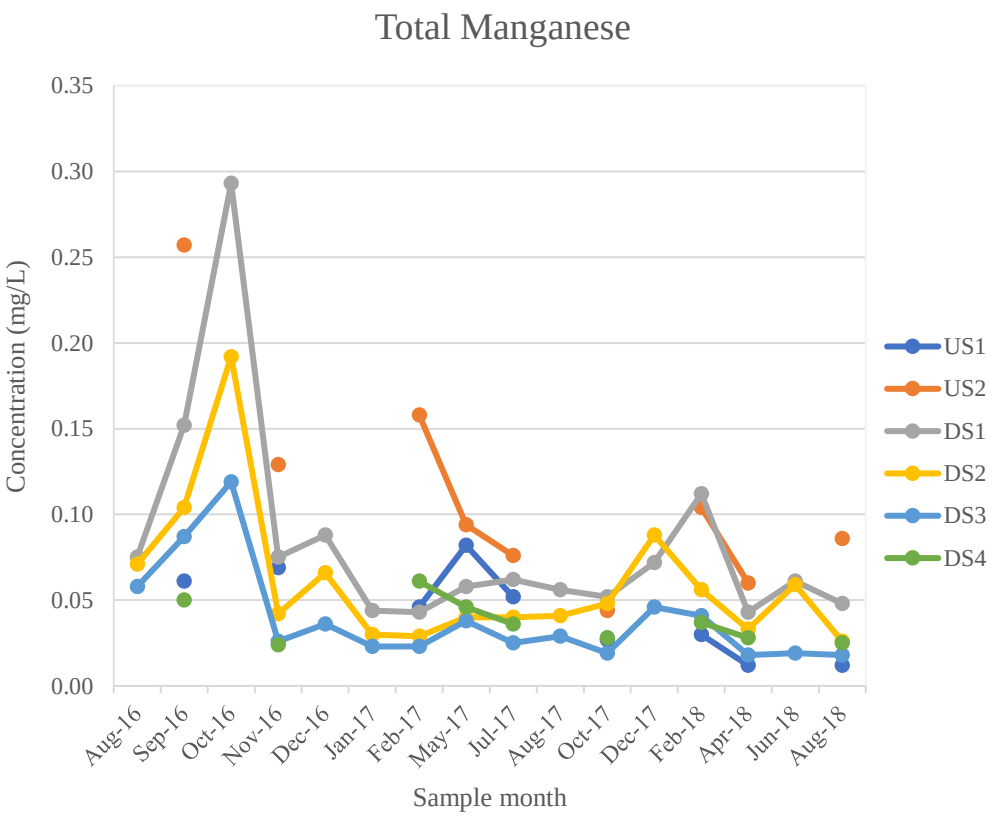

Dissolved Barium
0.03
0.02
0.02
0.01
0.01
0.00
Concentration (mg/L)
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

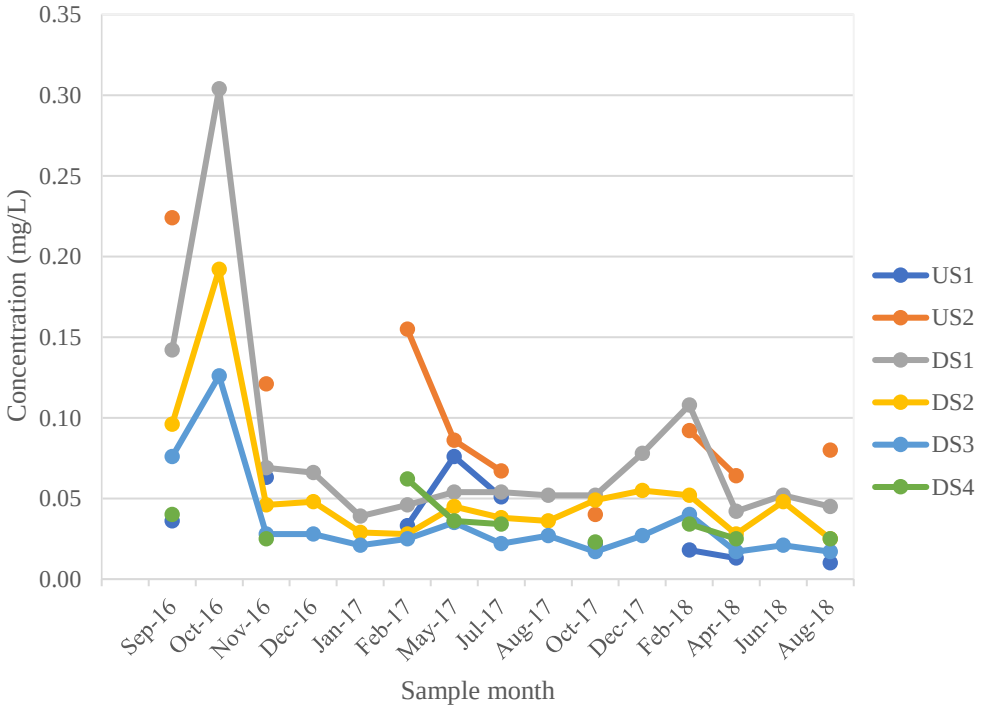

Total Cobalt
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Concentration (mg/L)
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

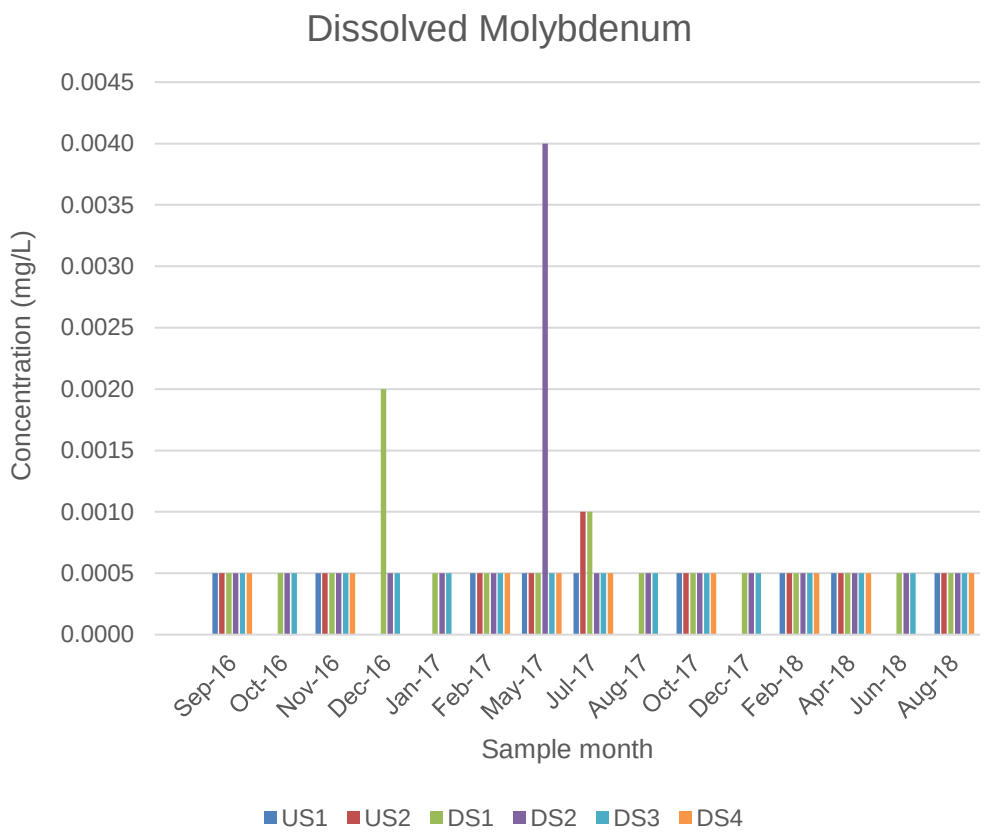

Dissolved Cobalt
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Concentration (mg/L)
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

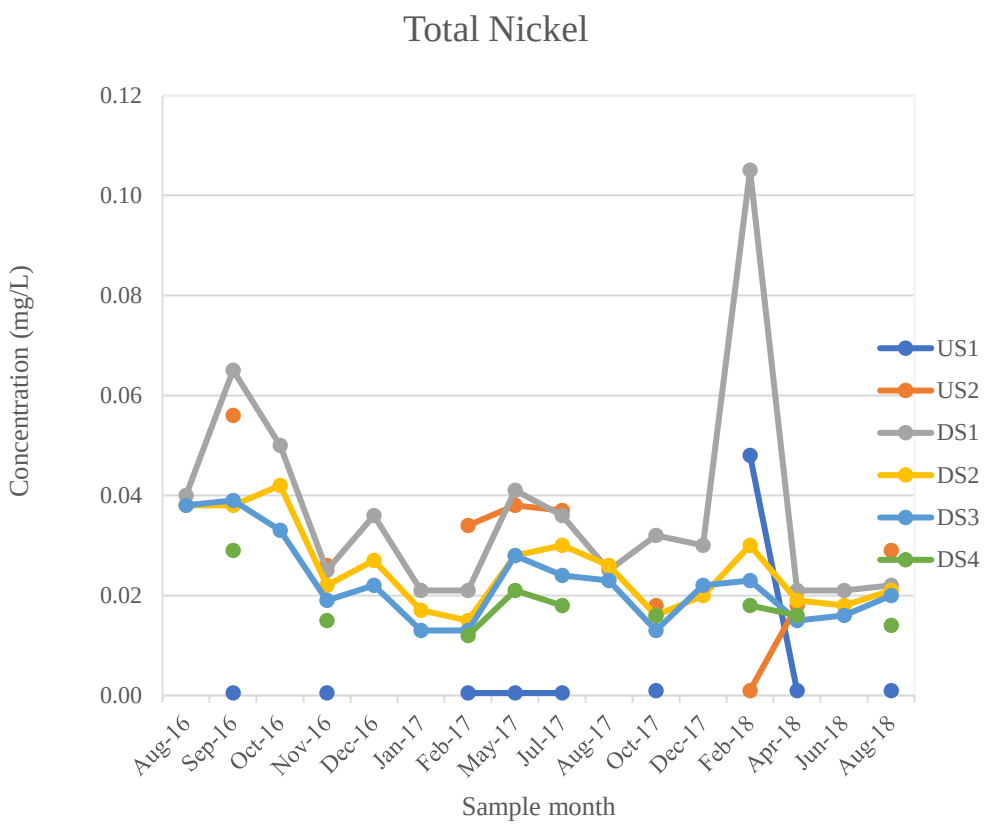

Total Lithium
0.025
0.020
0.015
0.010
0.005
0.000
Concentration (mg/L)
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

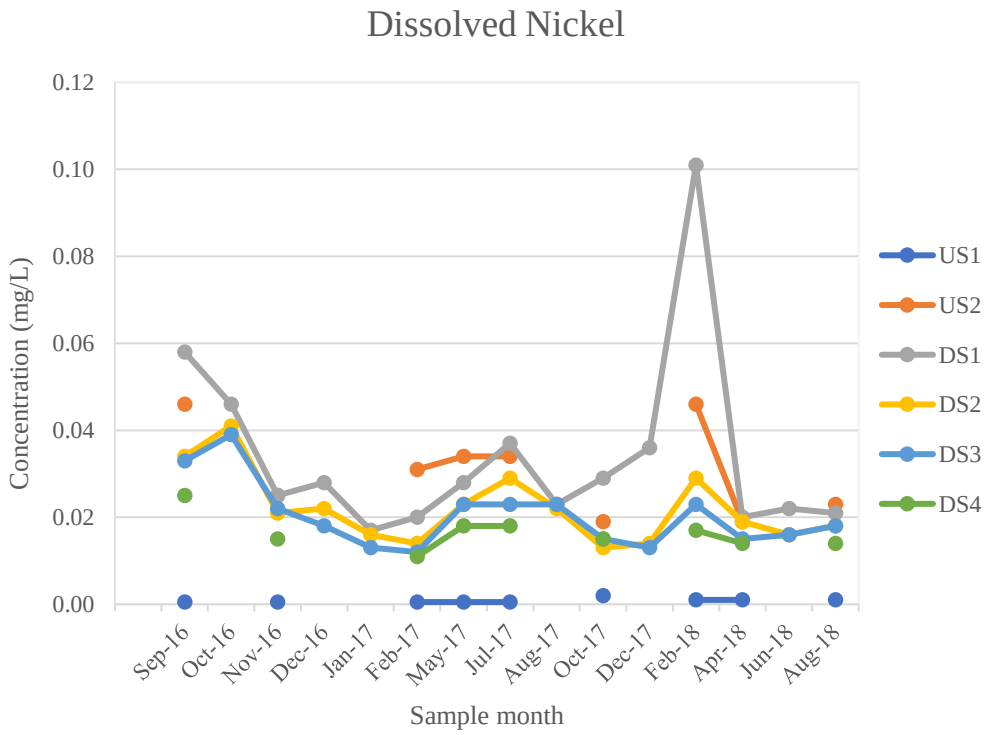

Dissolved Lithium
0.03
0.02
0.02
0.01
0.01
0.00
Concentration (mg/L)
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

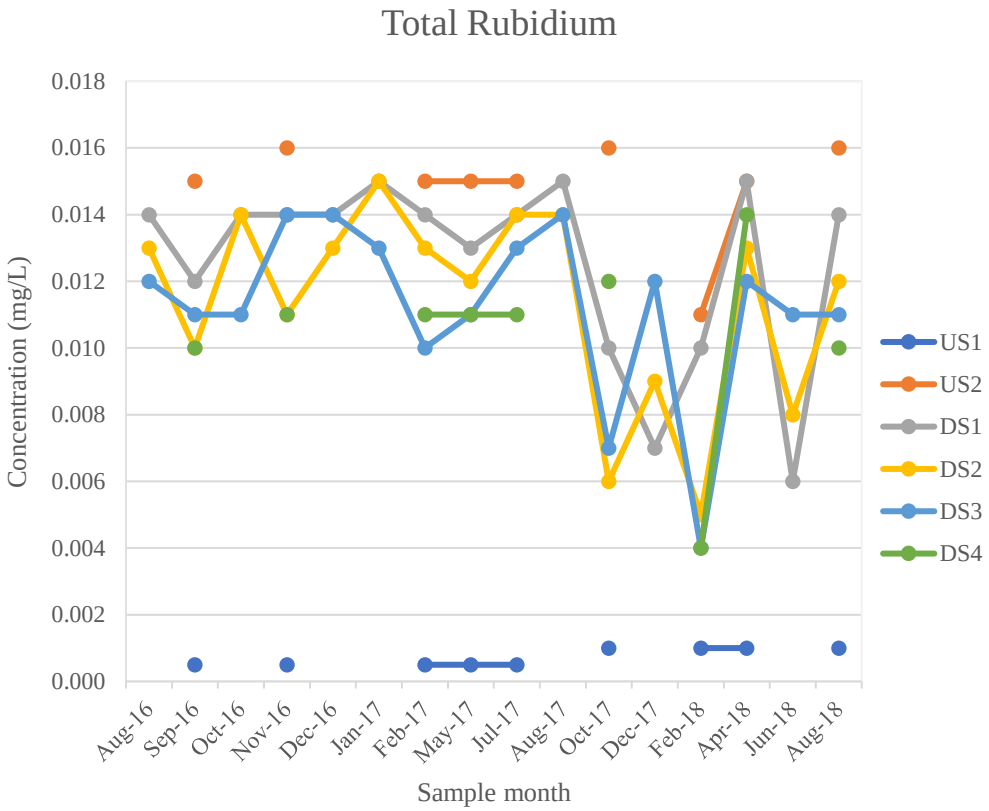

Total Manganese
Concentration (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

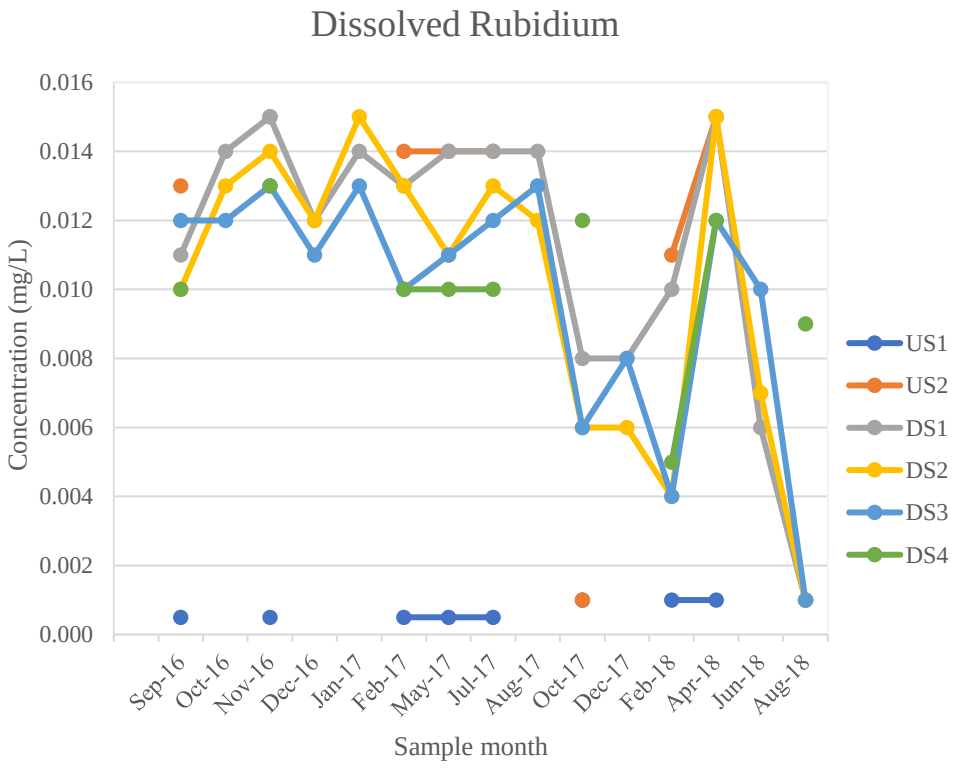

Dissolved Manganese
Concentration (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

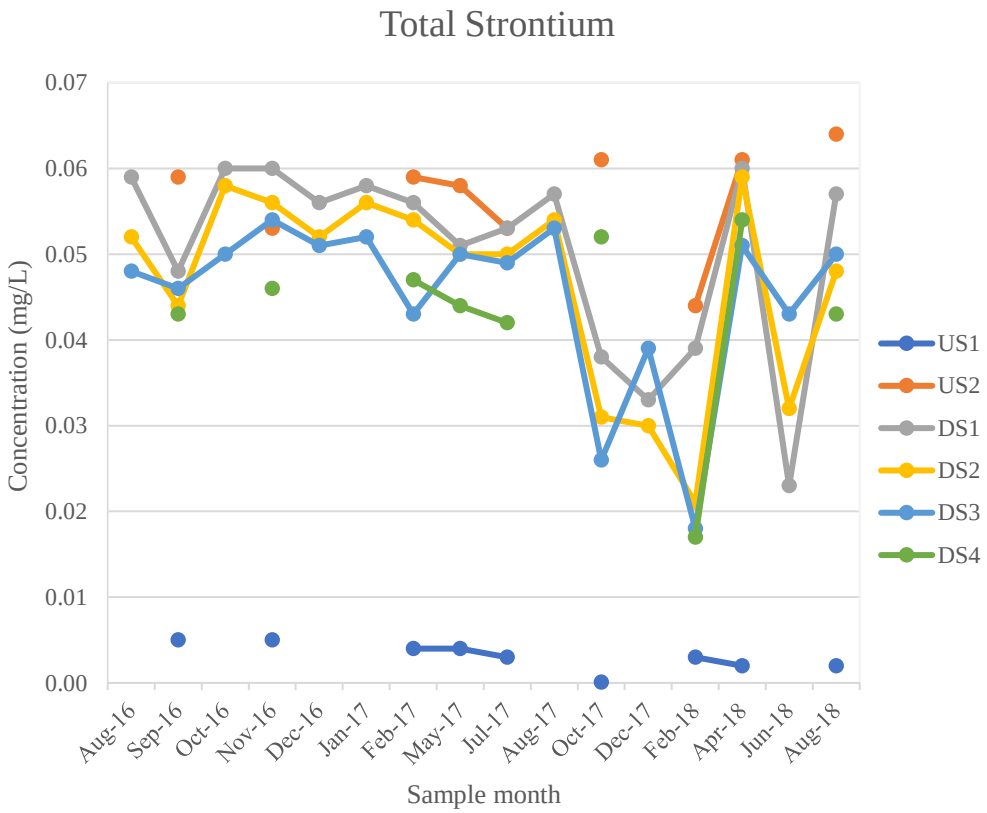

Dissolved Molybdenum
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Concentration (mg/L)
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

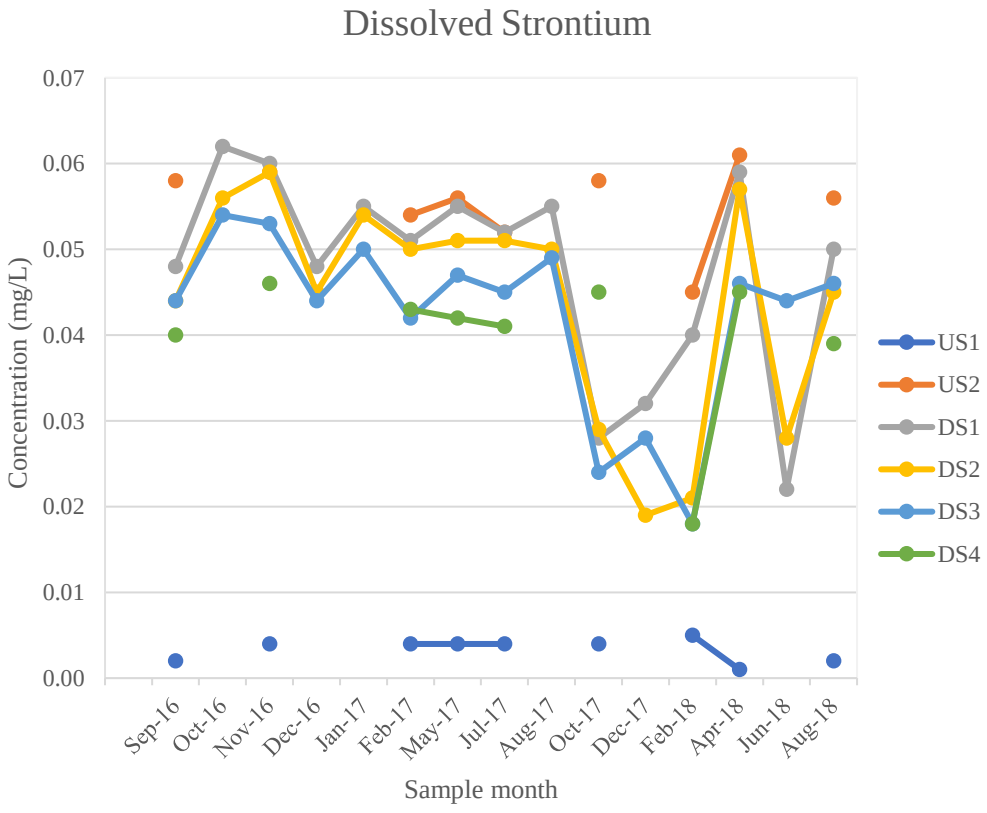

Total Nickel
Concentration (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

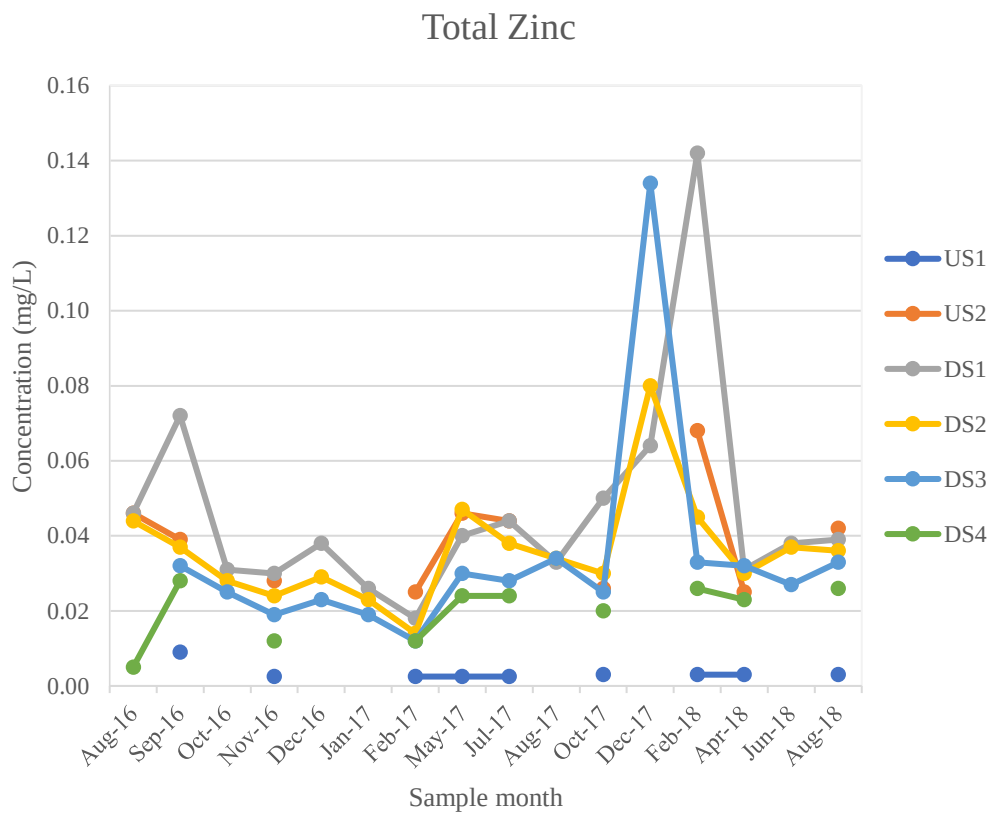

Dissolved Nickel
Concentration (mg/L)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

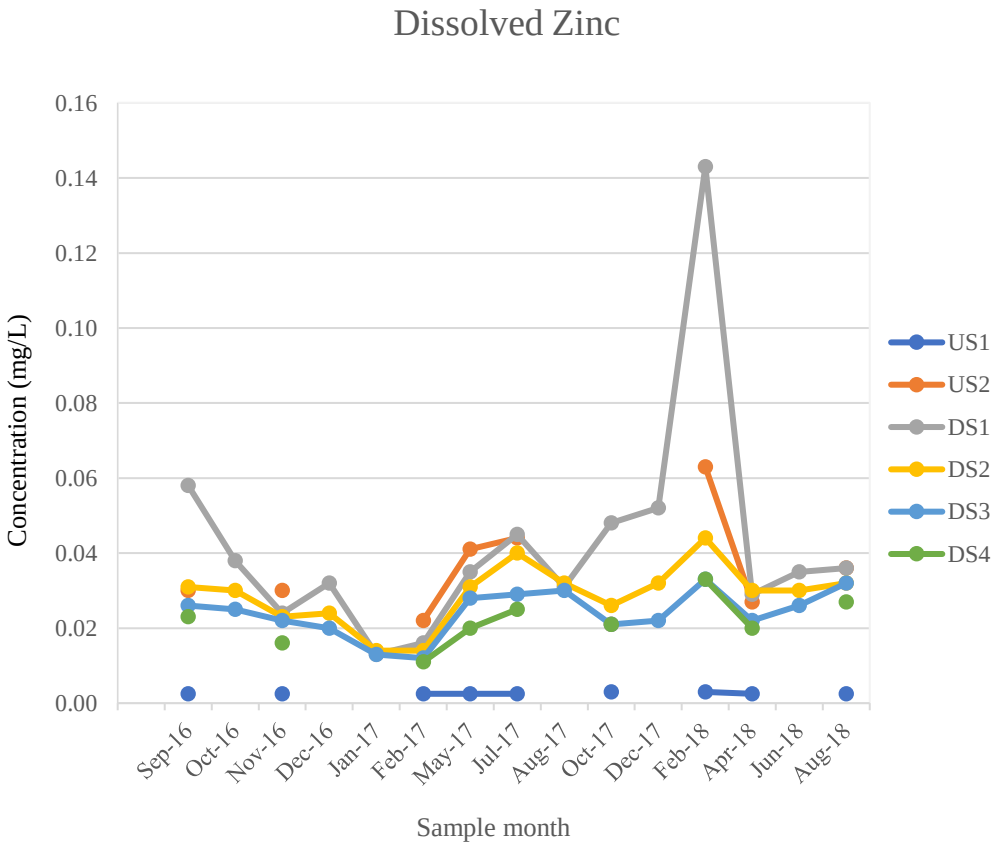

Total Rubidium
Concentration (mg/L)
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

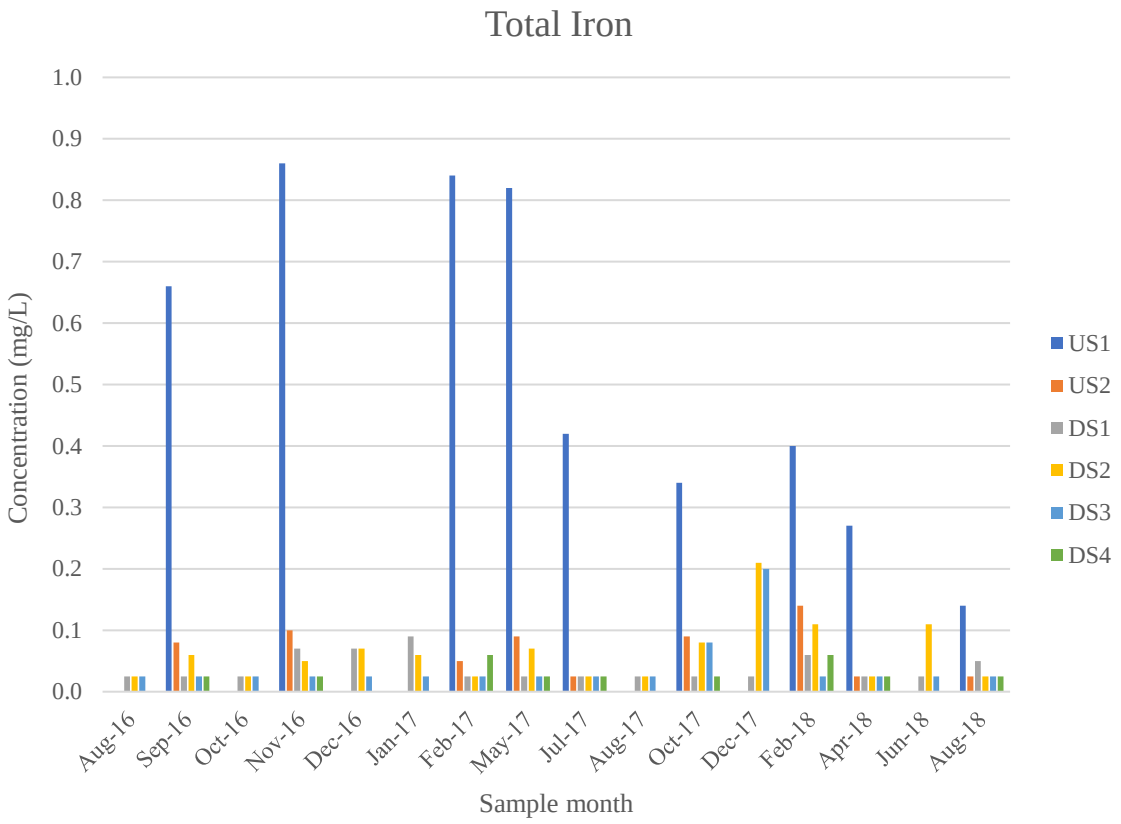

Dissolved Rubidium
Concentration (mg/L)
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

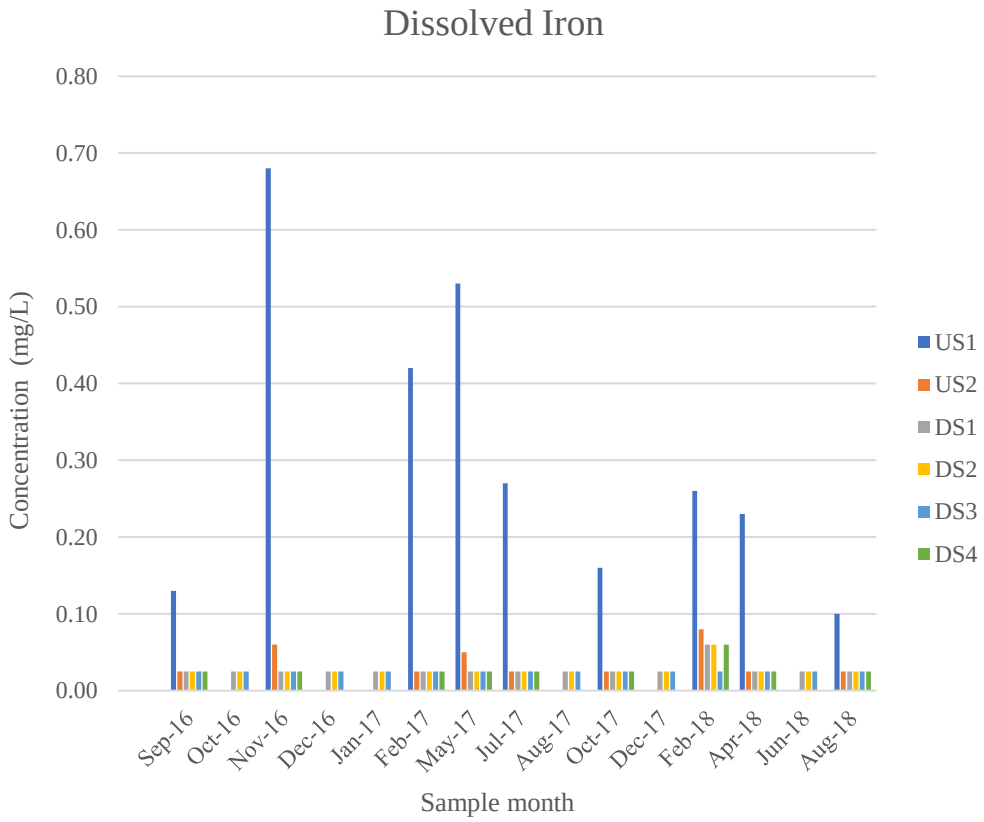

Total Strontium
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Concentration (mg/L)
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

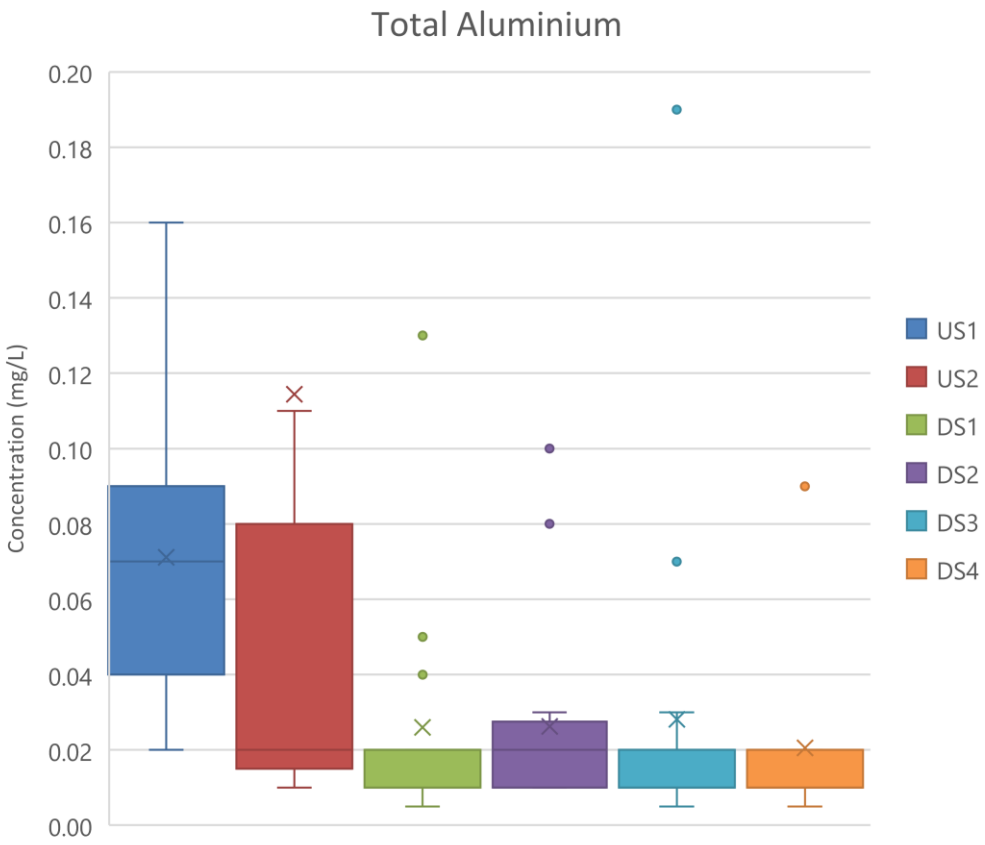

Dissolved Strontium
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Concentration (mg/L)
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

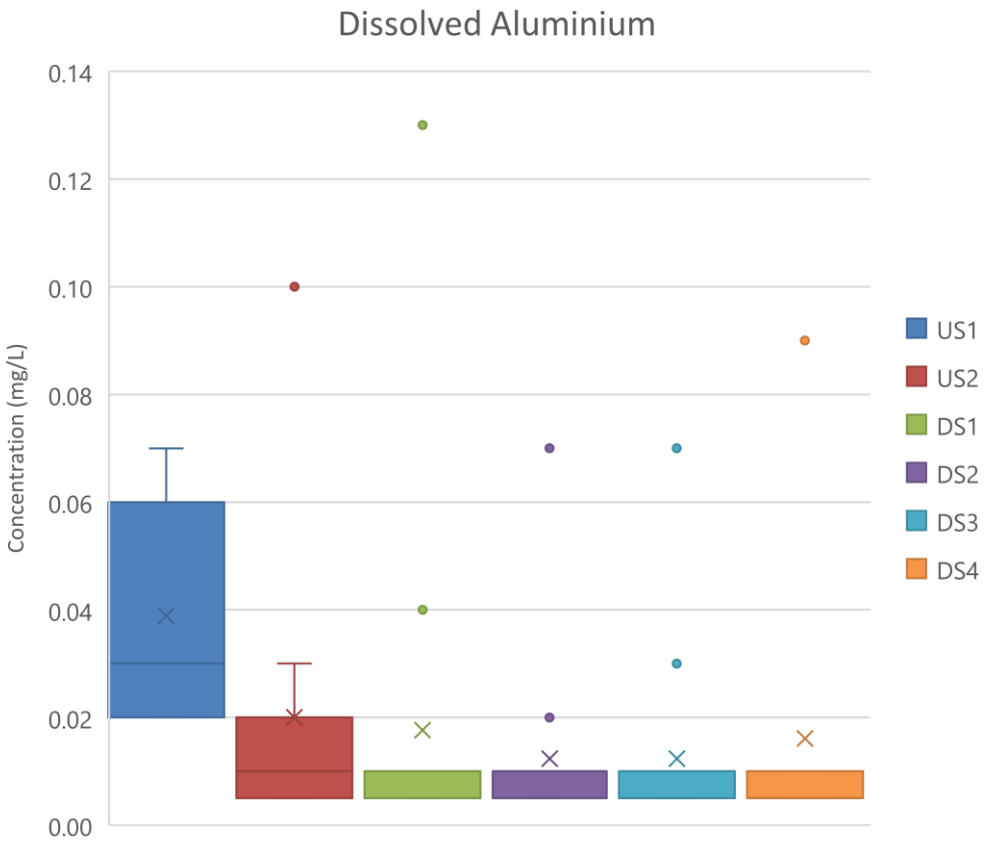

Total Zinc
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Concentration (mg/L)
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

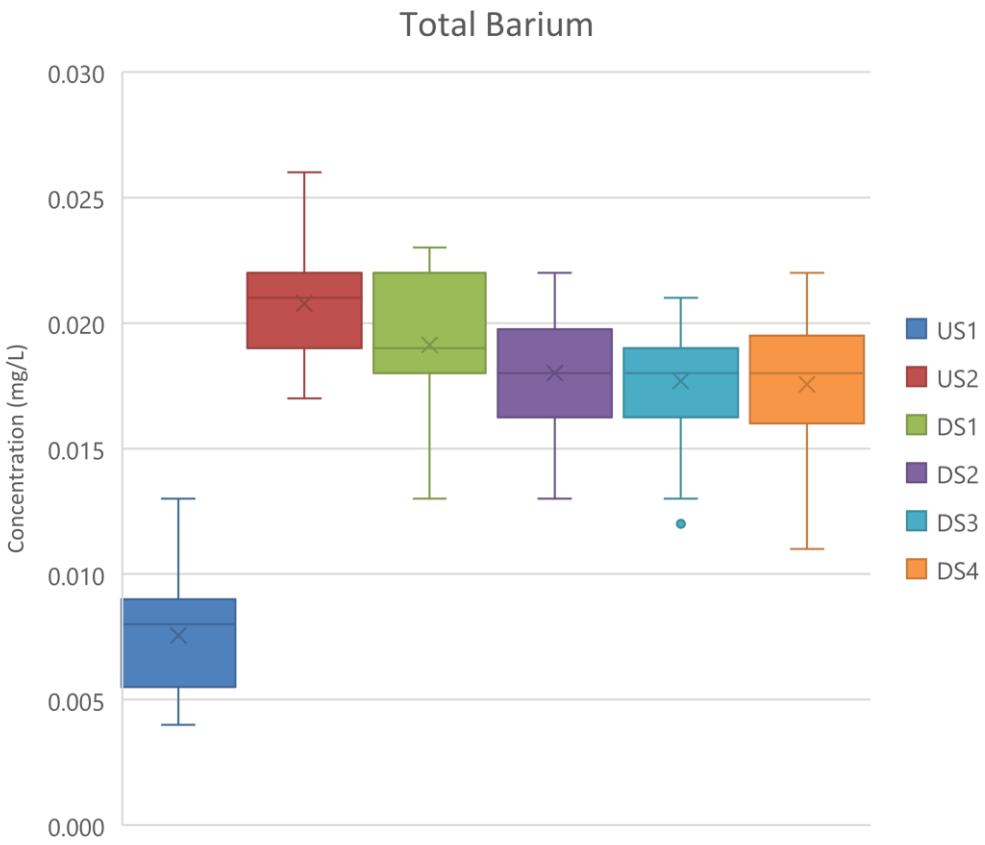

Dissolved Zinc
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Concentration (mg/L)
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

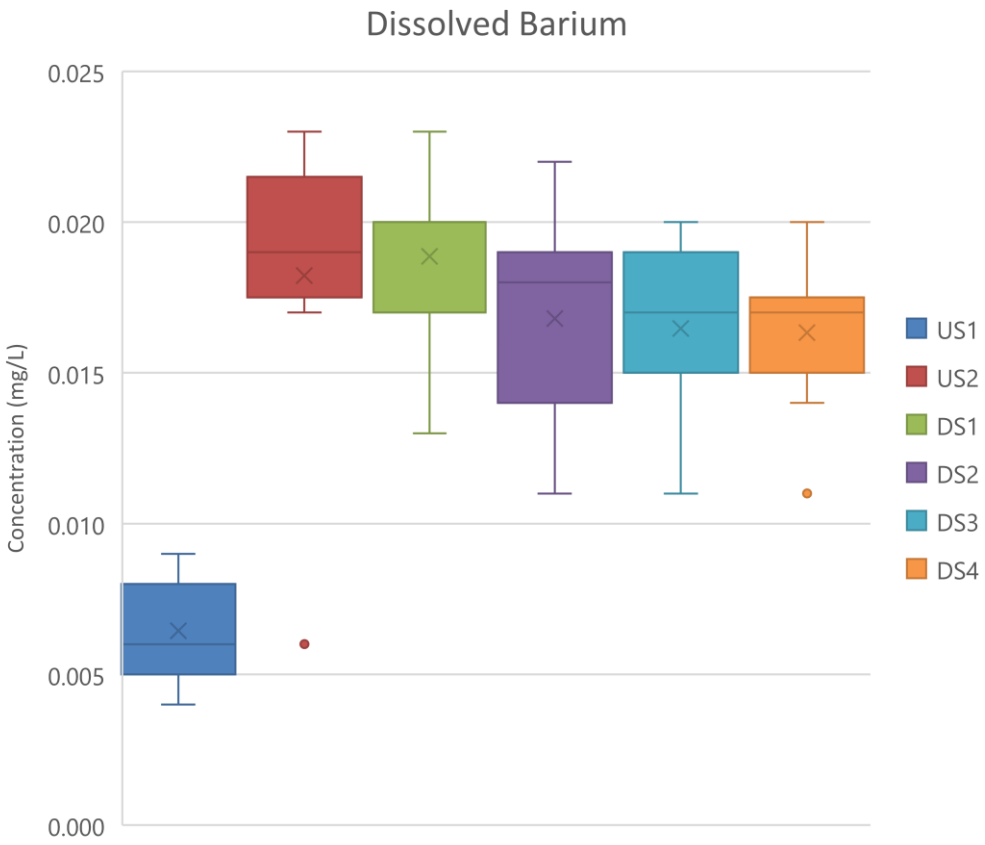

Total Iron
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Concentration (mg/L)
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

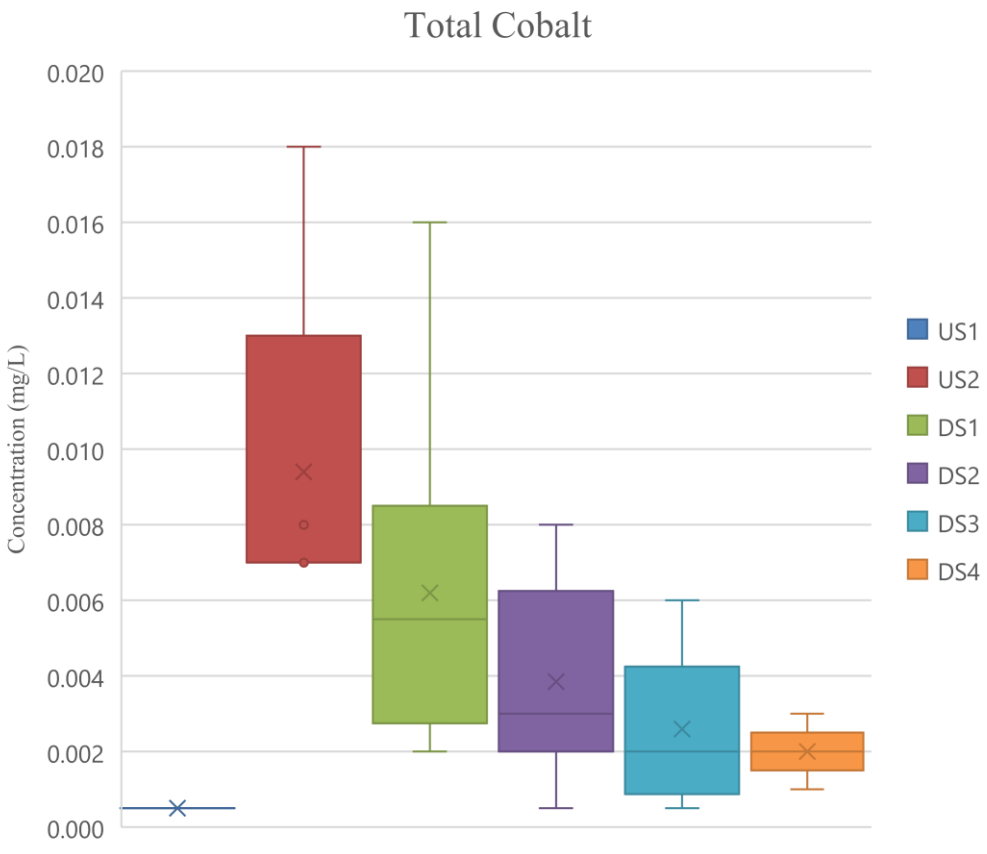

Dissolved Iron
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Concentration (mg/L)
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

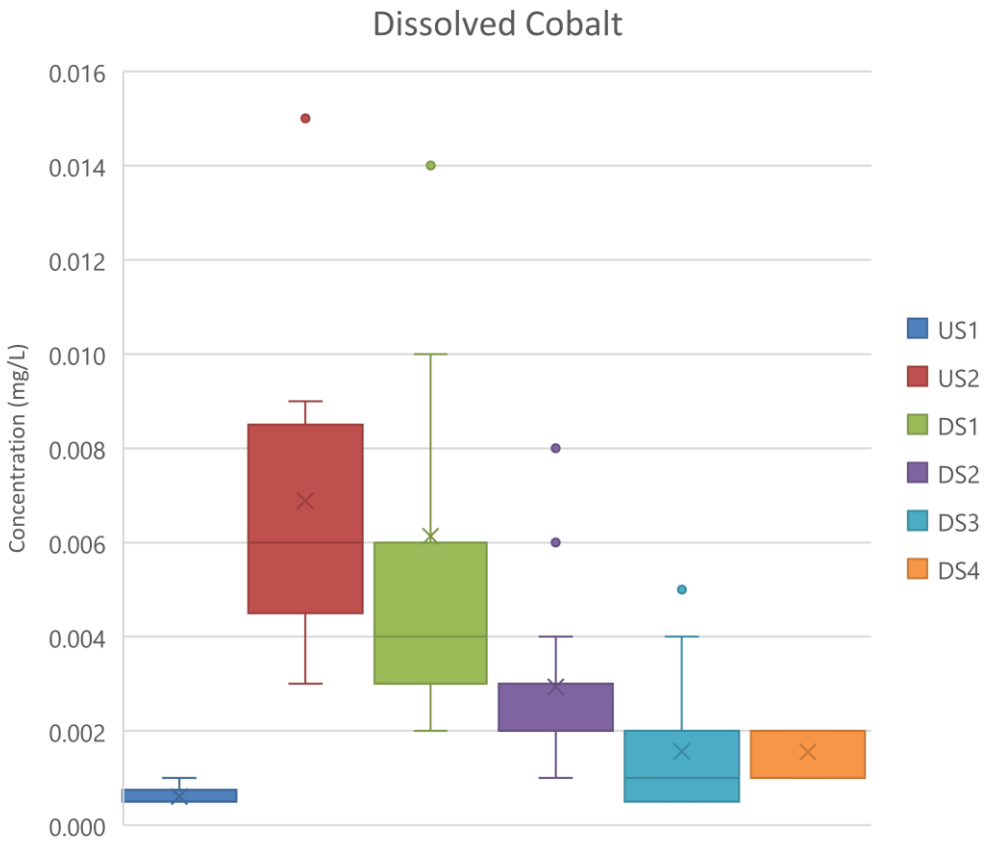

Total Aluminium
Concentration (mg/L)
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
US1
US2
DS1
DS2
DS3
DS4

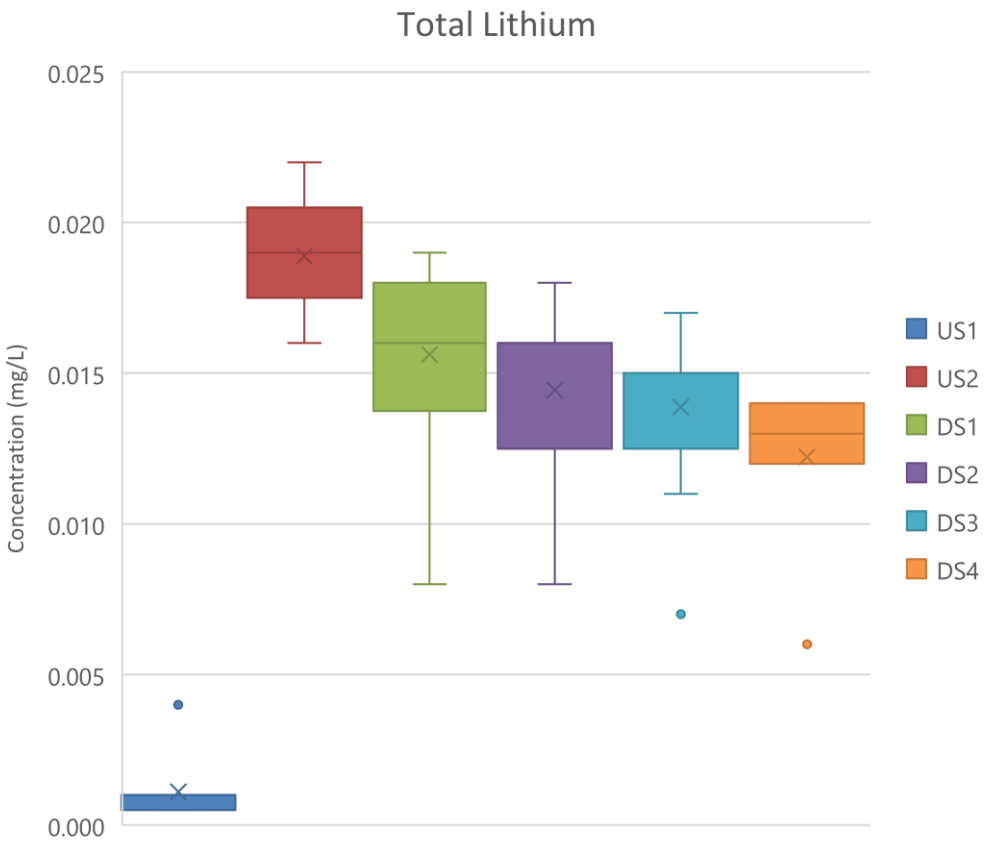

Dissolved Aluminium
Concentration (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
US1
US2
DS1
DS2
DS3
DS4

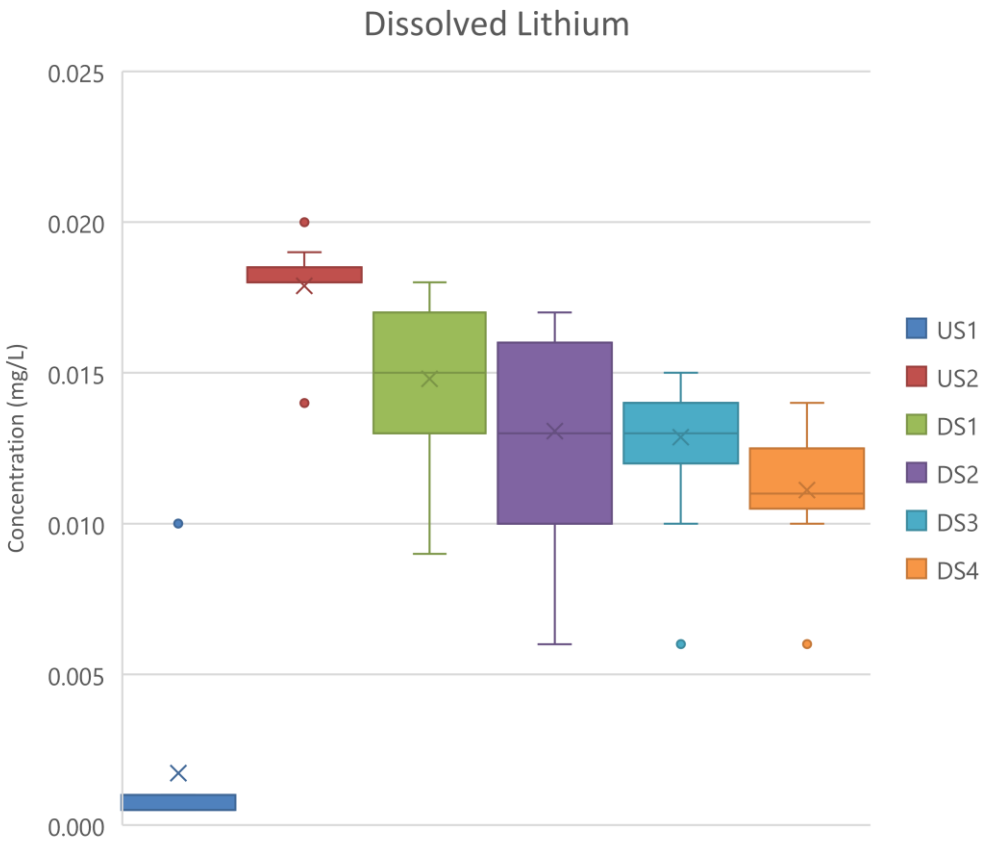

Total Barium
0.030
0.025
0.020
0.015
0.010
0.005
0.000
Concentration (mg/L)
US1
US2
DS1
DS2
DS3
DS4

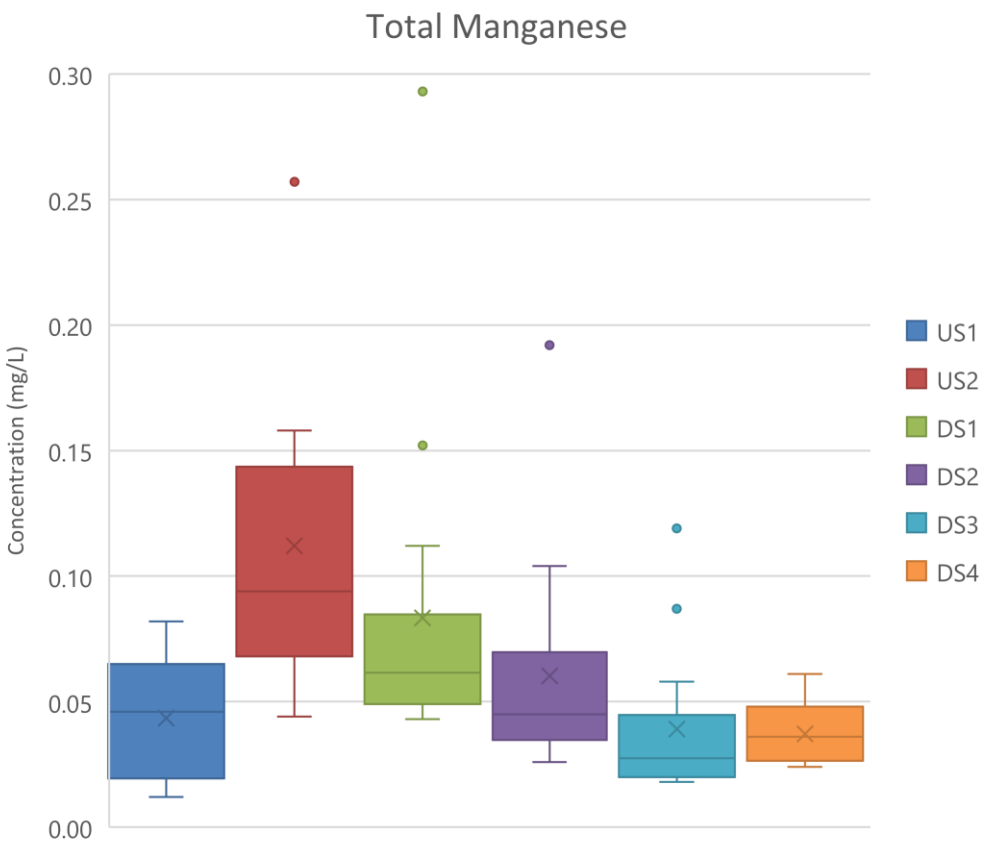

Dissolved Barium
0.025
0.020
0.015
0.010
0.005
0.000
Concentration (mg/L)
US1
US2
DS1
DS2
DS3
DS4

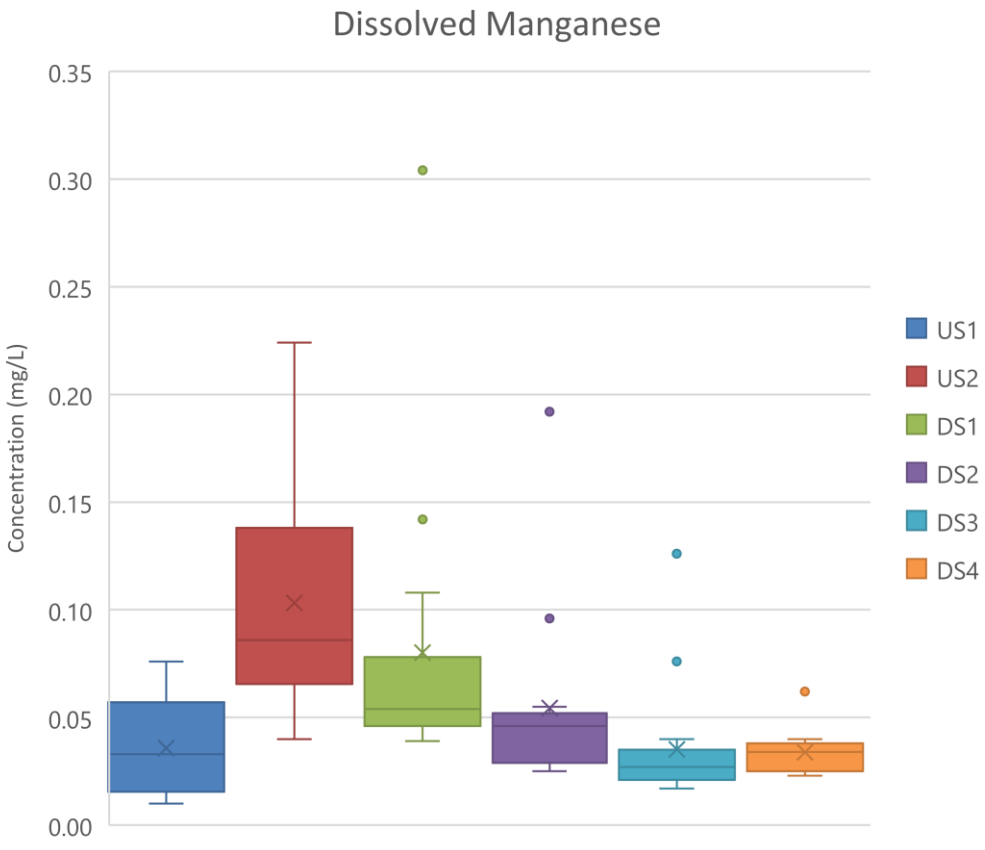

Total Cobalt
Concentration (mg/L)
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
US1
US2
DS1
DS2
DS3
DS4

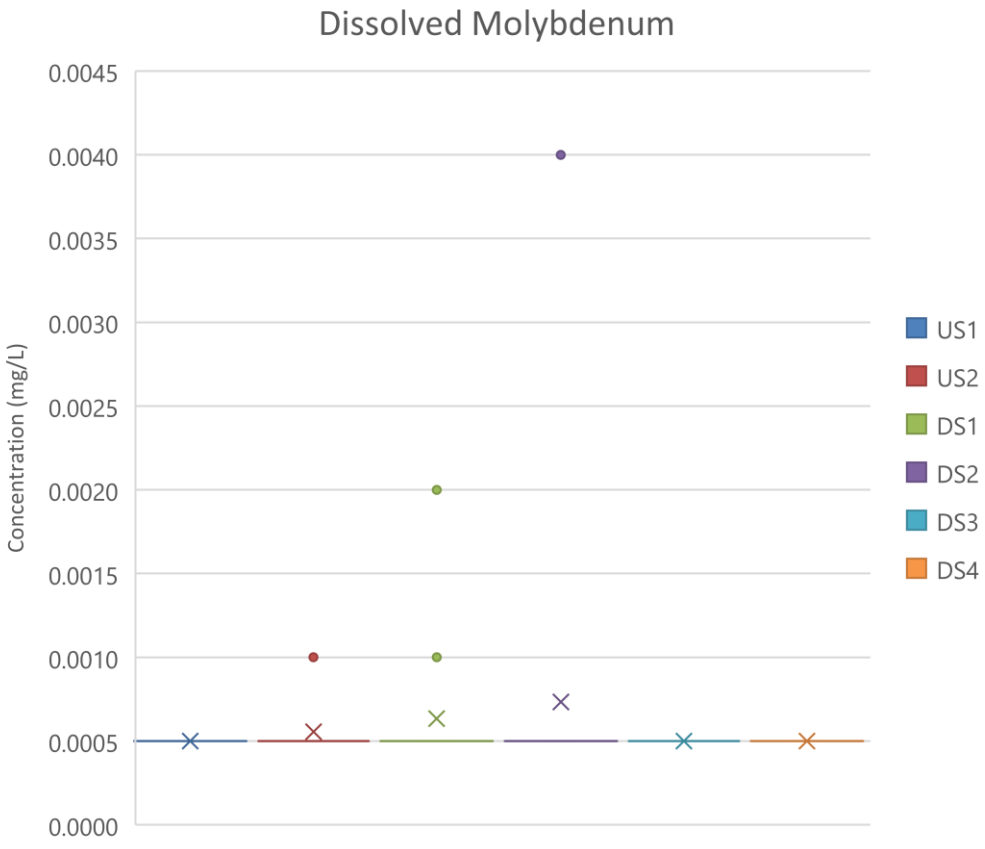

Dissolved Cobalt
Concentration (mg/L)
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
US1
US2
DS1
DS2
DS3
DS4

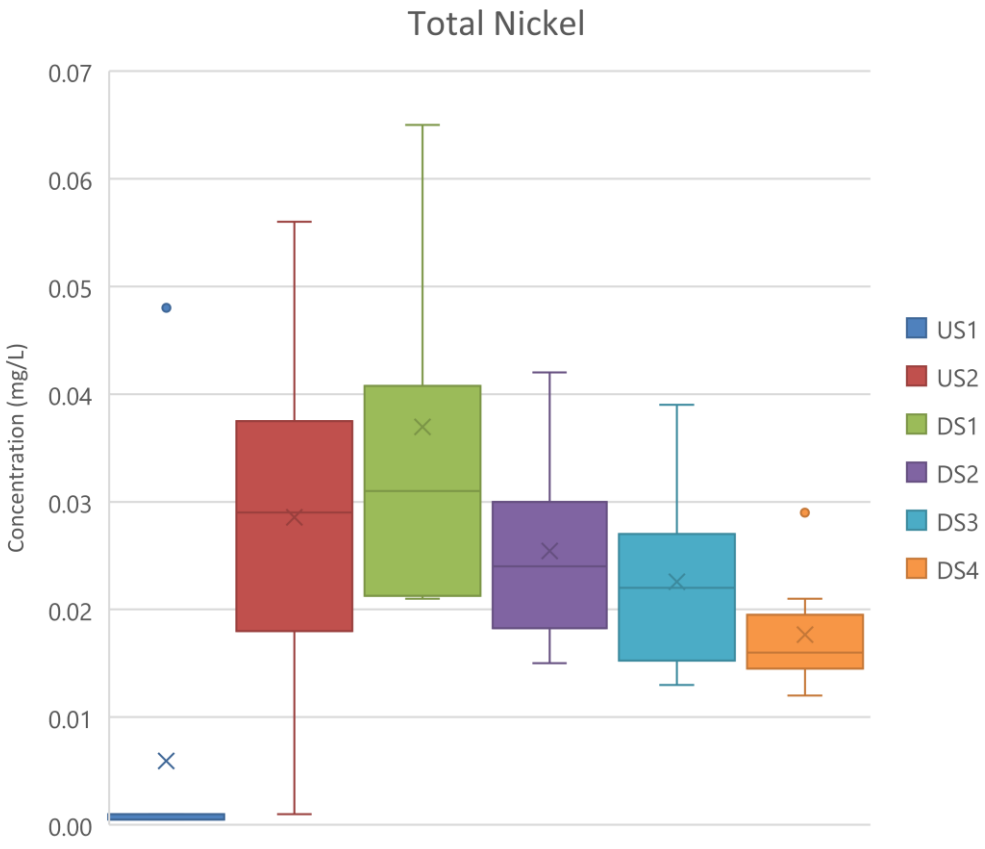

Total Lithium
Concentration (mg/L)
0.025
0.020
0.015
0.010
0.005
0.000
US1
US2
DS1
DS2
DS3
DS4

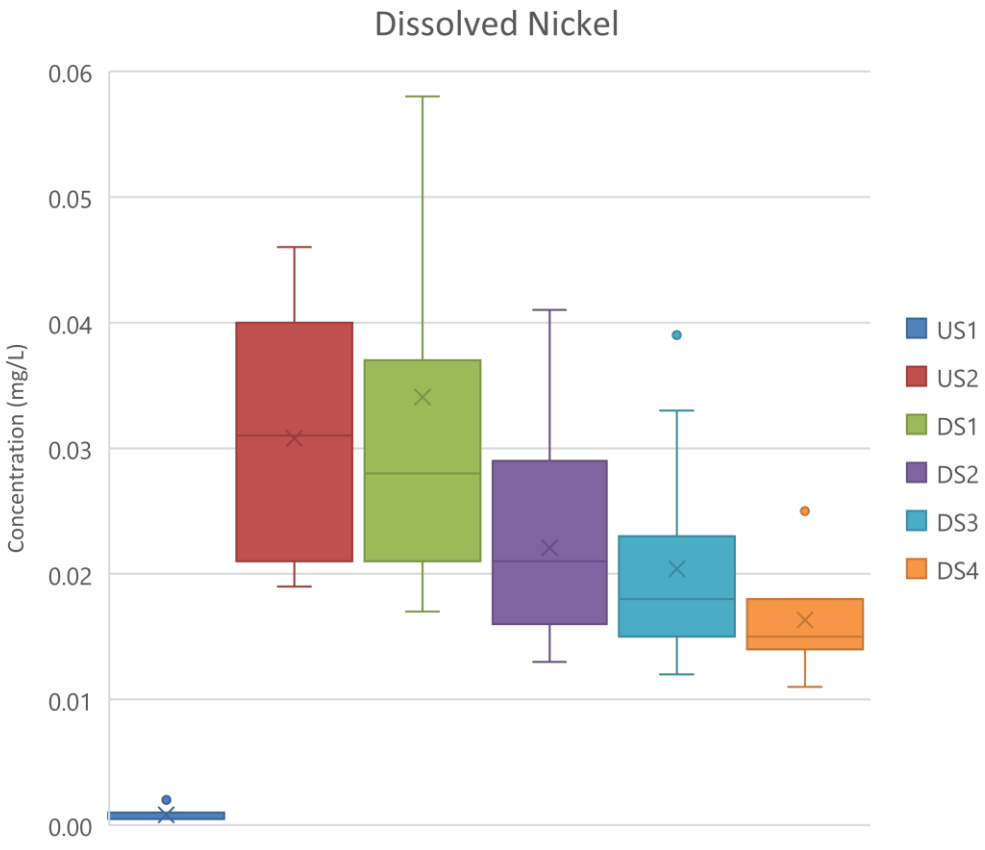

Dissolved Lithium
Concentration (mg/L)
0.025
0.020
0.015
0.010
0.005
0.000
US1
US2
DS1
DS2
DS3
DS4

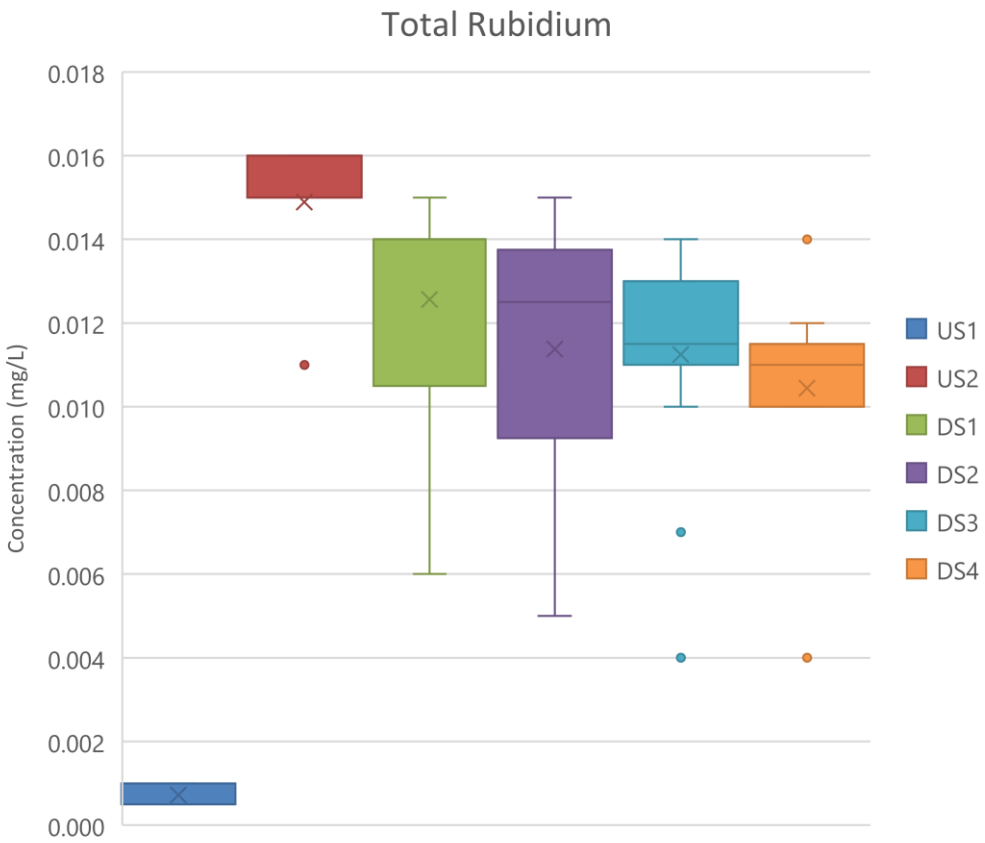

Total Manganese
Concentration (mg/L)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
US1
US2
DS1
DS2
DS3
DS4

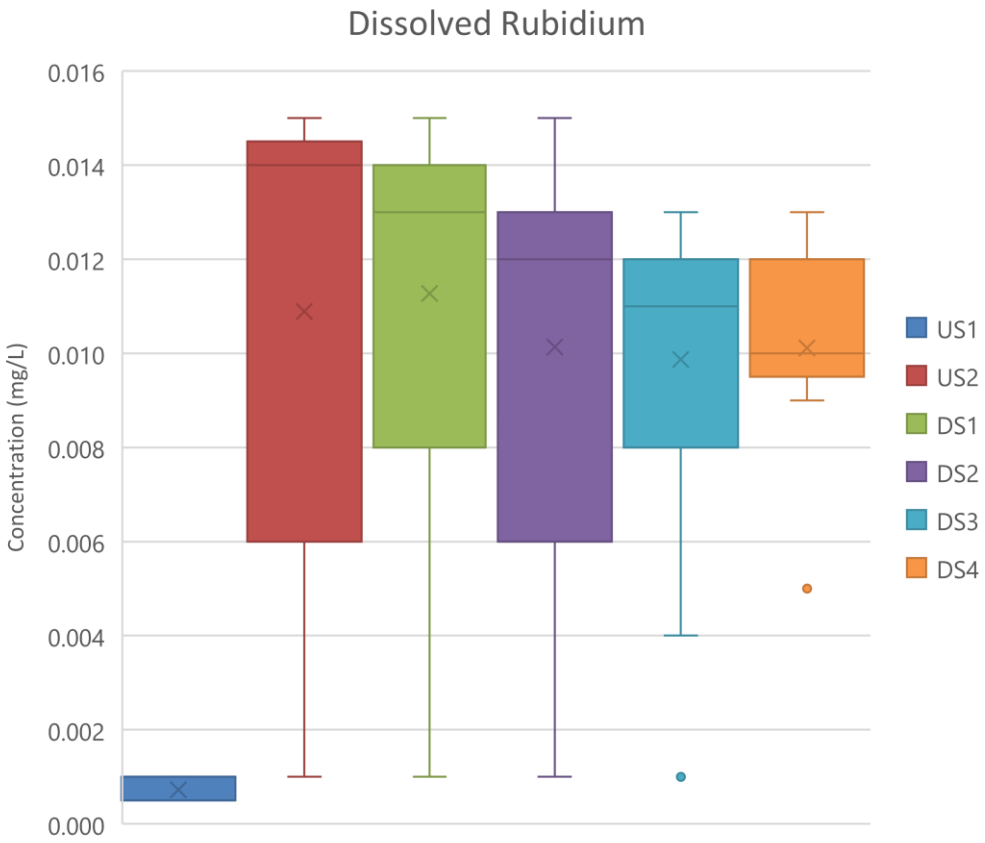

Dissolved Manganese
Concentration (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
US1
US2
DS1
DS2
DS3
DS4

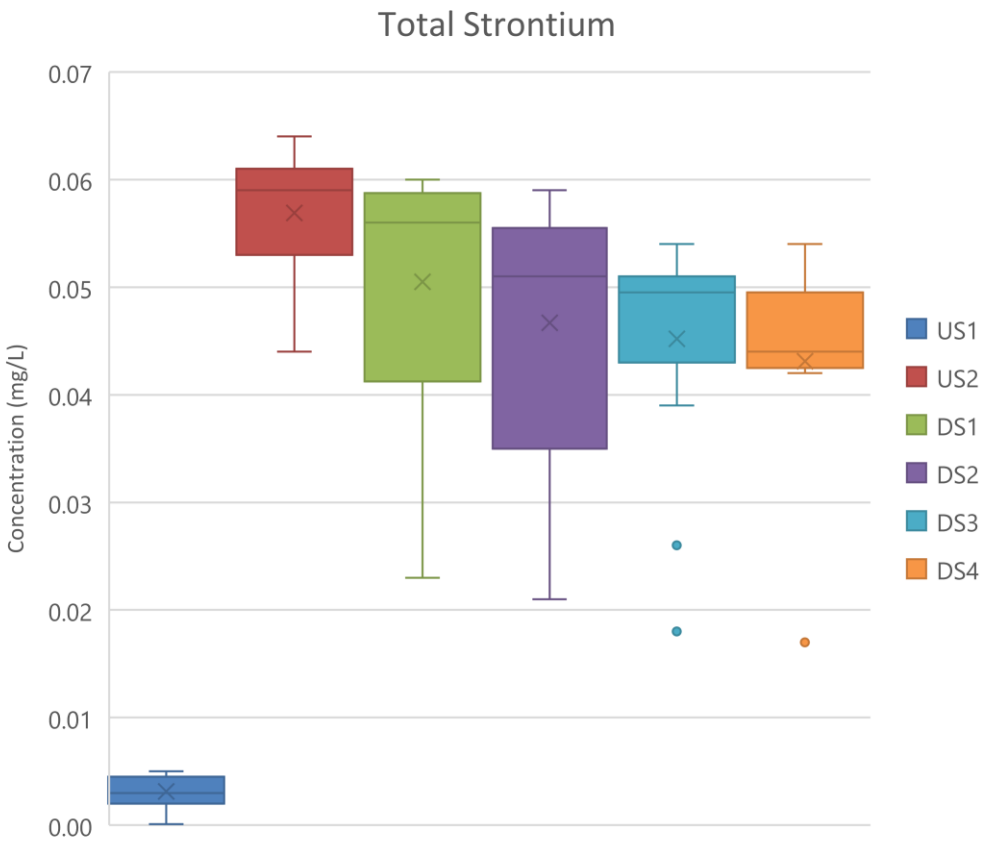

Dissolved Molybdenum
Concentration (mg/L)
0.0045
0.0040
0.0035
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
US1
US2
DS1
DS2
DS3
DS4

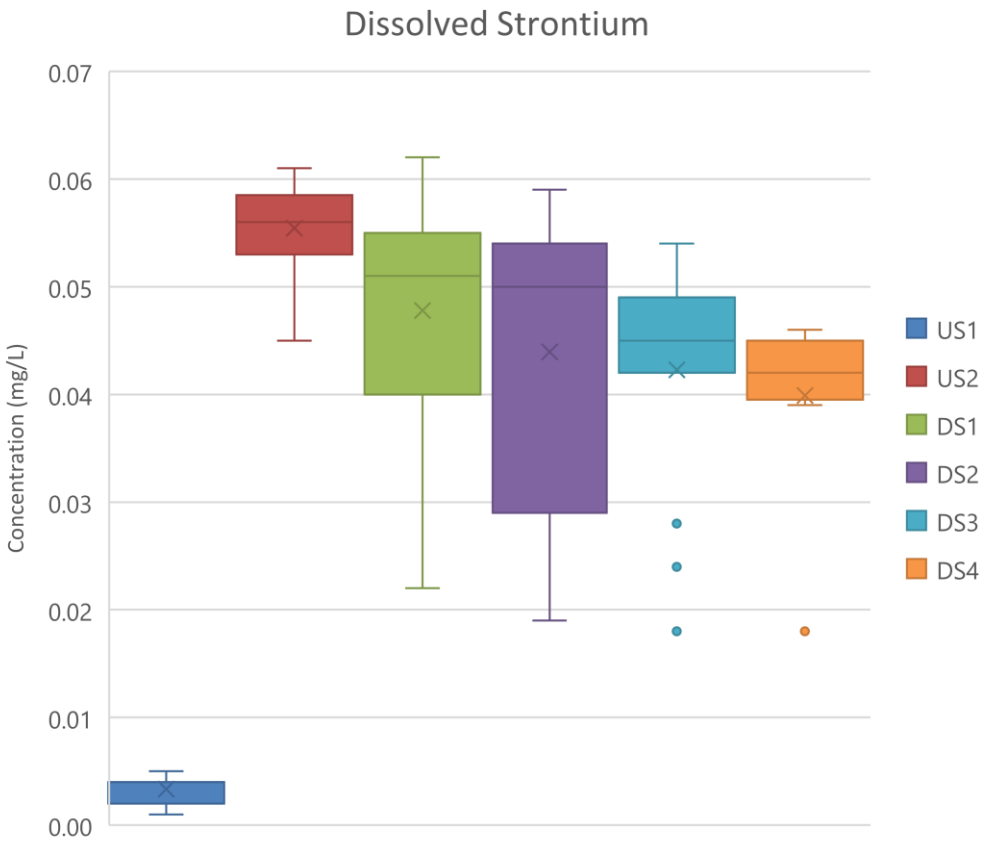

Total Nickel
Concentration (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
US1
US2
DS1
DS2
DS3
DS4

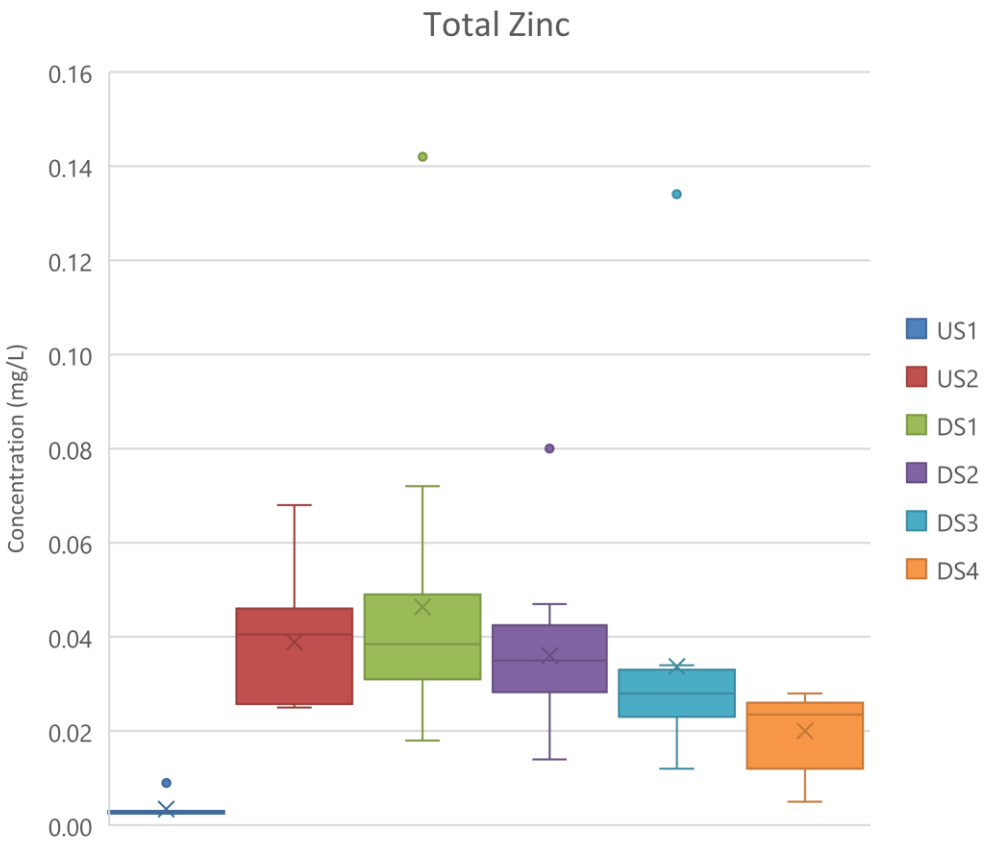

Dissolved Nickel
Concentration (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
US1
US2
DS1
DS2
DS3
DS4

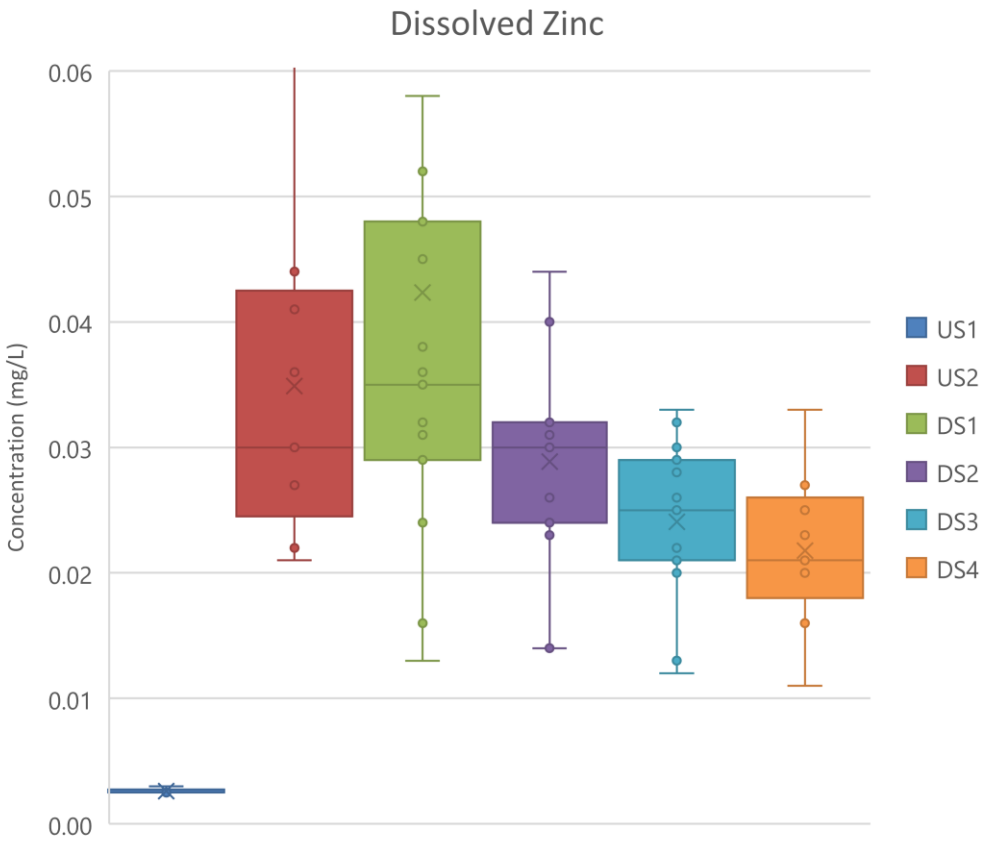

Total Rubidium
Concentration (mg/L)
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
US1
US2
DS1
DS2
DS3
DS4

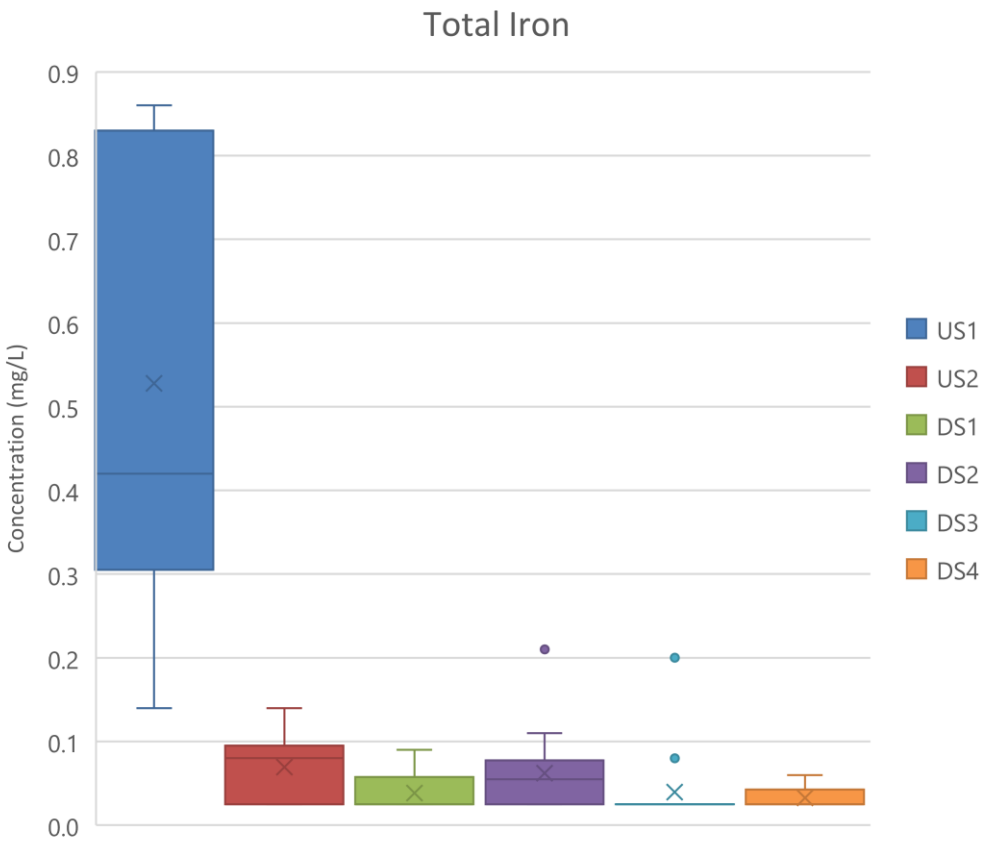

Dissolved Rubidium
Concentration (mg/L)
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000
US1
US2
DS1
DS2
DS3
DS4

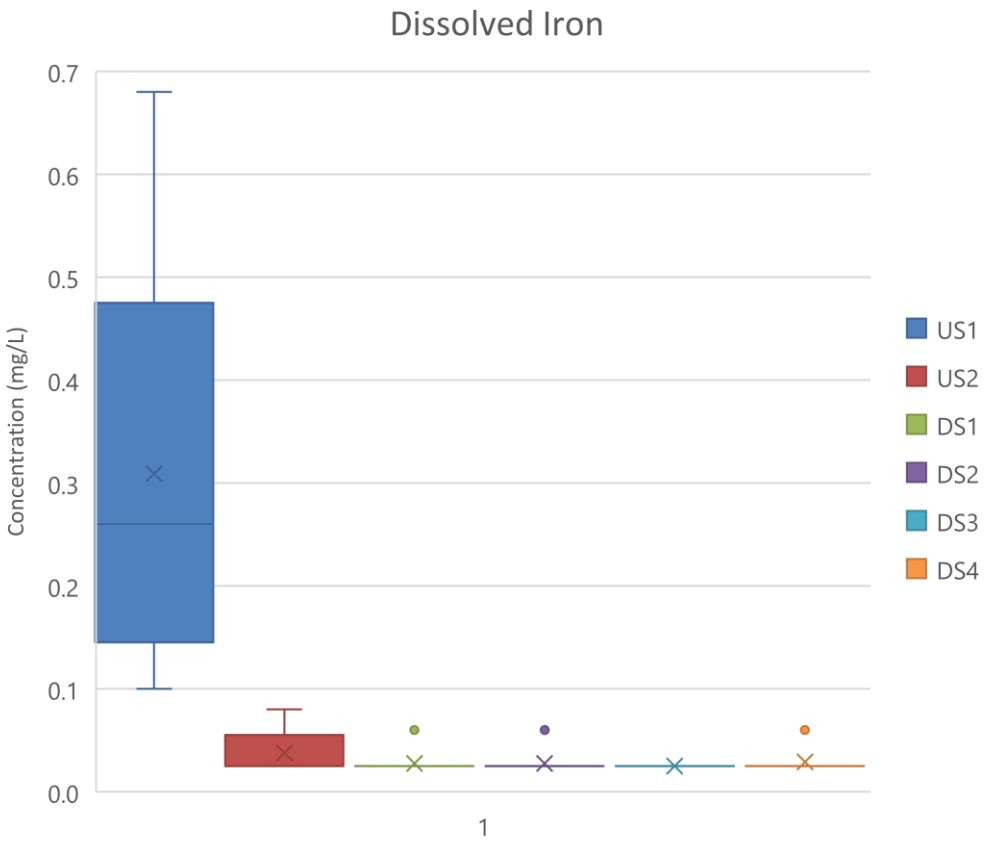

Total Strontium
Concentration (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
US1
US2
DS1
DS2
DS3
DS4


Dissolved Strontium
Concentration (mg/L)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
US1
US2
DS1
DS2
DS3
DS4


Total Zinc
Concentration (mg/L)
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
US1
US2
DS1
DS2
DS3
DS4


Dissolved Zinc
Concentration (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0.00
US1
US2
DS1
DS2
DS3
DS4


Total Iron
Concentration (mg/L)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
US1
US2
DS1
DS2
DS3
DS4


Dissolved Iron
Concentration (mg/L)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1
US1
US2
DS1
DS2
DS3
DS4

4. SEDIMENT QUALITY & COAL FINES MONITORING RESULTS

The Sediment Metals data for this reporting period are located in **Appendix B a**nd the available Microscopic Analysis Reports plus Petrography results are provided in **Appendix C.**

Section 4.1 provides a summary of sediment and fines monitoring methods and outlines how the data are presented.

Sediment total metals summary results are provided in **Section 4.2**. **Section 4.3** provides the Petrography summary results and **Section 4.4** summarises the results of the Visual inspection for coal fines.

4.1 Methods and Data Presentation

Field Methods:

Sediment sampling for the present six-monthly reporting period has been undertaken as per the EMP requirements:

- Three replicate sediment samples are collected to a depth of 10 cm at each of the nominated sites.
- The replicates are spaced 10m apart along a 20m stretch of the river.
- Samples are labelled and kept chilled for transport to the analysis laboratory.
- The laboratory then splits each replicate sample with one half submitted for total metal in sediment analysis for the same suite of analytes nominated for the water quality sampling.
- The other half of each split replicate sample is submitted for petrographic analysis.

For the coal-fine searches, visual inspections were made of the relevant sampling areas at all sampling events and at least once per quarter, visual searches were completed covering a distance of approximately 500m upstream and 500m downstream of each sampling location.

Data Presentation:

For **Section**s **4.2** and **4.3**, the results are presented in **Summary Tables**, and are shown graphically in **Control Charts** and **Box-plots**:

- The **Section 4.2 Summary Tables** present the analyte detection limit (DL), sample size, the number of sample values above DL, minimum, median, mean, standard deviation (SD) of the mean, 80th percentile and maximum value for each analyte over all sampling events to date. **Note that all concentration data are presented as mg/Kg.**
- Results for analytes that have all or most analytic results below detection are shaded in grey with no (or reduced) sample statistics calculated and no bar charts or box plots produced.
- Depending on sample size the following general rules apply to calculation of site statistics:
    - If no values >DL, DL indicated in all statistical cells (the min, max, mean cells etc).
    - if one value >DL, then maximum value only shown,
    - if two values >DL, then maximum and minimum values shown only,
    - If three values >DL (for sample size of 5 through to 10), then use half DL values for calculation of statistics, and show the DL as the minimum value.
    - For analytes with 3 or more values above DL, median, mean, SD and 80th percentile statistics are calculated using halve DL values.

- The **Control Charts** provide results for the concentrations of each analyte over time for all seven sites, from the first sample run in the first monitoring period (August 2016) to the most recent sample for this current monitoring period (August 2018). Most are shown in line graph mode.
    - Where analyte values are similar across sites making discrimination of site differences difficult to see in line graph mode, the control graphs are shown in the form of clustered bar charts.
    - For the initial sediment analysis (i.e., for samples collected in August 16), the detection limits for all analytes were set high and most were adjusted down for subsequent analyses. Consequently, statistical results for the first sample run where DL values have been set at half detection, result in a higher graphed value than subsequent data utilising half the lower detection limits. The site data that are affected are DS1 to DS3 and all analytes are affected except Aluminium, Boron, Iron and Sulphur as S (where the detection limit has remained unchanged at 50mg/kg) and for Cobalt, Manganese and Zinc where there were no values lower than detection for these sites on that occasion.
- **Box Plots** compare the summary statistical results for each analyte per site over the complete sampling program to data:
    - The upper and lower sides of the main box show the quartile (75 and 25 percentile) values for the data. The range between these values is called the interquartile range (IQR).
    - The line through the box shows the median (50 percentile) for the data and the cross (X) shows the mean value for the data.
    - The box 'whiskers' generally show the maximum and minimum values provided the data are all within 1.5 IQRs either side of the IQR.
    - If there are outlier data (i.e. values outside this range), they are shown as small circles located on both sides or on one side of the whiskers (depending whether the outliers are very low or very high value) and the whiskers on the side that have outliers then shows the 1.5 IQR limits for the data. Outliers will then indicate the relevant minimum or maximum value.

4.2 Sediment Total Metal Monitoring Data

The sediment total metal summary statistics for each sampling location and event are provided below in Site Summary **Tables 21 to 26**, Control Charts, and Box Plots:

- Selenium (DL < 1 mg/kg) and Boron (DL< 50mg/kg) concentrations were all <DL for all sites and for all sampling times to date, and are not plotted as Control Graphs or Box Plots.
- Cadmium (DL < 0.1mg/kg) concentrations were all <DL for all sites and for all sampling times to date with a signal replicate sample analysis at US2 that had a concentration value of 0.2 mg/kg. Cadmium results are not plotted as Control Graphs or Box Plots.
- Beryllium and Molybdenum concentrations were <DL (0.1mg/kg) at site US1 for 26 of the 27 replicate samples and for 23 of 27 the replicate samples at DS4.
- Uranium concentrations were <DL (0.1mg/kg) for 26 of the 27 replicate samples for US1 and 25 of 27 the replicate samples at DS4.
- Sulfur concentrations were <DL (50mg/kg) for 25 of 27 replicate samples at US1 and 24 of 27 the replicate samples at DS4.

Table 21 US1 Sediment Summary Statistics

	Total Metals																				
	Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Sulfur as S	Uranium	Zinc
Detection limit (DL)	50	0.1	0.1	0.1	0.1	50	0.1	0.1	0.1	0.1	50	0.1	0.1	0.1	0.1	0.1	0.1	1	0.1	50	0.1	0.5
Sample size (n)	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
n > DL	27	1	22	27	1	0	0	27	27	26	27	27	20	27	0	21	27	0	27	2	1	22
Min	210	-	0.1	0.8	-	<DL	<DL	0.2	0.1	0.1	810	0.3	0.1	11.2	<DL	0.1	0.1	<DL	0.2	90	-	0.5
Median	470.0	-	0.2	1.9	-	<DL	<DL	0.6	0.4	0.4	1830.0	0.6	0.1	46.2	<DL	0.2	0.3	<DL	0.6	-	-	0.8
Mean	881.5	-	0.2	3.3	-	<DL	<DL	0.8	0.8	0.7	2918.5	1.0	0.2	87.1	<DL	0.2	0.4	<DL	0.7	-	-	1.1
SD	1139.5	-	0.2	3.9	-	<DL	<DL	0.7	0.8	0.8	2549.3	1.4	0.1	112.7	<DL	0.3	0.3	<DL	0.7	-	-	1.0
80th percentile	856.0	-	0.3	3.5	-	<DL	<DL	1.2	1.0	1.0	3904.0	1.0	0.3	92.9	<DL	0.3	0.5	<DL	0.8	-	-	1.3
Max	4960	0.1	0.8	17	0.2	<DL	<DL	3.3	3.8	4.3	12200	7.2	0.6	553	<DL	1.3	1.4	<DL	3.3	140	0.2	4.9

Table 22 US2 Sediment Summary Statistics

	Total Metals																				
	Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Sulfur as S	Uranium	Zinc
Detection limit (DL)	50	0.1	0.1	0.1	0.1	50	0.1	0.1	0.1	0.1	50	0.1	0.1	0.1	0.1	0.1	0.1	1	0.1	50	0.1	0.5
Sample size (n)	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
n > DL	27	21	27	27	26	0	6	27	27	27	27	27	27	27	26	27	27	0	27	9	12	27
Min	310	0.1	0.2	9.6	0.1	<DL	0.1	0.2	5.1	0.6	610	0.5	0.1	103	0.1	6	0.2	<DL	0.4	50	0.1	13.7
Median	620.0	0.2	0.3	22.2	0.2	<DL	0.1	0.7	210.0	1.1	1730.0	1.3	4.5	1970.0	1.2	166.0	0.6	<DL	1.3	25.0	0.1	220.0
Mean	1222.2	0.2	0.4	30.7	0.5	<DL	0.1	1.1	293.5	2.8	2634.1	2.0	4.8	2717.6	1.5	250.0	0.7	<DL	2.0	94.4	0.2	336.2
SD	1158.1	0.2	0.3	21.9	0.6	<DL	0.1	1.2	239.7	3.3	2546.5	1.6	2.8	2360.7	1.2	236.8	0.4	<DL	1.9	189.3	0.3	296.4
80th percentile	2618.0	0.3	0.5	39.3	0.5	<DL	0.1	2.0	349.6	4.1	4190.0	3.2	6.9	3154.0	1.9	293.2	1.1	<DL	2.6	60.0	0.2	385.8
Max	3740	0.8	1.4	93.3	2.5	<DL	0.4	4.9	893	13.5	10800	5.8	12.3	10800	6.4	902	1.7	<DL	7.3	940	1	1210

Table 23 DS1 Sediment Summary Statistics

	Total Metals																				
	Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Sulfur as S	Uranium	Zinc
Detection limit (DL)	50	0.1	0.1	0.1	0.1	50	0.1	0.1	0.1	0.1	50	0.1	0.1	0.1	0.1	0.1	0.1	1	0.1	50	0.1	0.5
Sample size (n)	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	47	48
n > DL	48	25	44	47	43	0	3	47	48	45	48	44	47	48	44	48	47	0	47	8	14	48
Min	260	0.1	0.1	0.1	0.1	<DL	0.1	0.1	0.4	0.1	330	0.1	0.1	2.5	0.1	0.2	0.1	<DL	0.1	50	0.1	0.5
Median	640.0	0.1	0.2	16.1	0.2	<DL	0.1	0.6	171.0	1.2	1090.0	1.1	4.1	1435.0	1.0	126.0	0.9	<DL	1.2	25.0	0.1	156.5
Mean	1181.5	0.2	0.4	19.1	0.3	<DL	0.1	0.9	202.5	1.5	1456.0	1.3	4.8	1657.2	1.1	139.3	0.9	<DL	1.3	34.4	0.1	177.3
SD	935.2	0.6	0.6	10.8	0.2	<DL	0.1	0.8	113.2	1.1	944.9	0.8	5.4	840.3	0.4	63.0	0.4	<DL	0.7	26.4	0.1	80.7
80th percentile	2076.0	0.1	0.3	20.4	0.4	<DL	0.1	1.1	220.0	1.8	1608.0	1.5	5.2	1896.0	1.2	158.8	1.2	<DL	1.6	25.0	0.1	202.2
Max	4000	0.4	0.8	72.1	1.7	<DL	0.2	4	656	7.1	4440	4.7	40	4230	2.4	392	2.1	<DL	4	170	0.7	483

Table 24 DS2 Sediment Summary Statistics

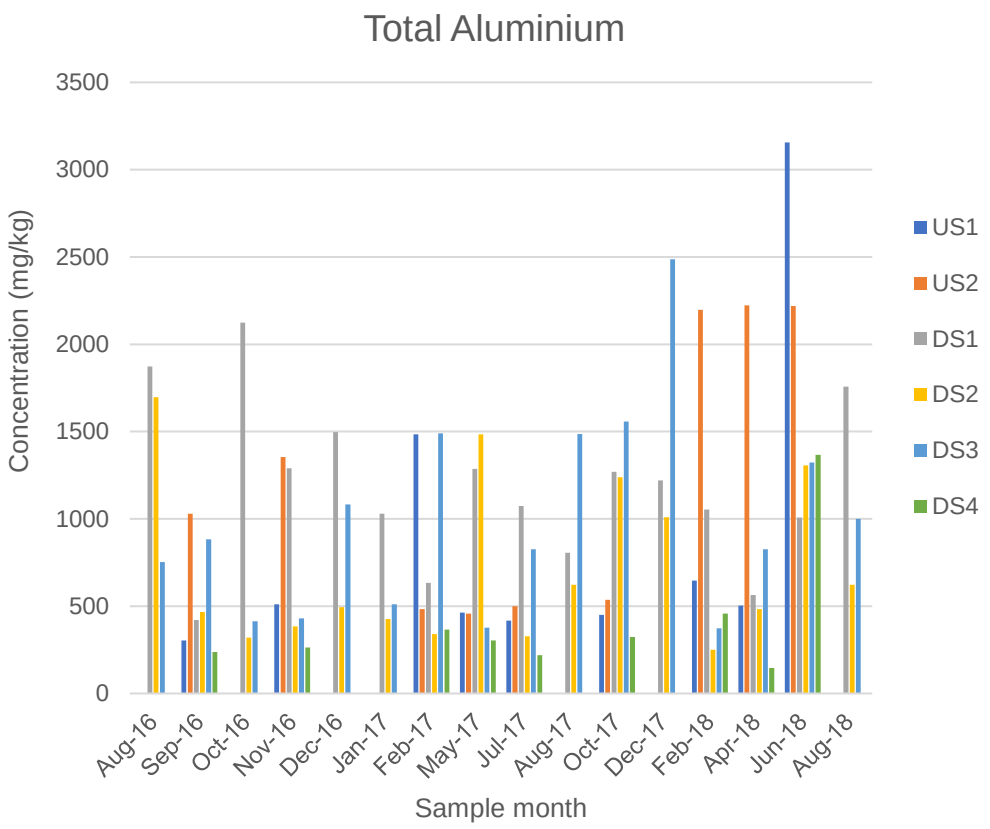
	Total Metals																				
	Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Sulfur as S	Uranium	Zinc
Detection limit (DL)	50	0.1	0.1	0.1	0.1	50	0.1	0.1	0.1	0.1	50	0.1	0.1	0.1	0.1	0.1	0.1	1	0.1	50	0.1	0.5
Sample size (n)	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47
n > DL	47	4	27	45	21	0	0	47	47	44	47	44	47	47	42	47	47	0	45	6	10	47
Min	23.4	0.1	0.1	0.1	0.1	<DL	<DL	0.3	3.8	0.1	410	0.1	0.5	13.5	0.1	11	0.3	<DL	0.1	50	0.1	18.3
Median	450.0	0.1	0.1	4.5	0.1	<DL	<DL	0.7	25.3	0.7	950.0	0.9	1.0	188.0	0.2	21.4	0.7	<DL	0.9	25.0	0.1	28.5
Mean	726.9	0.2	0.3	5.9	0.1	<DL	<DL	1.1	25.9	1.0	1611.9	1.2	1.1	214.8	0.2	25.7	0.8	<DL	1.1	32.7	0.1	34.7
SD	709.8	0.6	0.6	4.3	0.1	<DL	<DL	1.0	12.5	0.7	1648.1	0.7	0.5	116.1	0.2	12.1	0.4	<DL	0.6	24.0	0.0	17.6
80th percentile	766.0	0.1	0.2	7.5	0.2	<DL	<DL	1.4	35.7	1.4	2210.0	1.6	1.4	294.4	0.3	35.5	1.0	<DL	1.7	25.0	0.1	46.0
Max	3050	0.2	0.5	20.3	0.4	<DL	<DL	4.8	71.1	3.2	8870	3.7	3.2	548	0.6	79.2	2.1	<DL	3	160	0.2	111

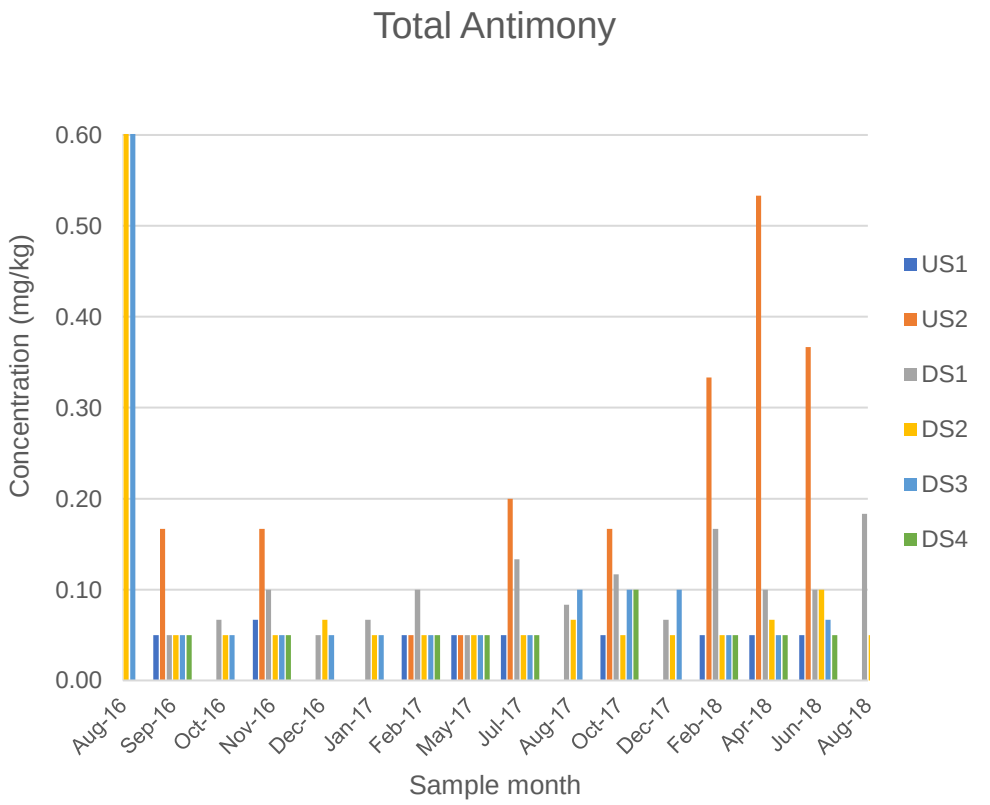
Table 25 DS3 Sediment Summary Statistics

	Total Metals																				
	Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Sulfur as S	Uranium	Zinc
Detection limit (DL)	50	0.1	0.1	0.1	0.1	50	0.1	0.1	0.1	0.1	50	0.1	0.1	0.1	0.1	0.1	0.1	1	0.1	50	0.1	0.5
Sample size (n)	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48	48
n > DL	48	3	21	45	14	0	2	47	48	45	48	45	47	48	24	48	48	0	45	13	10	48
Min	160	0.1	0.1	0.1	0.1	<DL	0.1	0.1	4	0.1	160	0.1	0.1	18.7	0.1	5.6	0.3	<DL	0.1	50	0.1	8
Median	405.0	0.1	0.1	4.0	0.1	<DL	-	0.8	13.6	0.7	1200.0	0.8	0.7	121.5	0.1	13.7	0.8	<DL	0.9	25.0	0.1	21.9
Mean	988.0	0.2	0.3	7.5	0.2	<DL	-	1.2	25.8	1.8	1625.8	1.7	0.8	195.3	0.2	22.3	0.9	<DL	1.4	72.8	0.1	31.0
SD	1330.5	0.6	0.6	10.4	0.4	<DL	-	1.0	30.3	3.2	1391.7	2.4	0.4	212.6	0.2	19.7	0.6	<DL	1.6	151.4	0.3	27.5
80th percentile	1614.0	0.1	0.2	8.9	0.2	<DL	-	1.9	35.6	2.4	2216.0	2.2	1.1	252.0	0.2	28.5	1.2	<DL	1.5	60.0	0.1	37.1
Max	6600	0.2	0.9	62.3	2.7	<DL	0.2	5.1	145	20.3	5910	14.6	2.6	1070	0.5	99.3	3.2	<DL	9.4	920	1.6	128

Table 26 DS4 Sediment Summary Statistics

	Total Metals																				
	Aluminium	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Lithium	Manganese	Molybdenum	Nickel	Rubidium	Selenium	Strontium	Sulfur as S	Uranium	Zinc
Detection limit (DL)	50.0	0.1	0.1	0.1	0.1	50.0	0.1	0.1	0.1	0.1	50.0	0.1	0.1	0.1	0.1	0.1	0.1	1.0	0.1	50.0	0.1	0.5
Sample size (n)	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
n > DL	27.0	0	7.0	27.0	4.0	0	0	27.0	27.0	26.0	27.0	27.0	27.0	27.0	5.0	27.0	27.0	0	27.0	4.0	2.0	27.0
Min	130.0	<DL	0.1	1.0	0.1	<DL	<DL	0.2	2.1	0.1	290.0	0.3	0.1	7.6	0.1	1.7	0.2	<DL	0.2	50.0	0.2	2.3
Median	250.0	<DL	0.1	2.5	0.1	<DL	<DL	0.4	8.4	0.3	650.0	0.5	0.6	46.6	0.1	7.9	0.4	<DL	0.6	25.0	-	11.6
Mean	409.3	<DL	0.1	4.8	0.1	<DL	<DL	0.5	12.1	0.8	946.7	0.9	0.6	94.9	0.1	11.7	0.5	<DL	1.0	36.5	-	16.0
SD	646.9	<DL	0.0	7.4	0.2	<DL	<DL	0.4	12.2	1.3	969.6	1.0	0.4	115.3	0.1	10.9	0.4	<DL	1.5	37.0	-	16.1
80th percentile	376.0	<DL	0.1	4.8	0.1	<DL	<DL	0.7	19.8	0.8	920.0	1.0	0.8	168.2	0.1	16.5	0.6	<DL	0.8	25.0	-	22.7
Max	3530.0	<DL	0.2	37.6	0.9	<DL	<DL	1.7	58.0	5.6	5040.0	5.5	1.6	535.0	0.3	46.5	1.6	<DL	8.1	200.0	0.4	64.7


Total Aluminium
Concentration (mg/kg)
3500
3000
2500
2000
1500
1000
500
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4


Total Antimony
Concentration (mg/kg)
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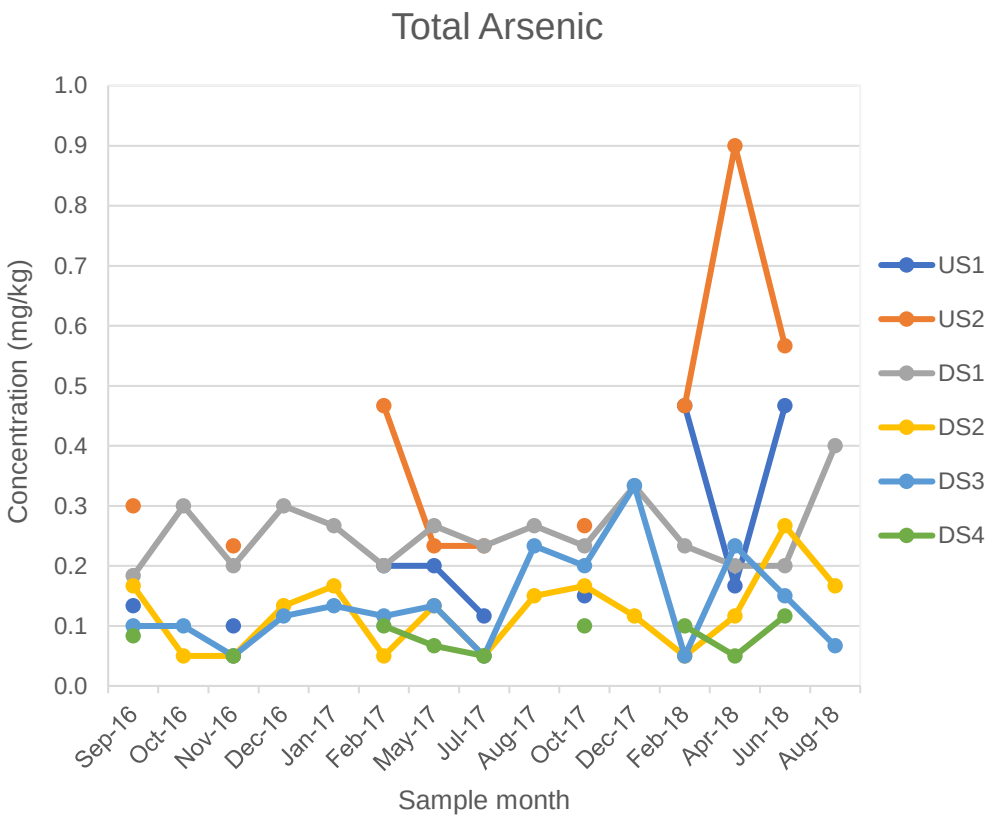
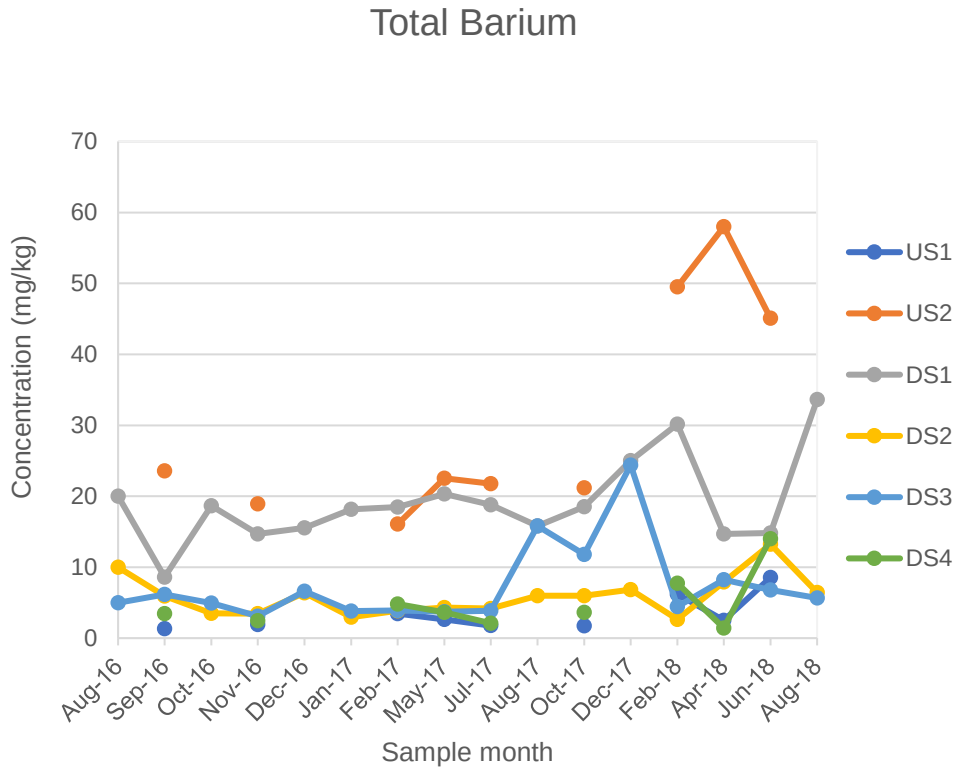
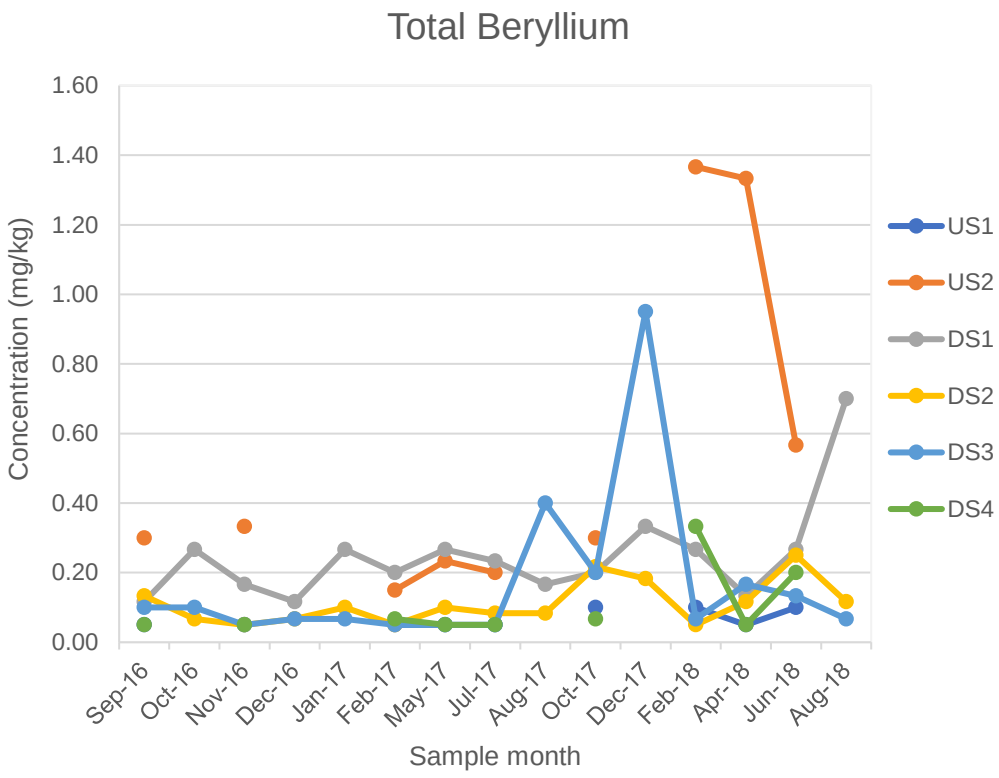
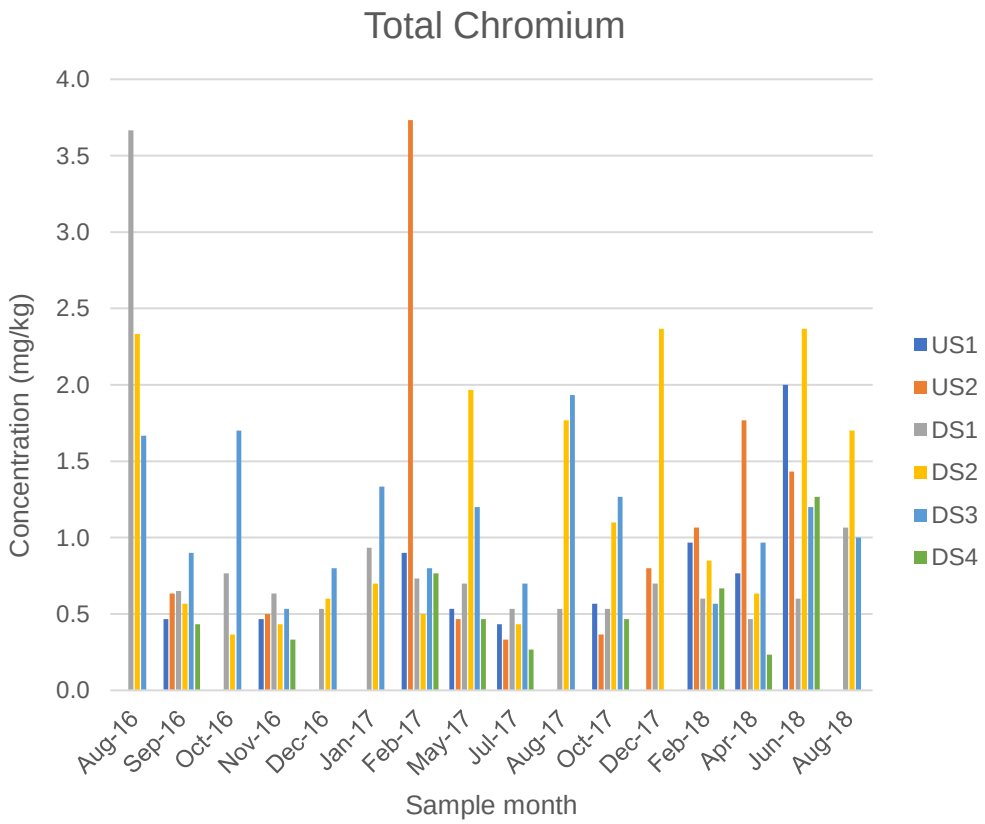
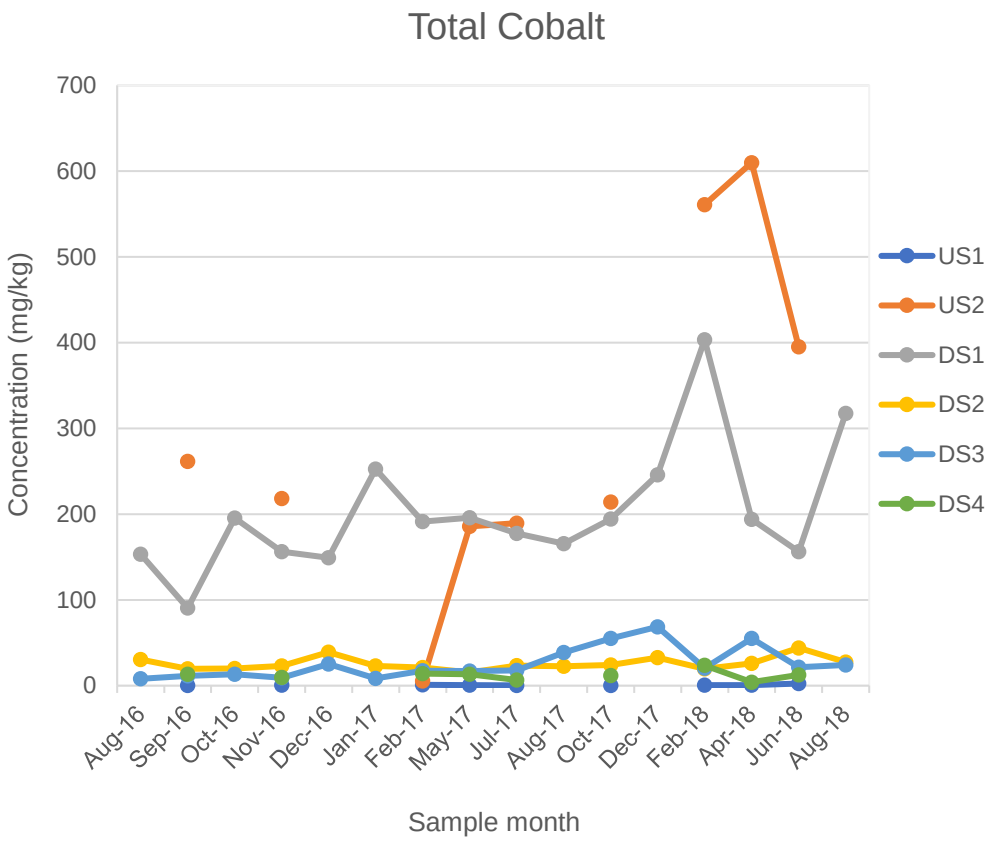
0.50
0.40
0.30
0.20
0.10
0.00
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

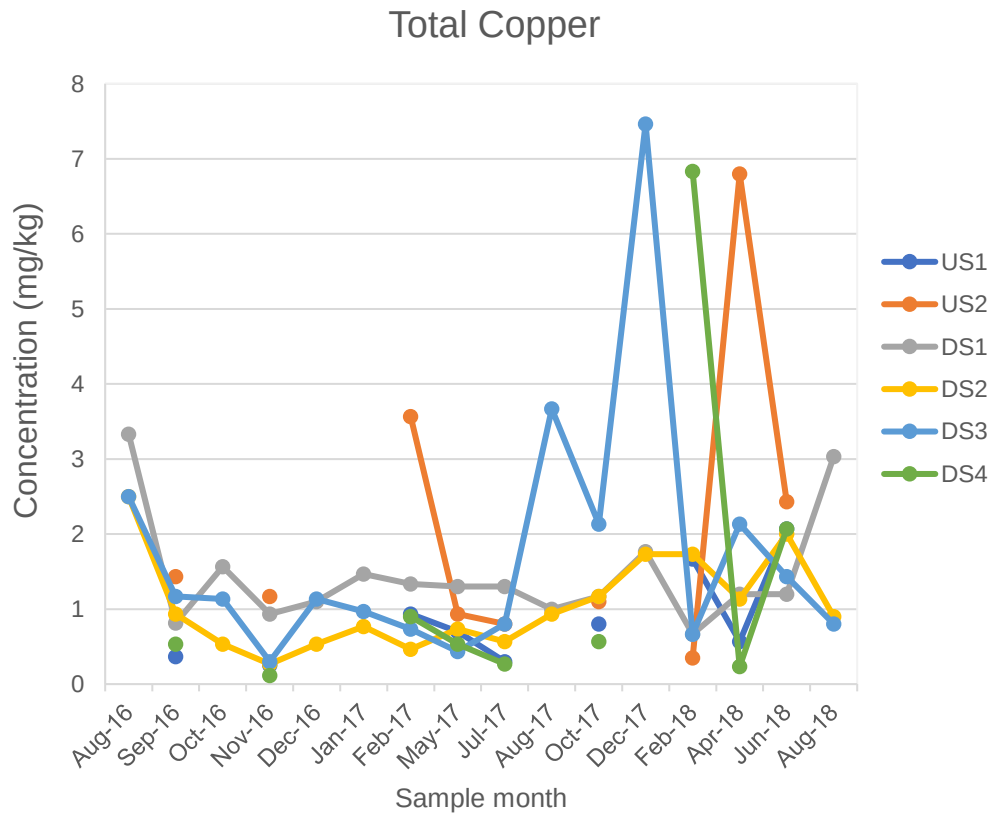

Total Arsenic
Concentration (mg/kg)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

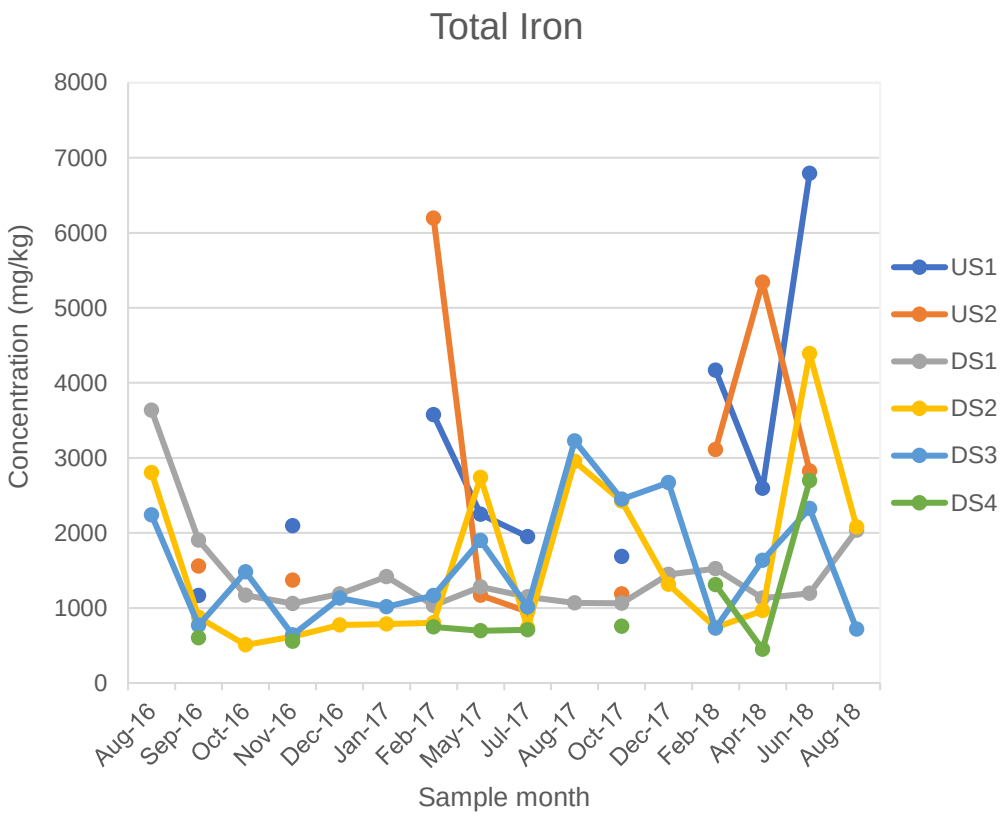

Total Barium
Concentration (mg/kg)
70
60
50
40
30
20
10
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

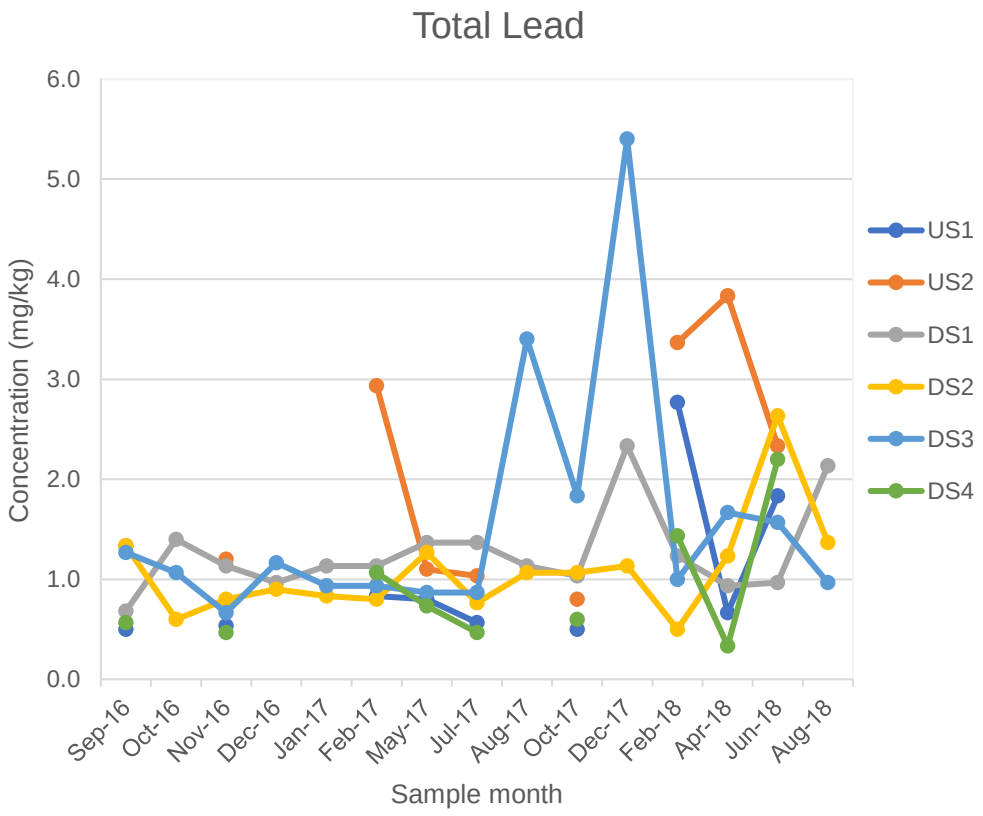

Total Beryllium
Concentration (mg/kg)
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

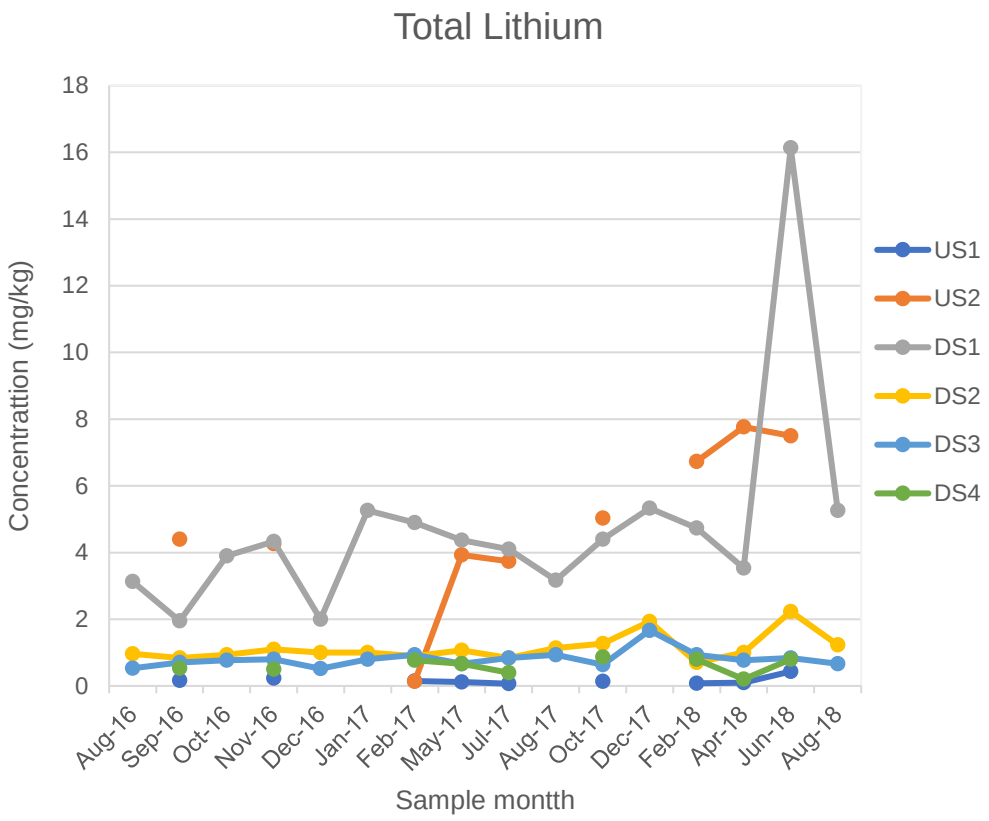

Total Chromium
Concentration (mg/kg)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

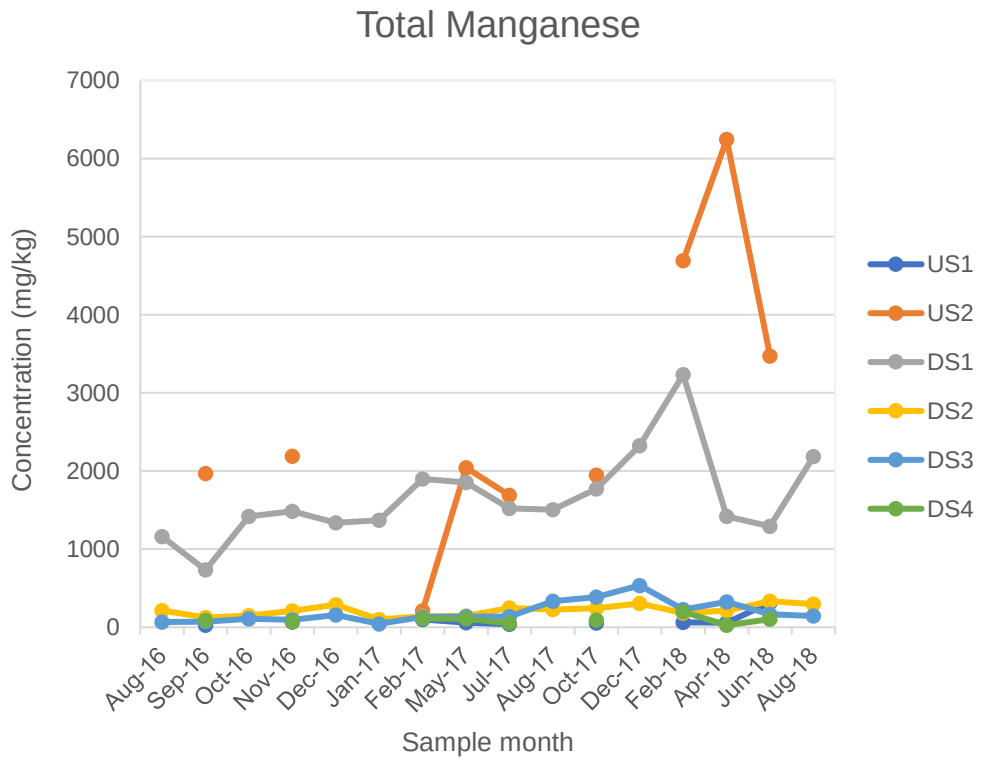

Total Cobalt
Concentration (mg/kg)
700
600
500
400
300
200
100
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

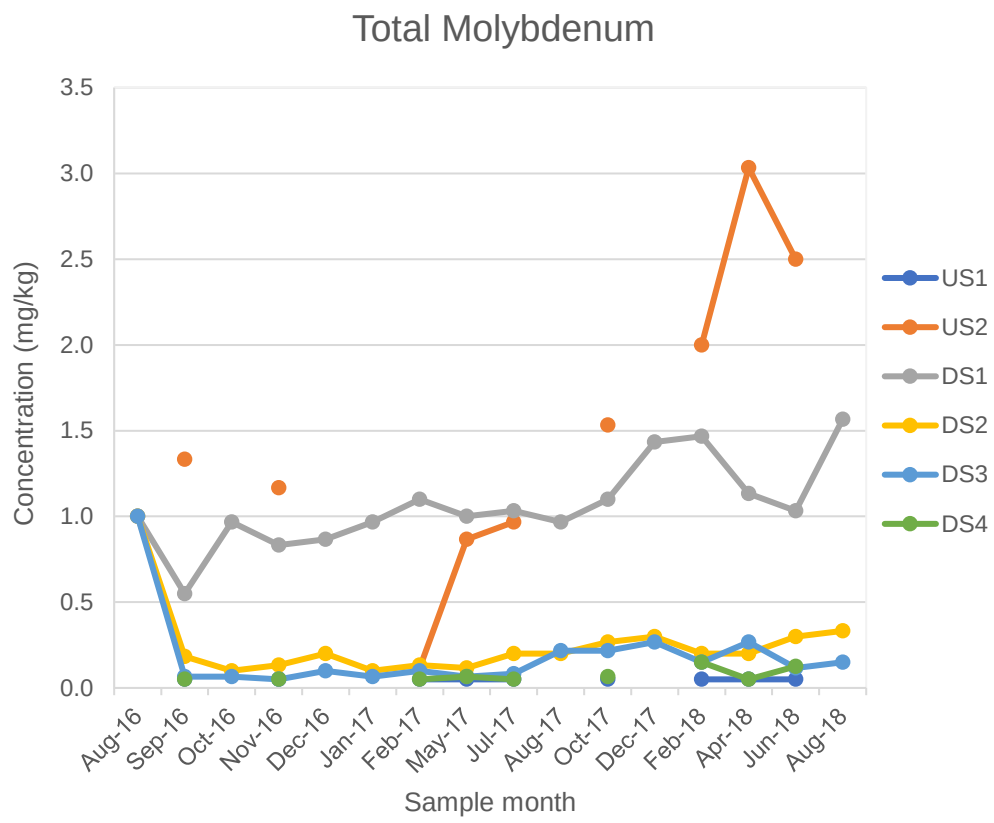

Total Copper
Concentration (mg/kg)
8
7
6
5
4
3
2
1
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

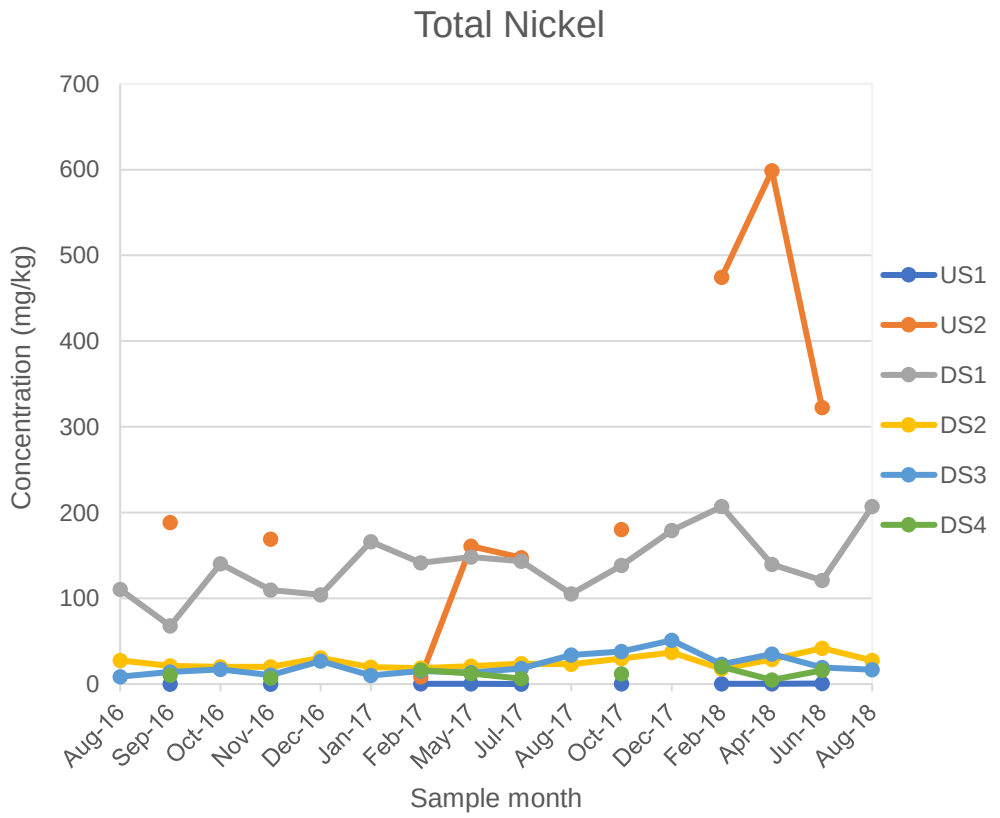

Total Iron
Concentration (mg/kg)
8000
7000
6000
5000
4000
3000
2000
1000
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

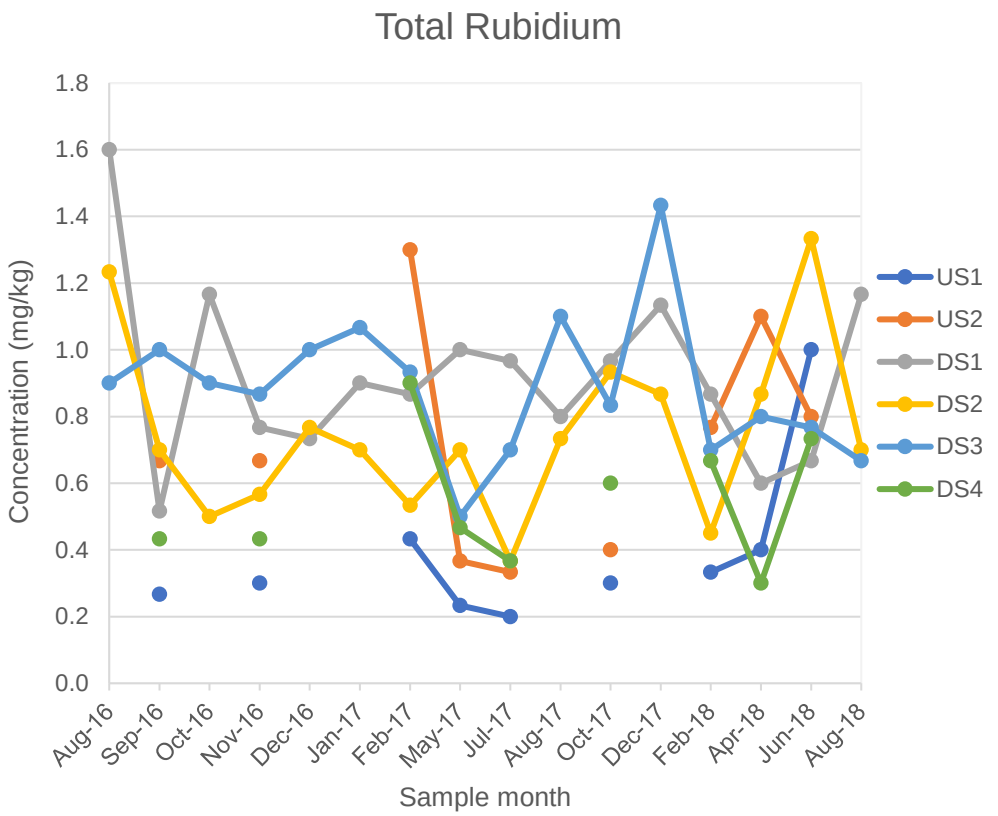

Total Lead
Concentration (mg/kg)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

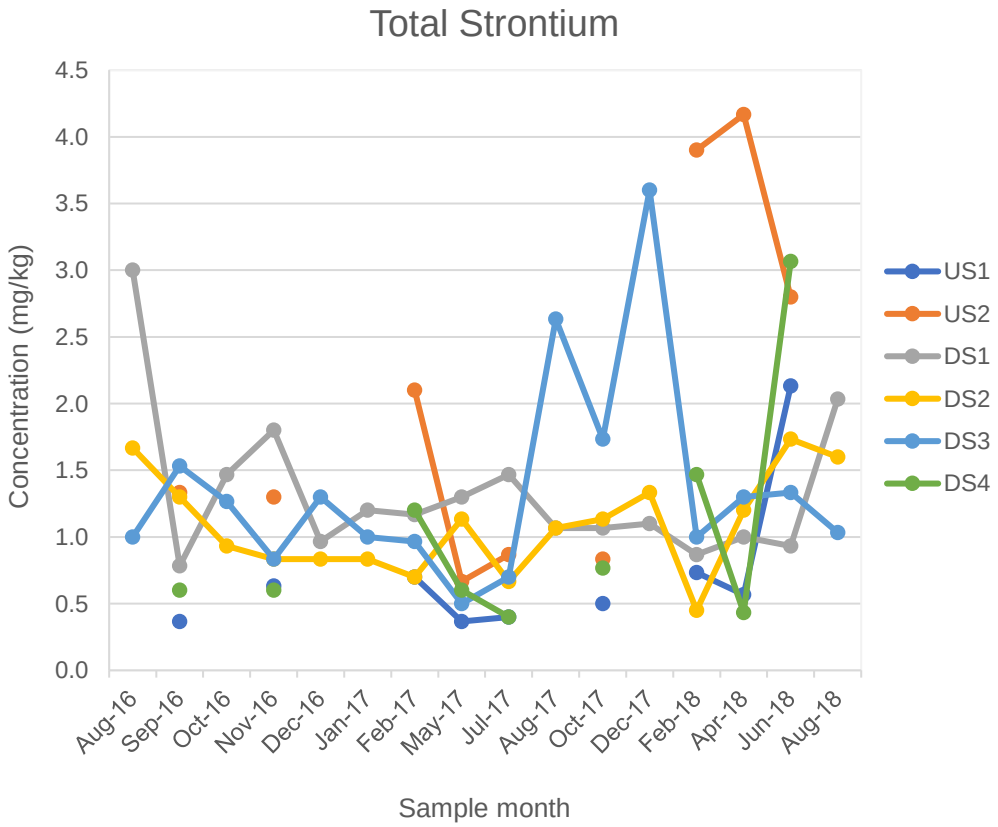

Total Lithium
Concentrattion (mg/kg)
18
16
14
12
10
8
6
4
2
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample montth
US1
US2
DS1
DS2
DS3
DS4

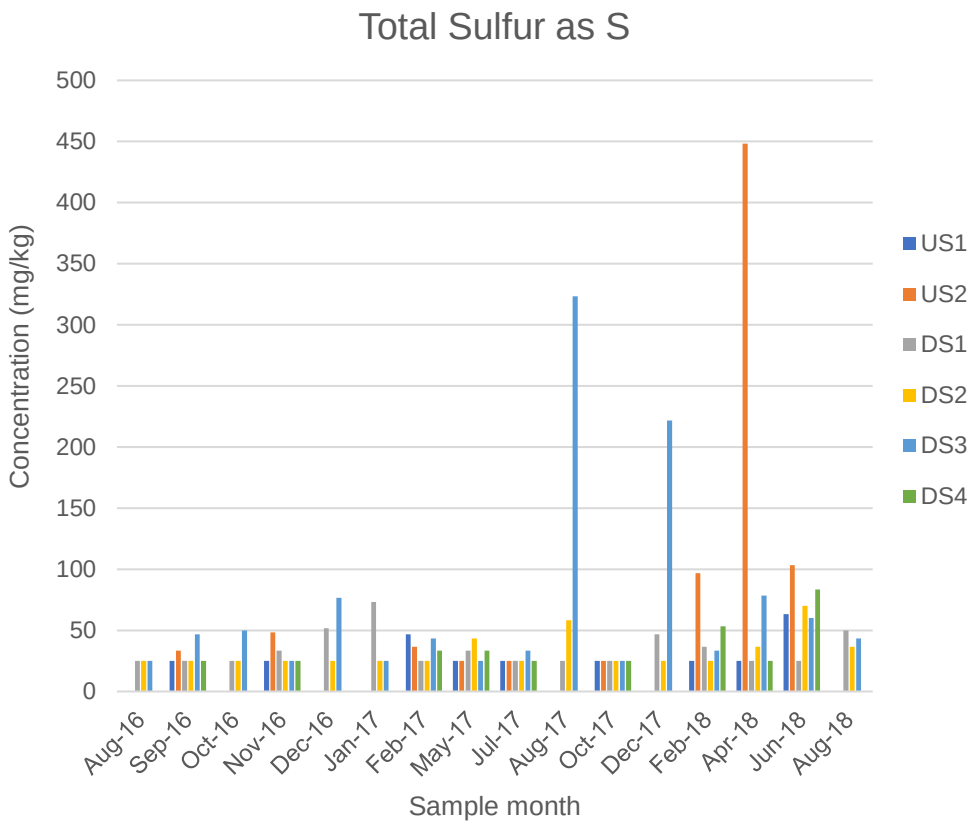

Total Manganese
Concentration (mg/kg)
7000
6000
5000
4000
3000
2000
1000
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

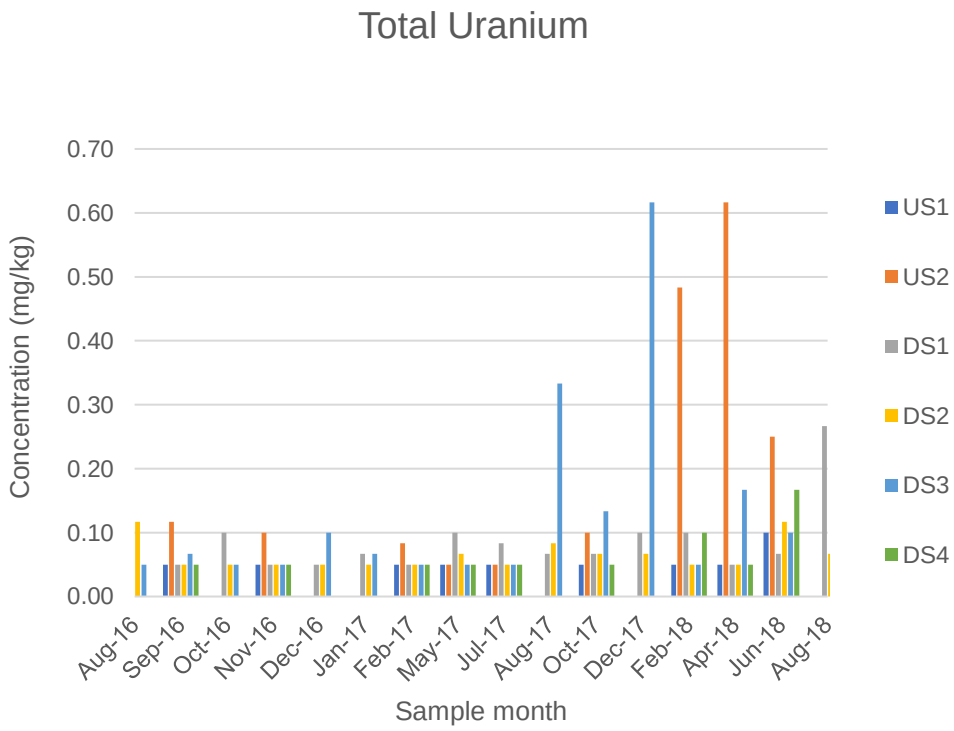

Total Molybdenum
Concentration (mg/kg)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

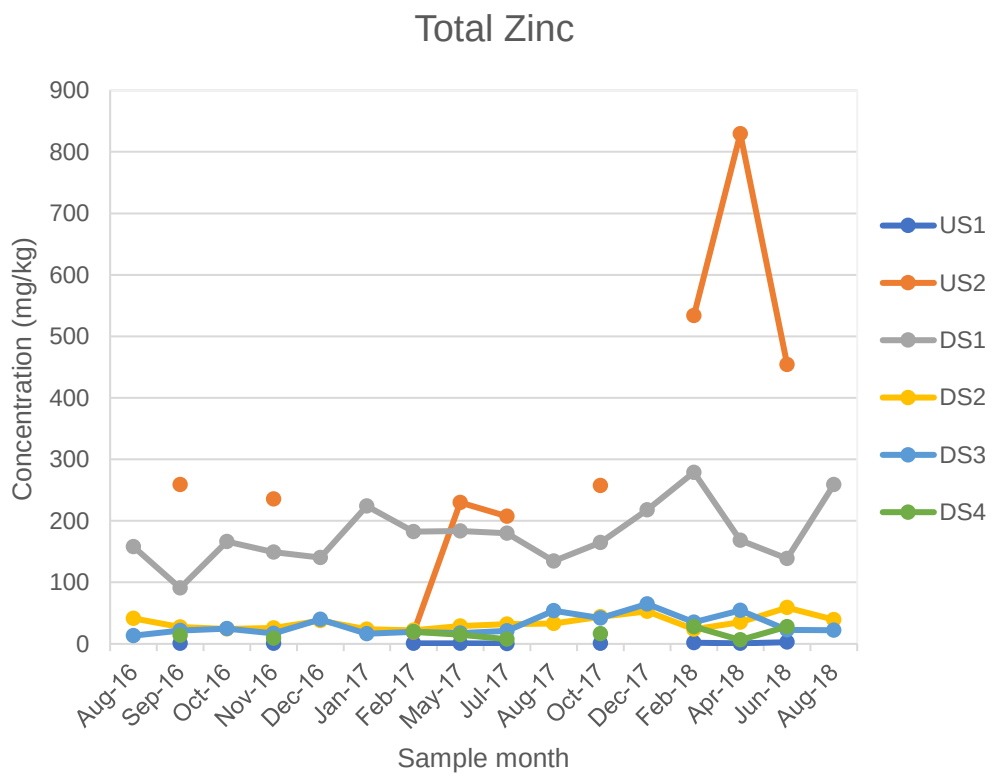

Total Nickel
Concentration (mg/kg)
700
600
500
400
300
200
100
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

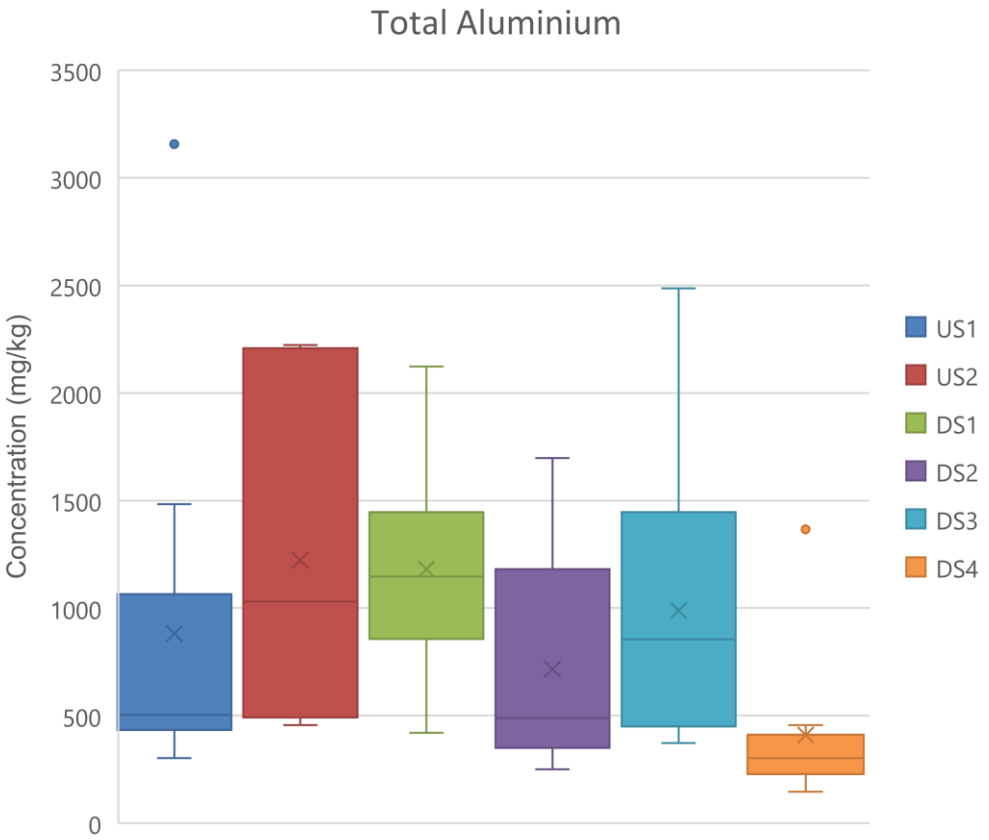

Total Rubidium
Concentration (mg/kg)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

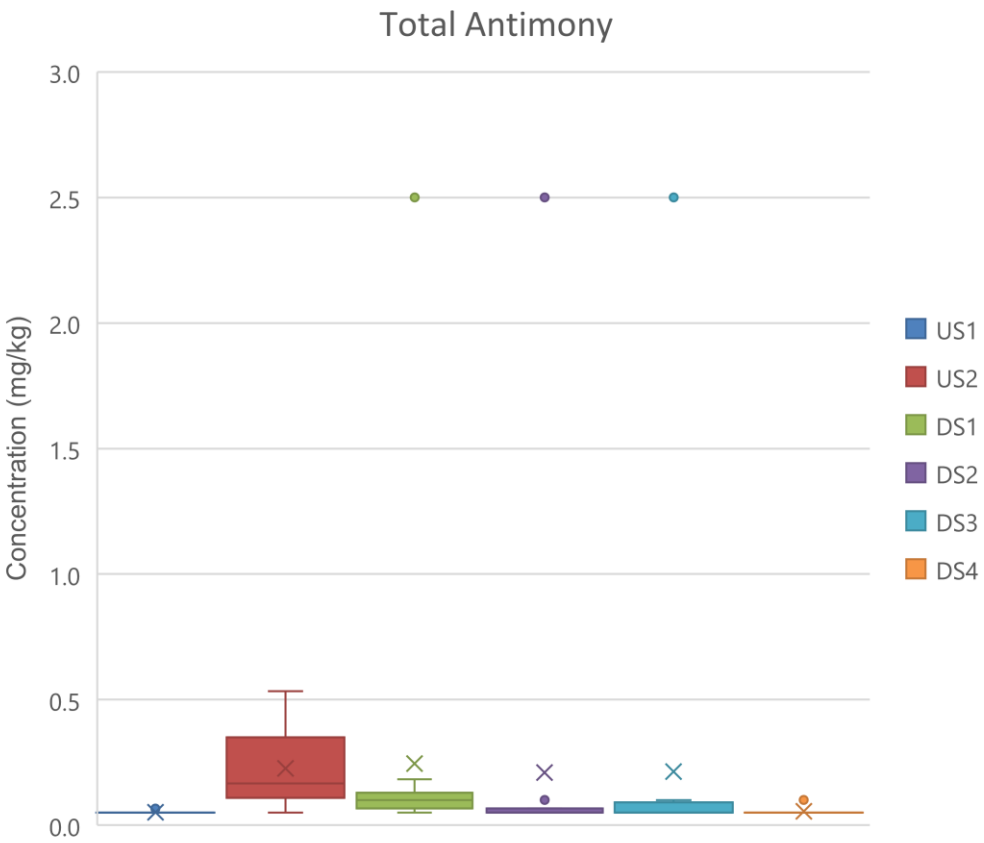

Total Strontium
Concentration (mg/kg)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

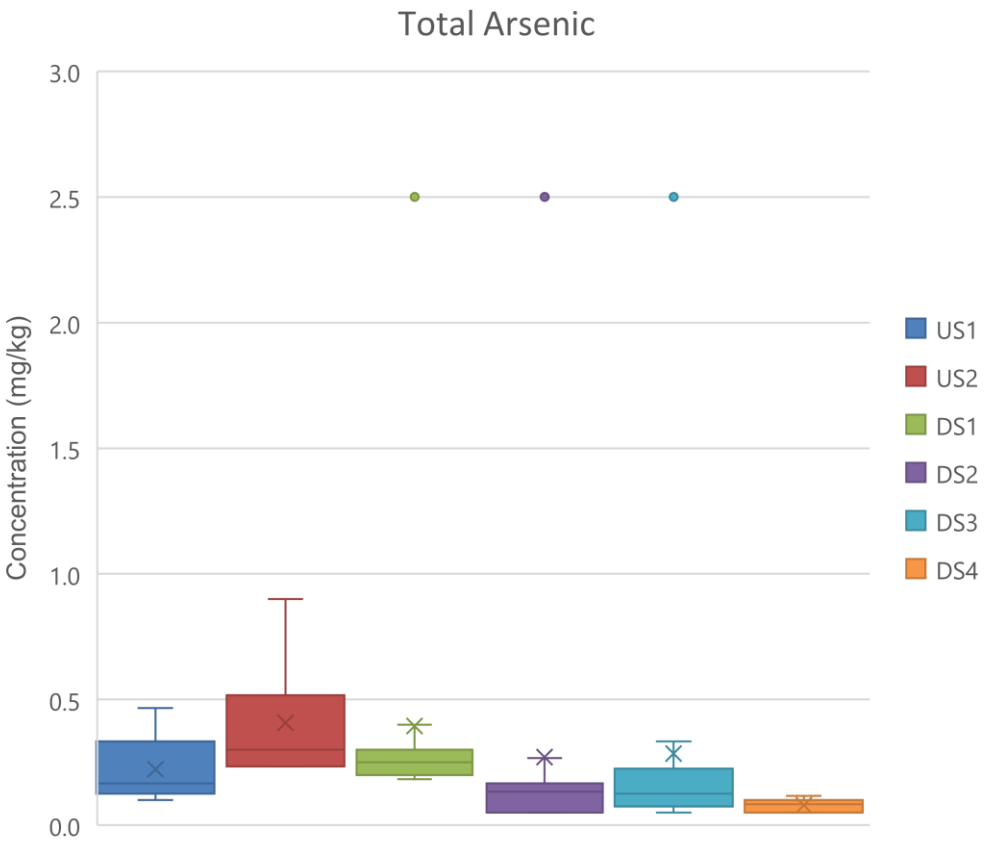

Total Sulfur as S
Concentration (mg/kg)
500
450
400
350
300
250
200
150
100
50
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

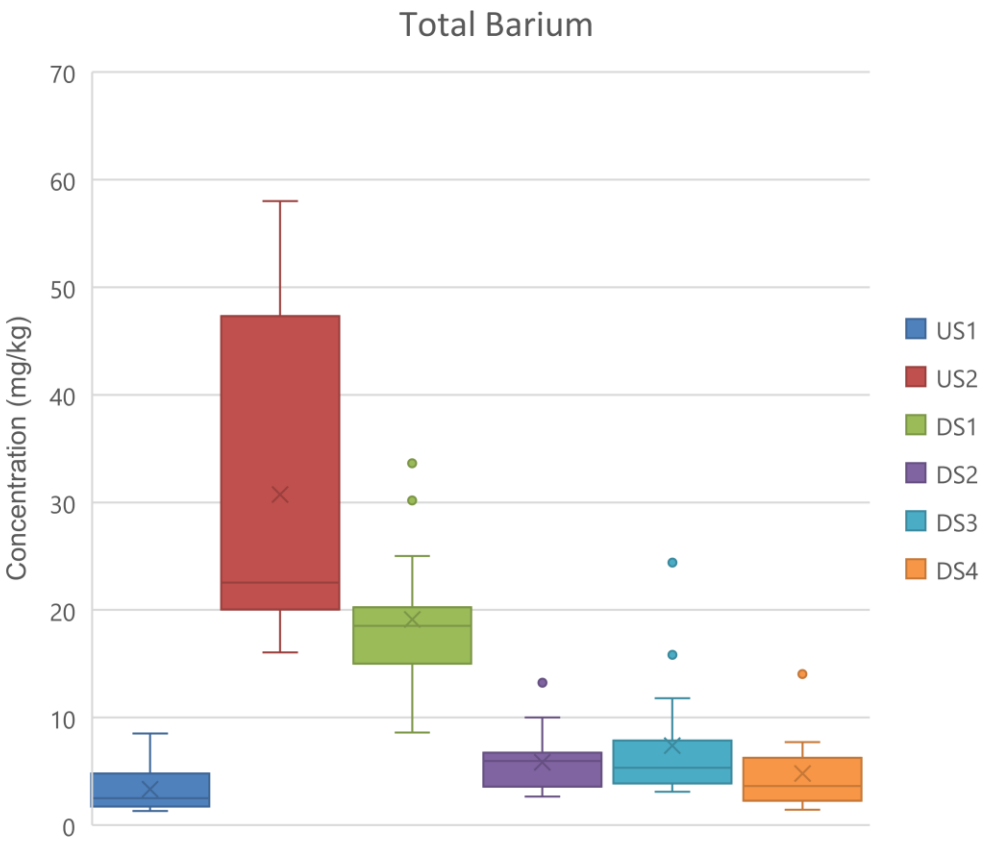

Total Uranium
Concentration (mg/kg)
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

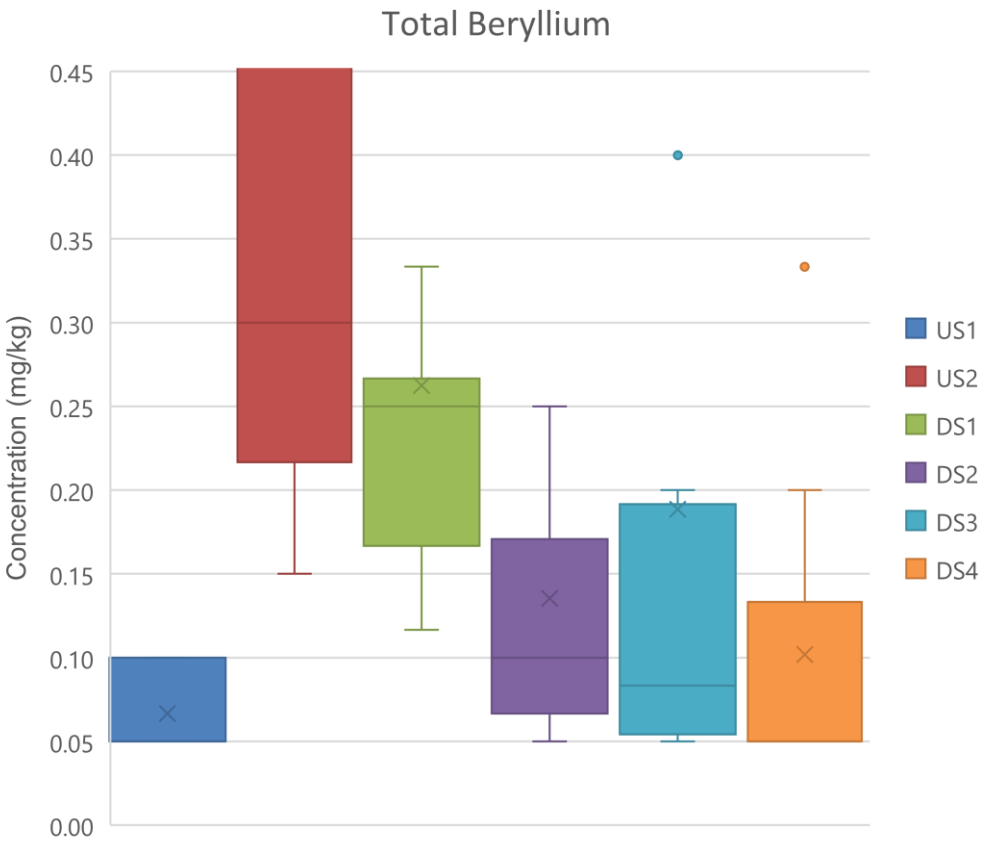

Total Zinc
Concentration (mg/kg)
900
800
700
600
500
400
300
200
100
0
Aug-16
Sep-16
Oct-16
Nov-16
Dec-16
Jan-17
Feb-17
May-17
Jul-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

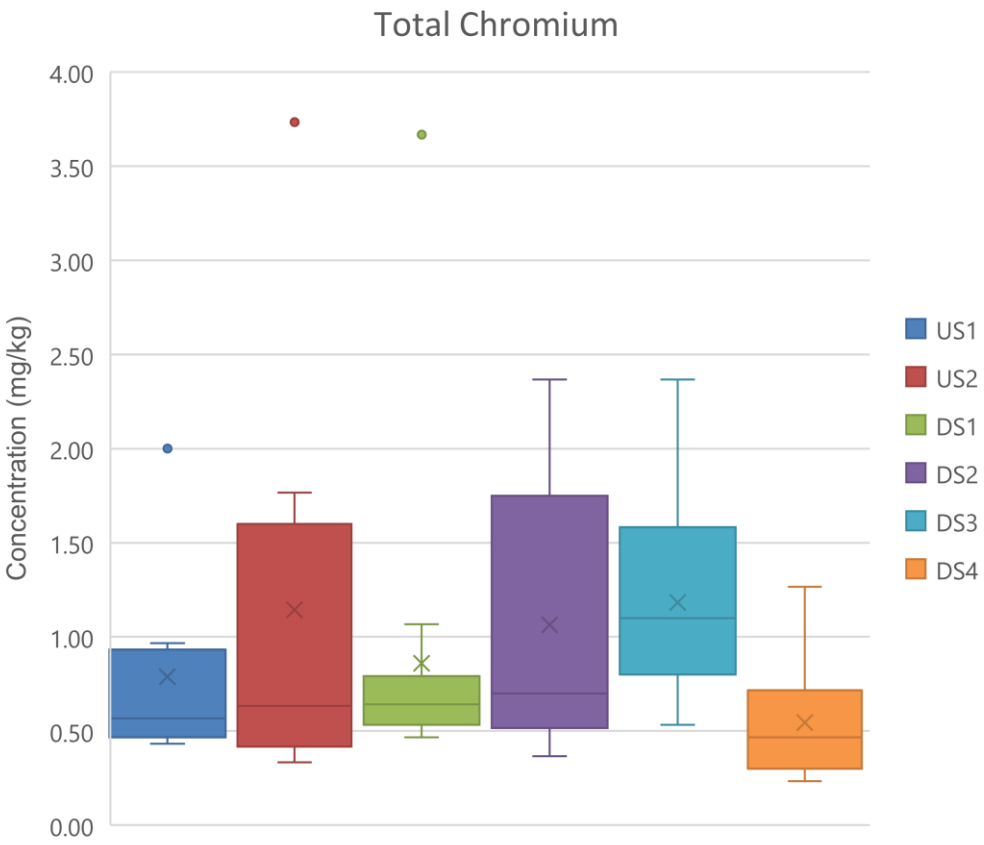

Total Aluminium
Concentration (mg/kg)
3500
3000
2500
2000
1500
1000
500
0
US1
US2
DS1
DS2
DS3
DS4

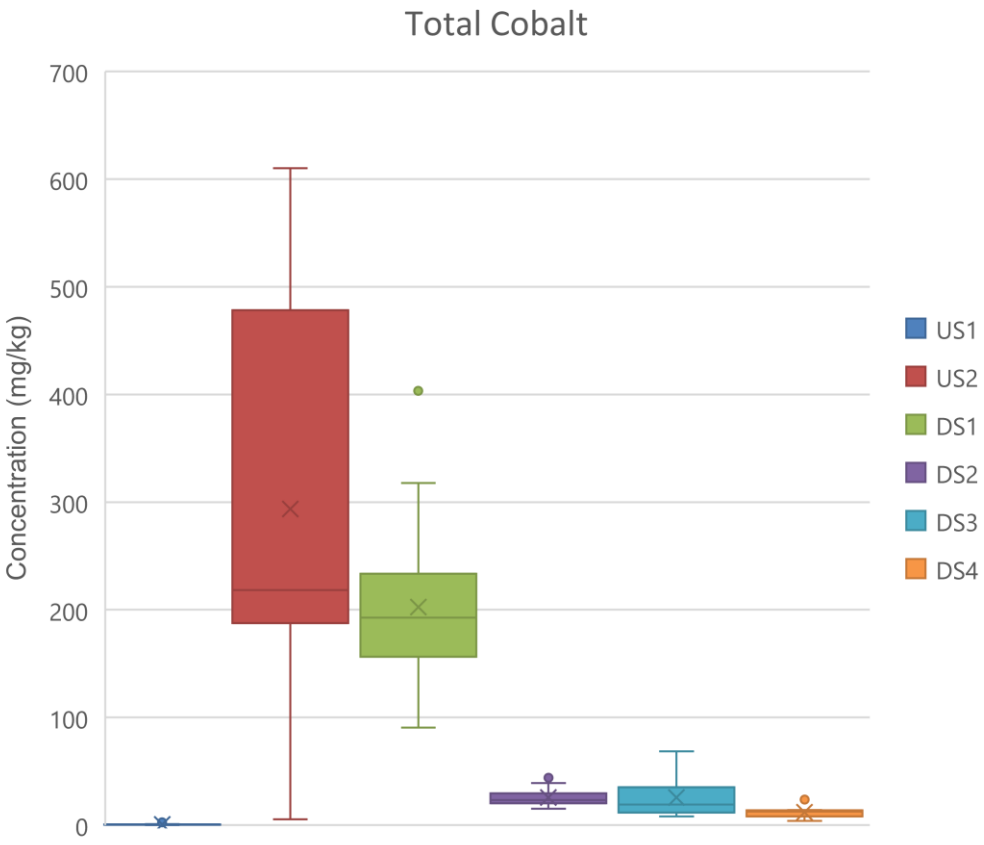

Total Antimony
Concentration (mg/kg)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
US1
US2
DS1
DS2
DS3
DS4

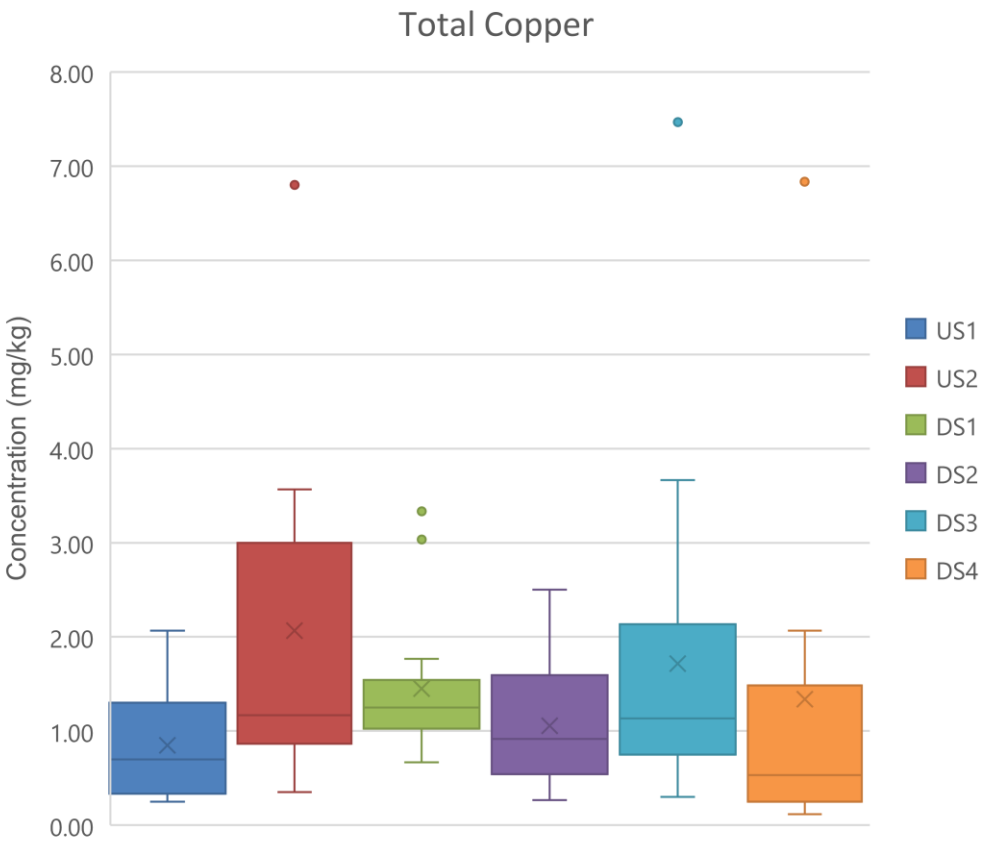

Total Arsenic
Concentration (mg/kg)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
US1
US2
DS1
DS2
DS3
DS4

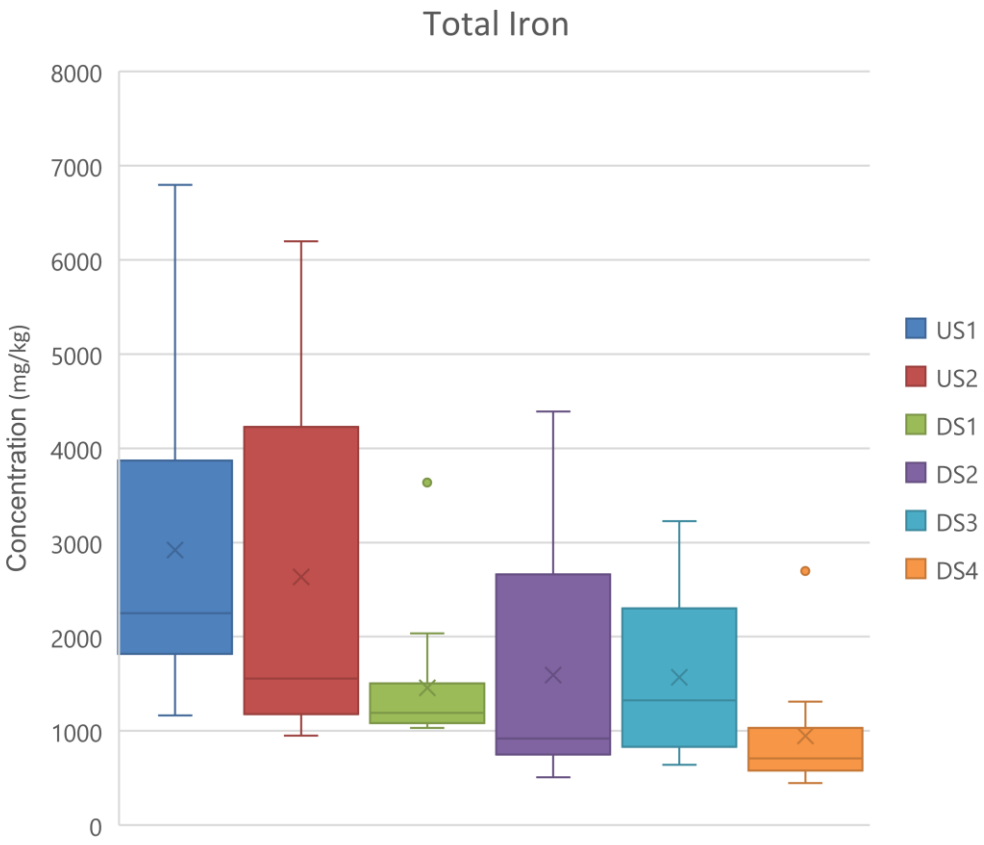

Total Barium
Concentration (mg/kg)
70
60
50
40
30
20
10
0
US1
US2
DS1
DS2
DS3
DS4

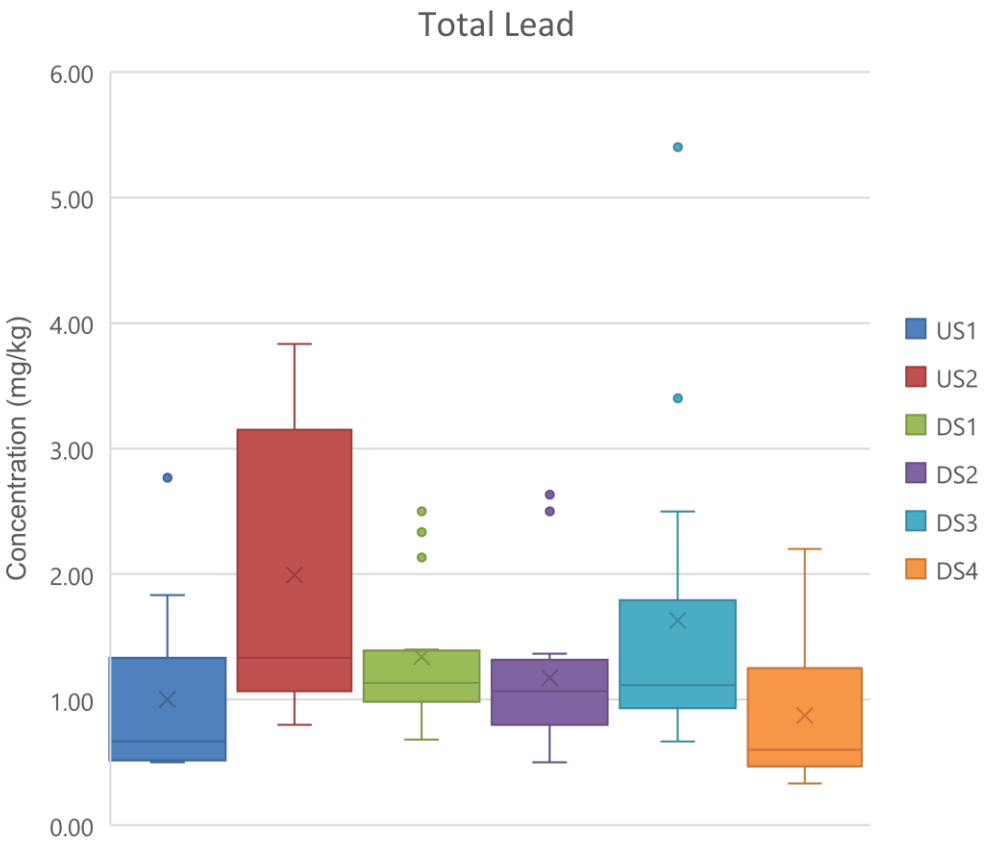

Total Beryllium
Concentration (mg/kg)
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
US1
US2
DS1
DS2
DS3
DS4

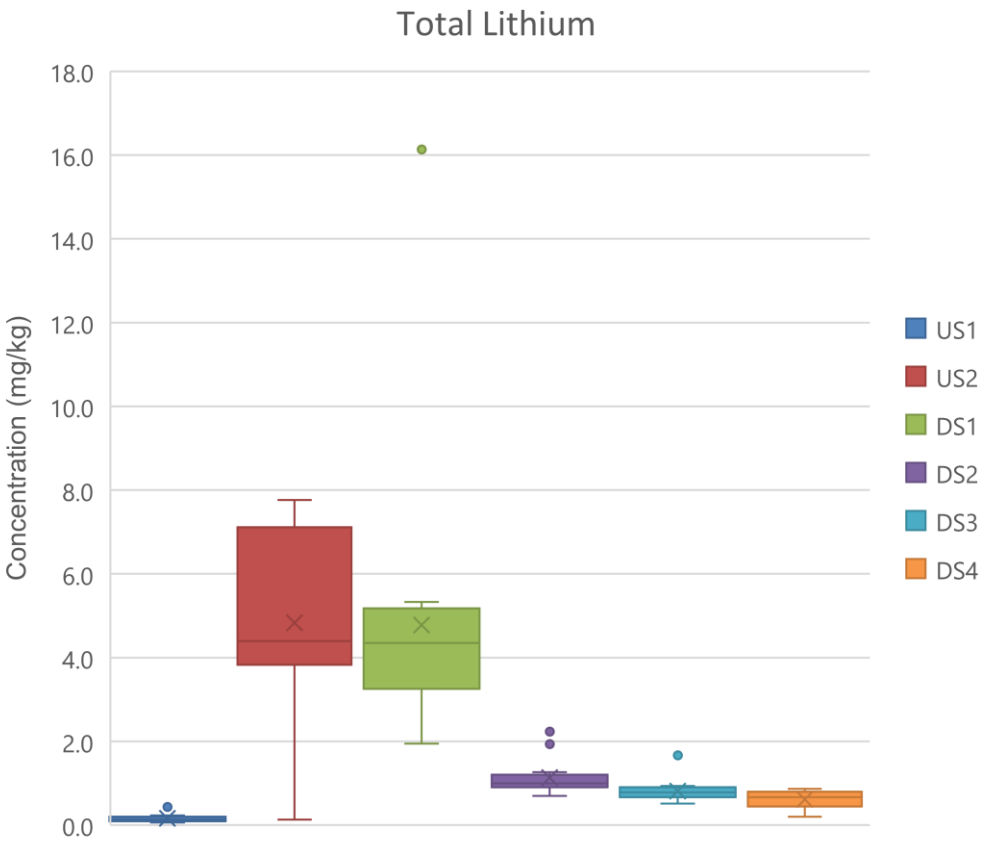

Total Chromium
Concentration (mg/kg)
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
US1
US2
DS1
DS2
DS3
DS4

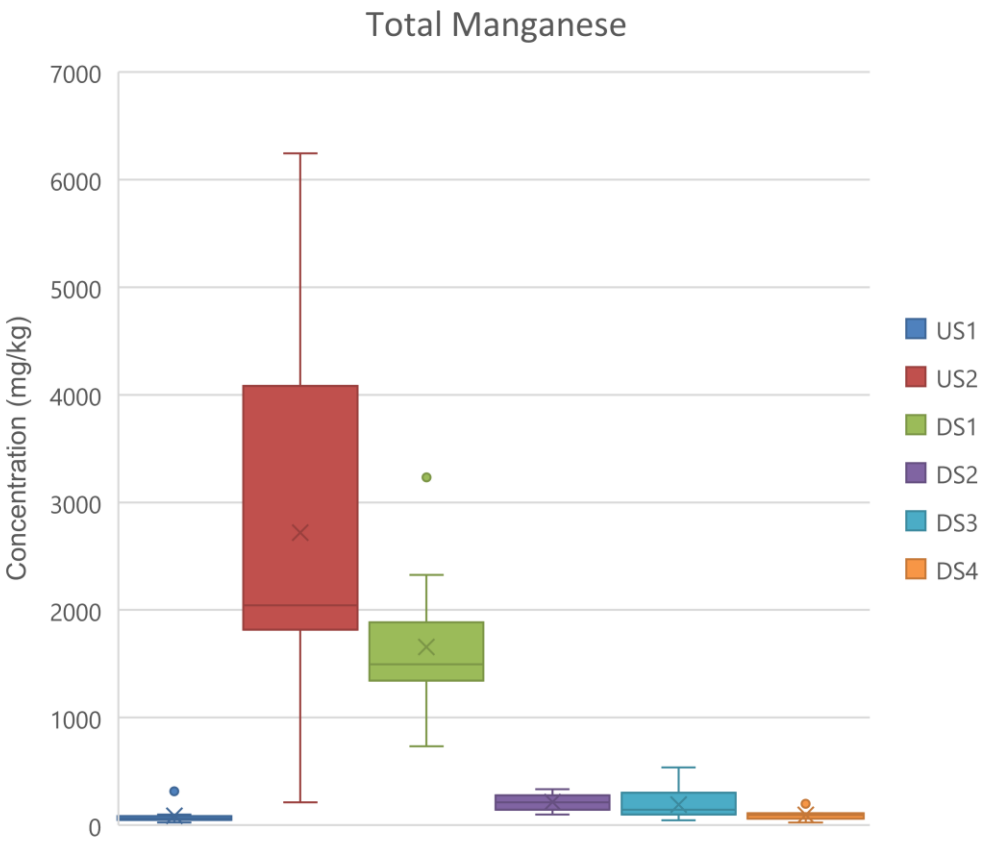

Total Cobalt
Concentration (mg/kg)
700
600
500
400
300
200
100
0
US1
US2
DS1
DS2
DS3
DS4

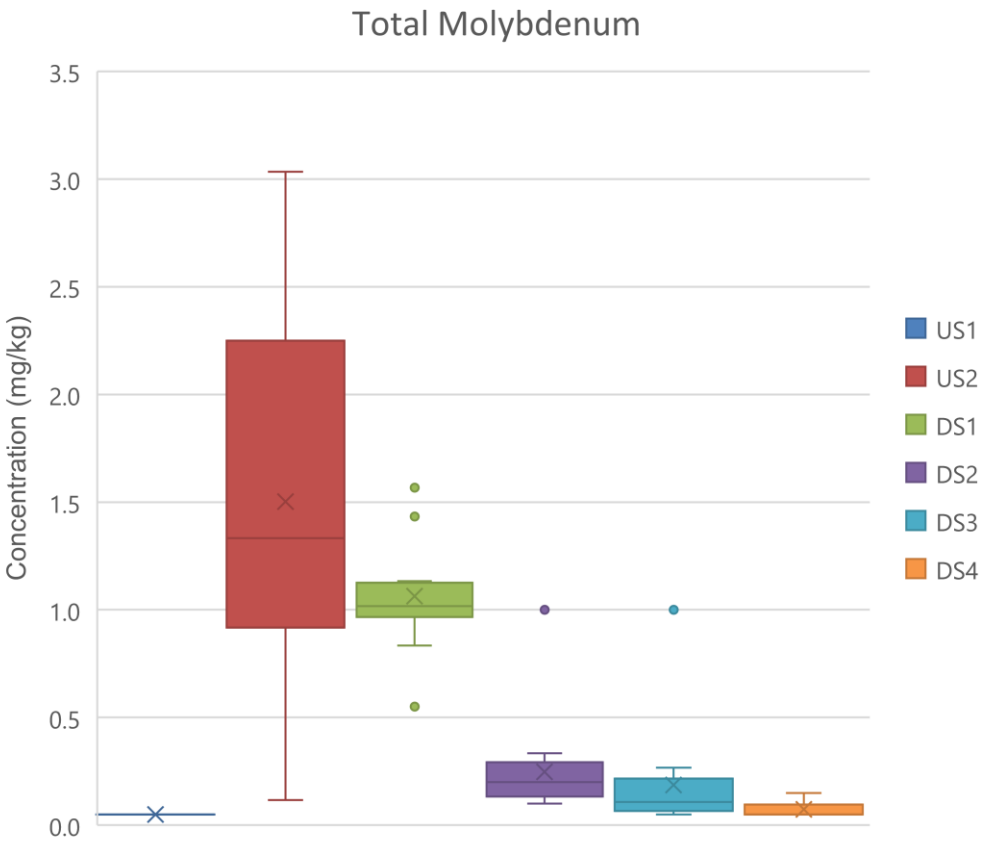

Total Copper
Concentration (mg/kg)
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
US1
US2
DS1
DS2
DS3
DS4

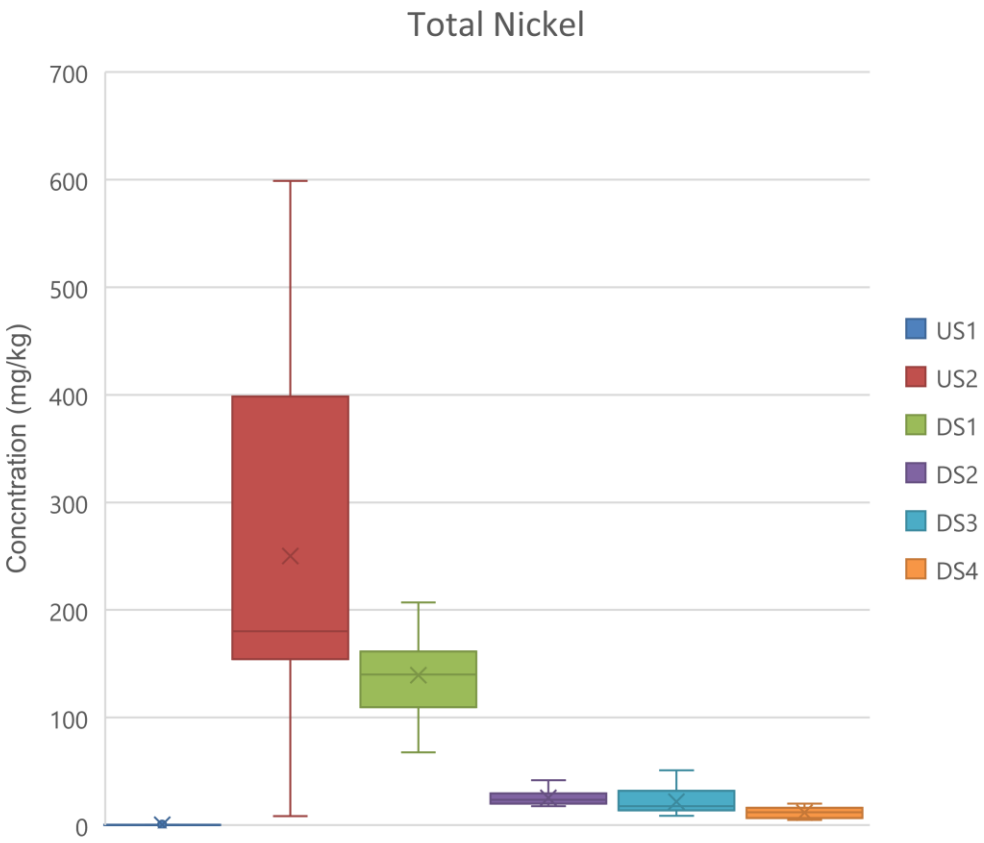

Total Iron
Concentration (mg/kg)
8000
7000
6000
5000
4000
3000
2000
1000
0
US1
US2
DS1
DS2
DS3
DS4

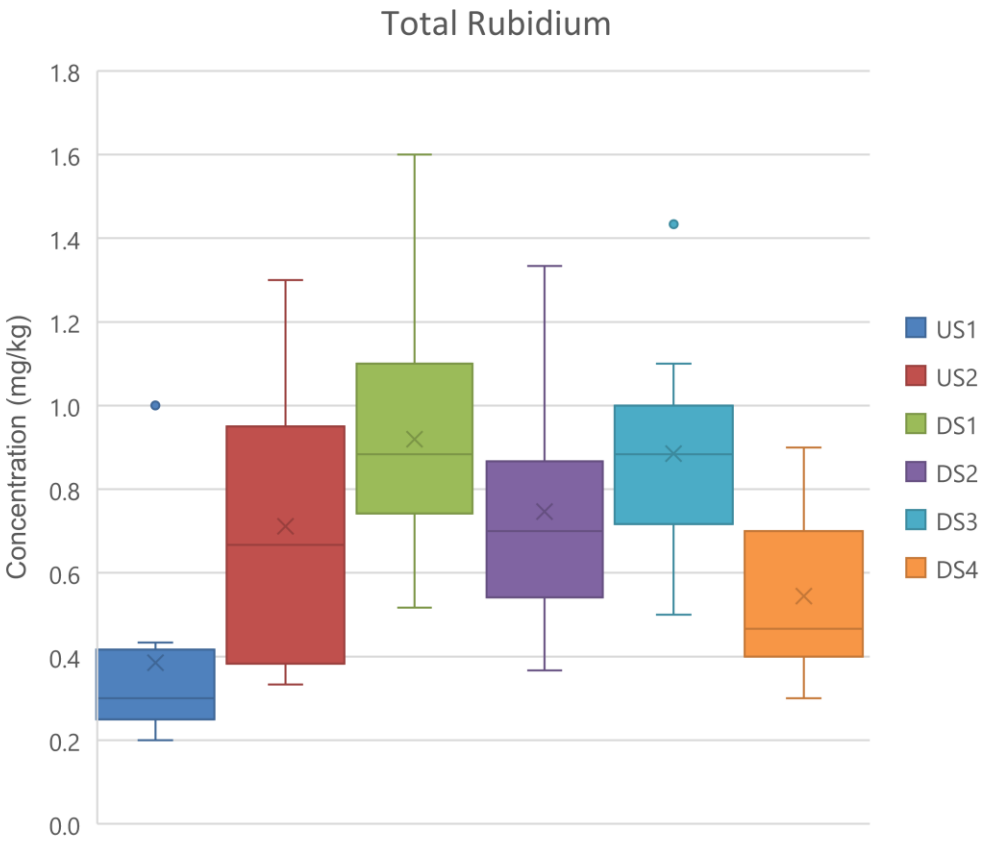

Total Lead
Concentration (mg/kg)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
US1
US2
DS1
DS2
DS3
DS4

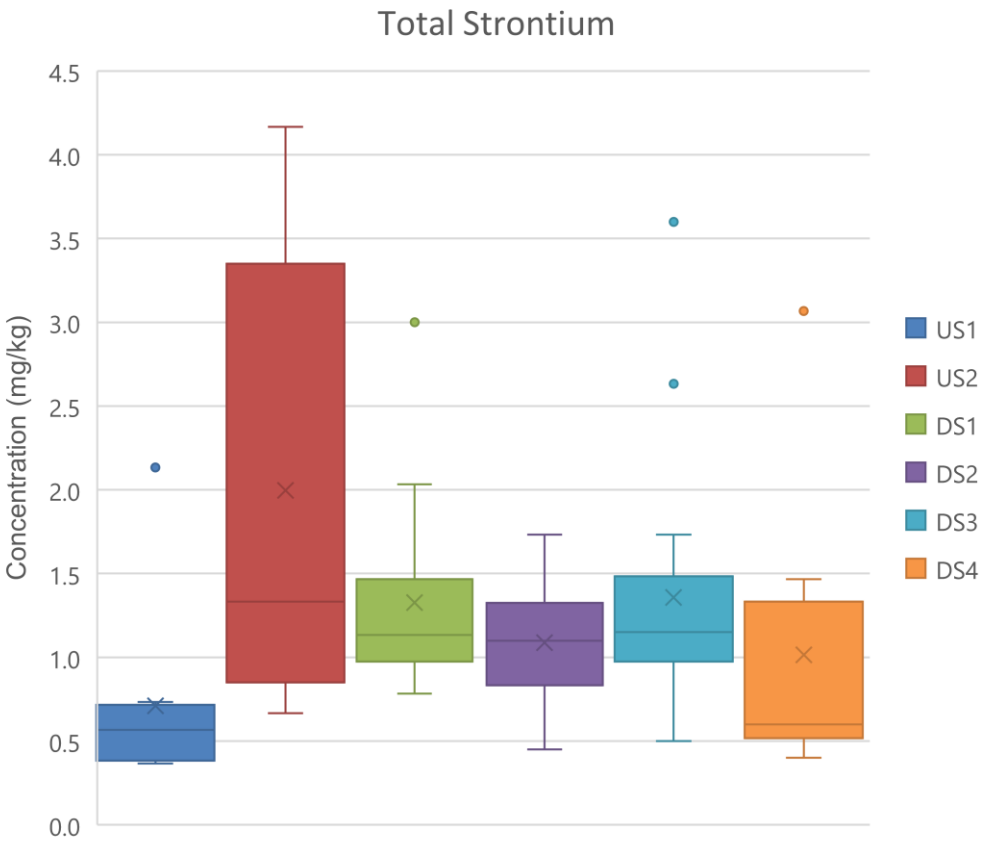

Total Lithium
Concentration (mg/kg)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
US1
US2
DS1
DS2
DS3
DS4

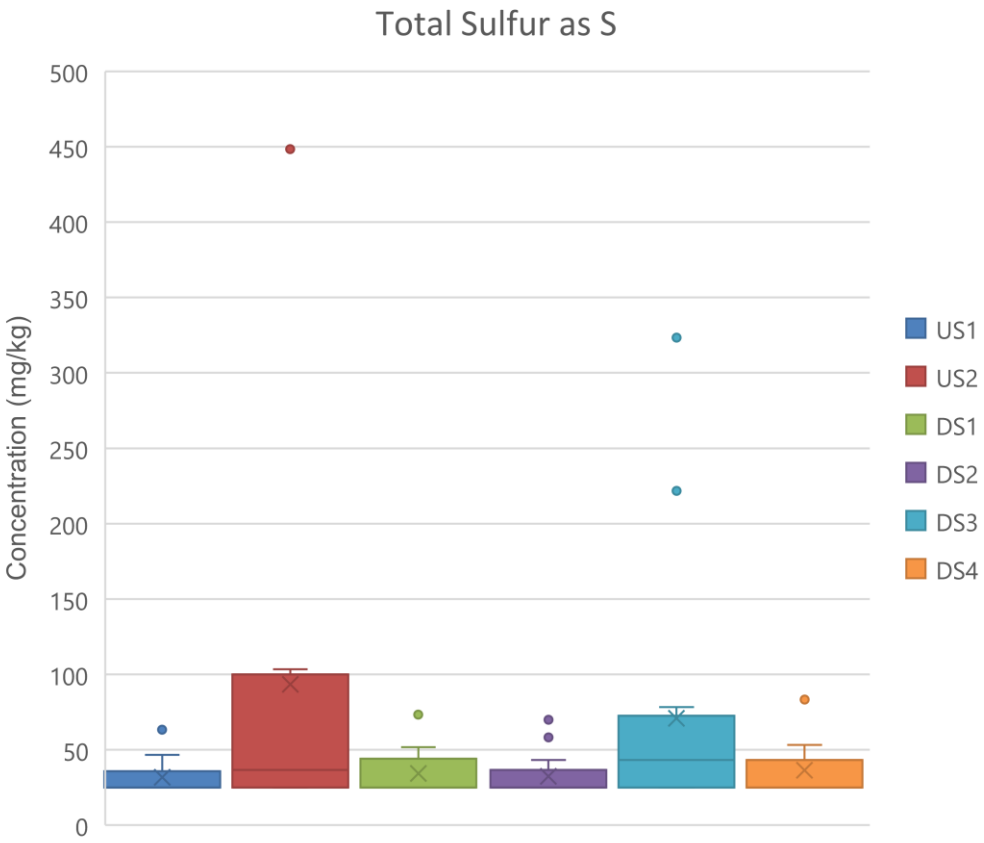

Total Manganese
Concentration (mg/kg)
7000
6000
5000
4000
3000
2000
1000
0
US1
US2
DS1
DS2
DS3
DS4

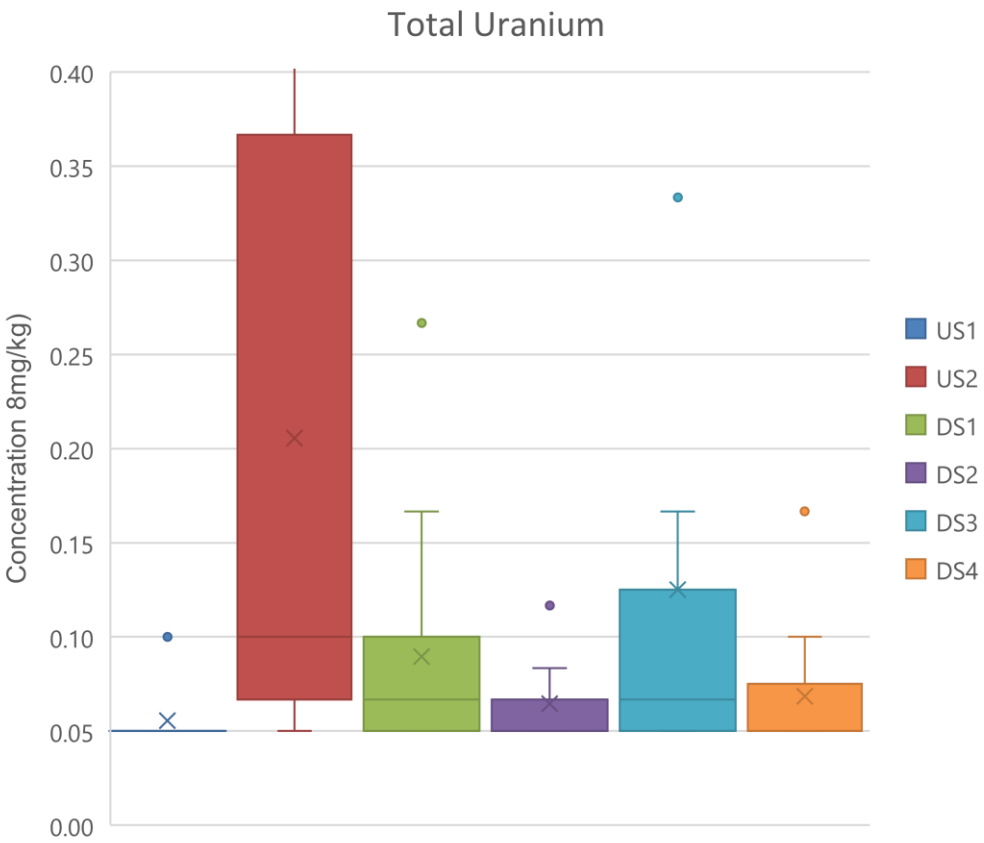

Total Molybdenum
Concentration (mg/kg)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
US1
US2
DS1
DS2
DS3
DS4

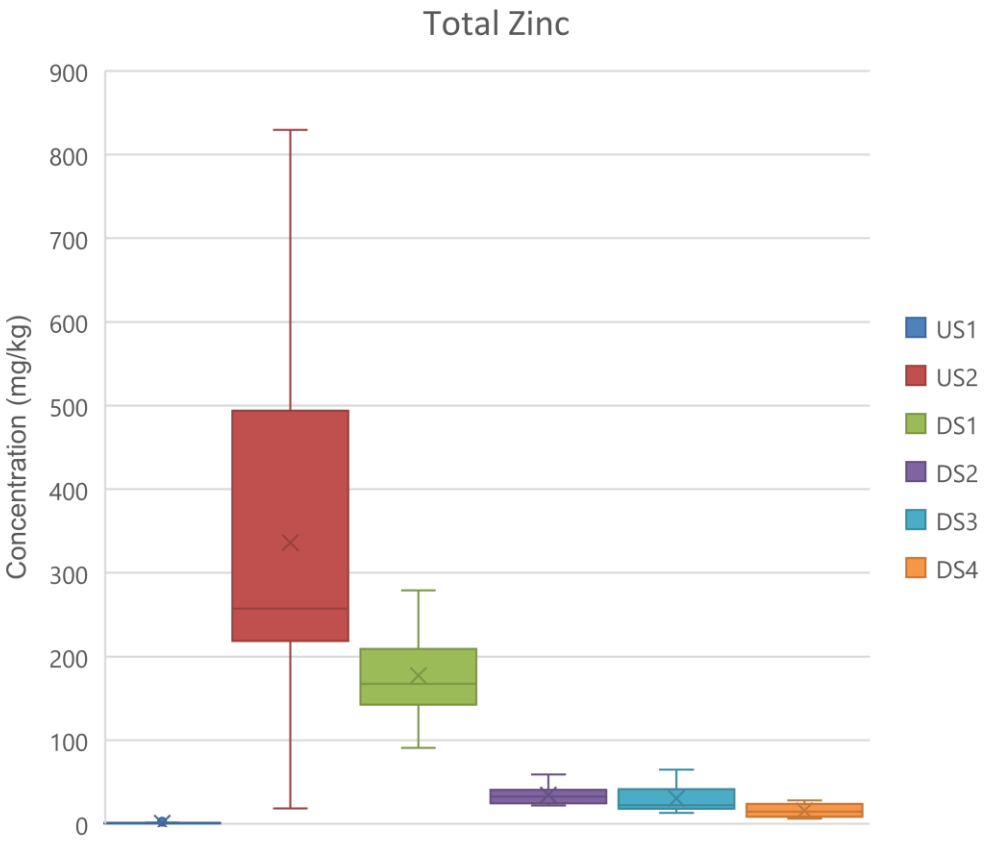

Total Nickel
Concntration (mg/kg)
700
600
500
400
300
200
100
0
US1
US2
DS1
DS2
DS3
DS4


Total Rubidium
Concentration (mg/kg)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
US1
US2
DS1
DS2
DS3
DS4


Total Strontium
Concentration (mg/kg)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
US1
US2
DS1
DS2
DS3
DS4


Total Sulfur as S
Concentration (mg/kg)
500
450
400
350
300
250
200
150
100
50
0
US1
US2
DS1
DS2
DS3
DS4


Total Uranium
Concentration 8mg/kg)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
US1
US2
DS1
DS2
DS3
DS4


Total Zinc
Concentration (mg/kg)
900
800
700
600
500
400
300
200
100
0
US1
US2
DS1
DS2
DS3
DS4

4.3 Petrographic Analysis

Petrographic analysis requires air drying of the sediment sub-samples, plus crushing any oversize material down to a 1mm top size. The crushed samples are then mounted in an acrylic resin, which is polished via a multistage polishing procedure to produce a suitable surface for reflected light microscopy. A point count of each sample is then conducted with the material under the crosshairs of the microscope being classified as coal, char, mineral matter or organic matter. 500 points are counted on each sample at 500x magnification. The point counts are then converted to percentages.

Percent mineral concentrations for the October 2017 report were incorrect and ALS Laboratory provided a revised report for inclusion in this six monthly report.

Appendix C provides the Revised October 17 Microscopic Report plus the April, June and August 2018 Microscopic Reports prepared by ALS Laboratory for this reporting period. Updated site summary statistics (Sample Number, Minimum, Median, Mean and Standard Deviation of the Mean (SD)), are shown in **Tables 27 to 32.**

Variation in site percent coal, char, mineral matter and organic matter over time are shown in **Control Charts** below and the statistical data for all sites to date are compared in **Box Plots** following the Control Charts.

	Table 27 US1 Microscopic Summary Statistics			
	Coal (%)	**Char (%)**	**Mineral (%)**	**Organic (%)**
Sample #	24	24	24	24
Min	0	0	96	0
Median	0.2	0	98.6	1.3
Mean	0.2	0.5	97.7	2.0
SD	0.4	1.9	1.8	1.9
Max	1	9	100	8

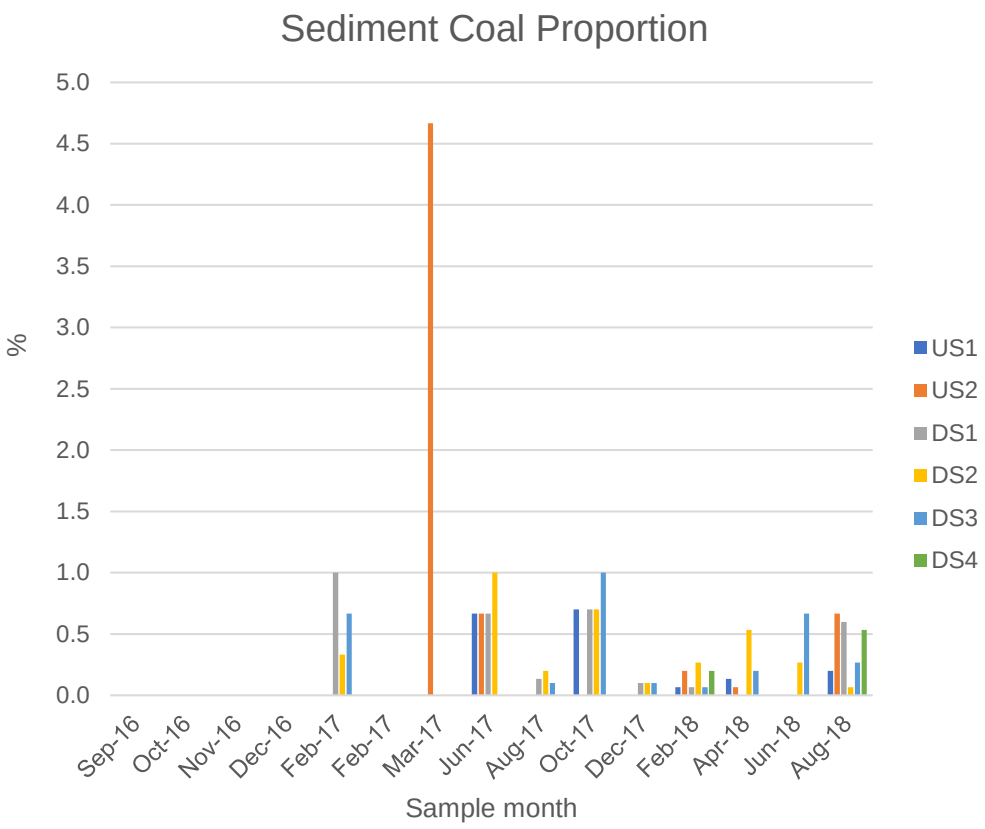
	Table 28 US2 Microscopic Summary Statistics			
	Coal (%)	**Char (%)**	**Mineral (%)**	**Organic (%)**
Sample #	24	24	24	24
Min	0	0	87	0
Median	0.0	0.0	96.4	3.0
Mean	0.8	0.6	95.3	3.8
SD	1.6	1.8	3.5	3.2
Max	6	7	100	13

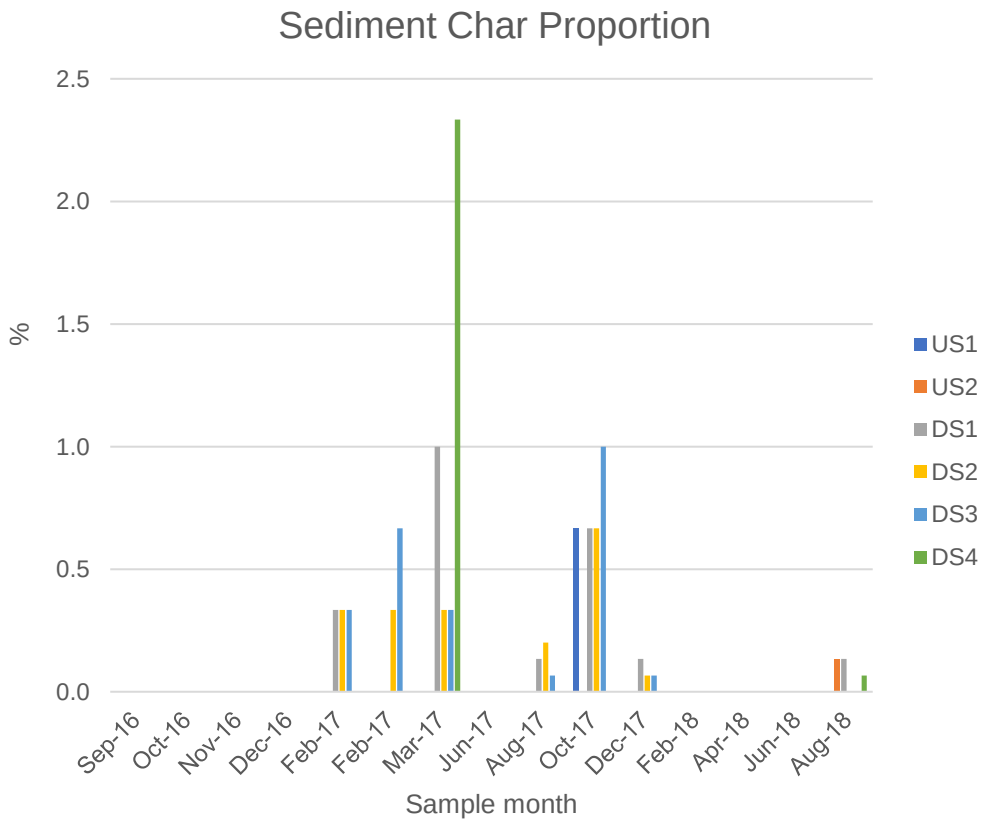
	Table 29 DS1 Microscopic Summary Statistics			
	Coal (%)	**Char (%)**	**Mineral (%)**	**Organic (%)**
Sample #	45	45	45	45
Min	0	0	84	0
Median	0.0	0.0	97.4	2.0
Mean	0.2	0.3	97.1	2.5
SD	0.5	0.7	3.0	2.9
Max	2	3	100	16

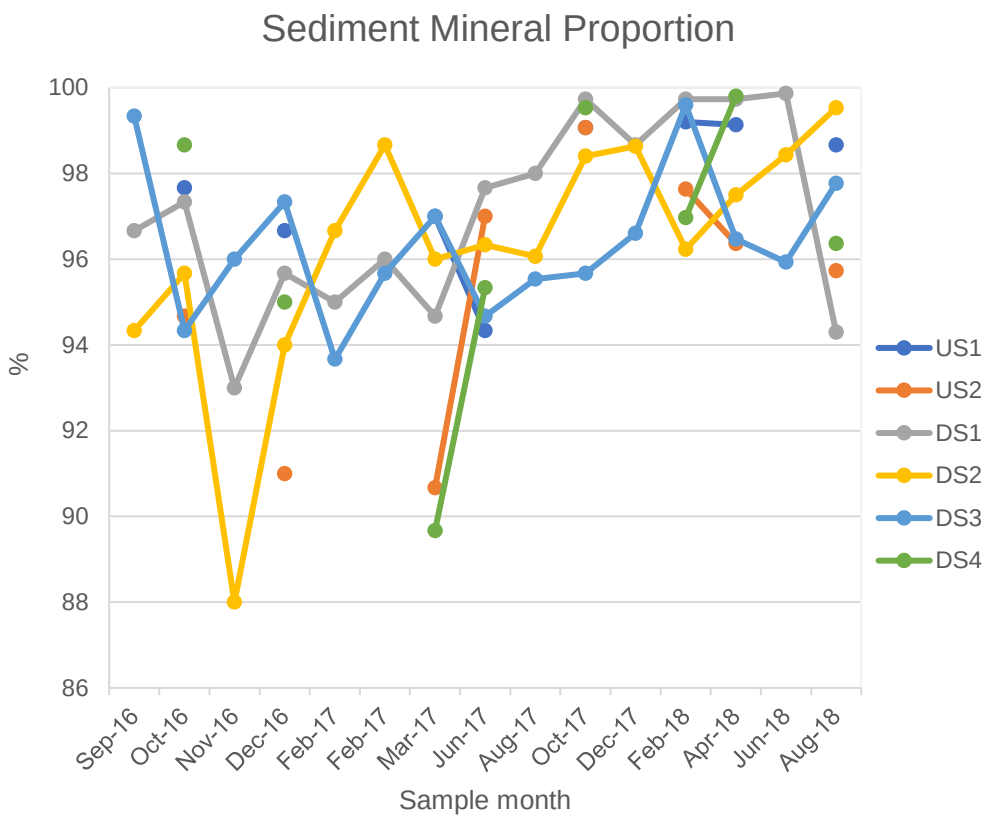
	Table 30 DS2 Microscopic Summary Statistics			
	Coal (%)	**Char (%)**	**Mineral (%)**	**Organic (%)**
Sample #	45	45	45	45
Min	0	0	78	0
Median	0.0	0.0	98.0	2.0
Mean	0.2	0.8	96.3	3.1
SD	0.5	2.8	4.3	4.2
Max	2	15	100	22

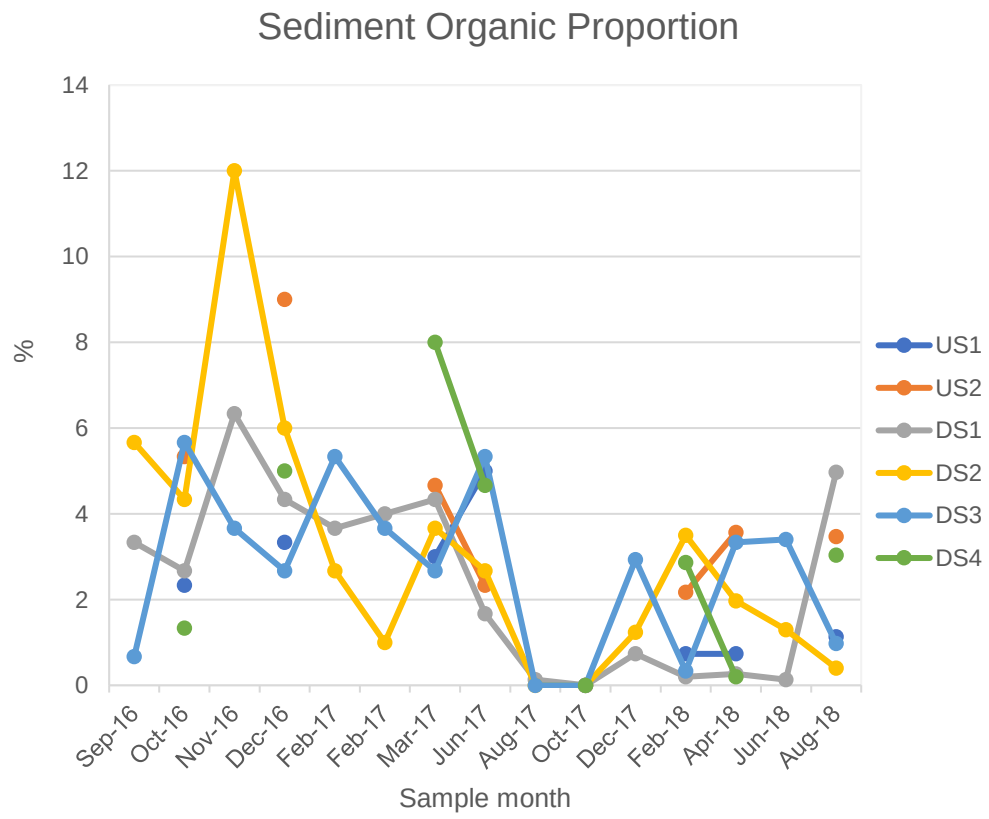
	Table 31 DS3 Microscopic Summary Statistics			
	Coal (%)	**Char (%)**	**Mineral (%)**	**Organic (%)**
Sample #	45	45	45	45
Min	0	0	85	0
Median	0.0	0.0	98.0	1.3
Mean	0.3	1.9	96.2	2.8
SD	0.5	7.5	4.2	3.6
Max	2	47	100	13

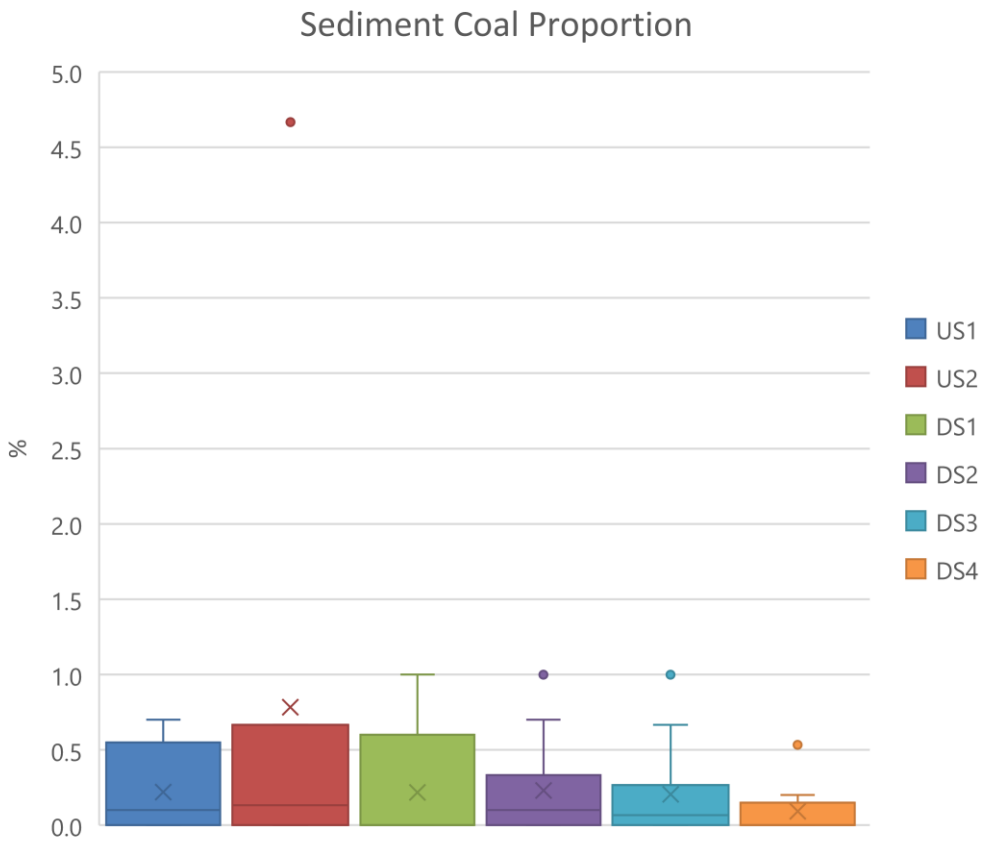
	Table 32 DS4 Microscopic Summary Statistics			
	Coal (%)	**Char (%)**	**Mineral (%)**	**Organic (%)**
Sample #	24	24	24	24
Min	0	0	88	0
Median	0.0	0.0	98.9	1.0
Mean	0.1	0.6	96.4	3.1
SD	0.4	1.5	4.3	3.7
Max	1.6	6	100	11

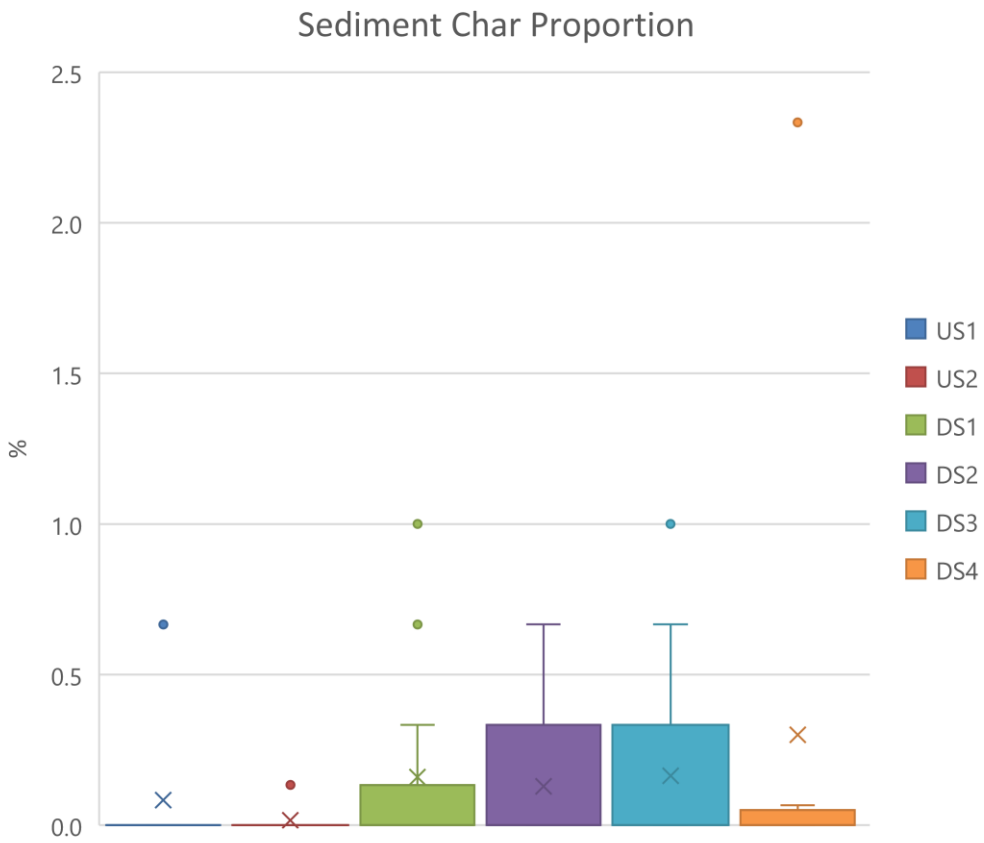

Sediment Coal Proportion
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
%
Sep-16
Oct-16
Nov-16
Dec-16
Feb-17
Feb-17
Mar-17
Jun-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

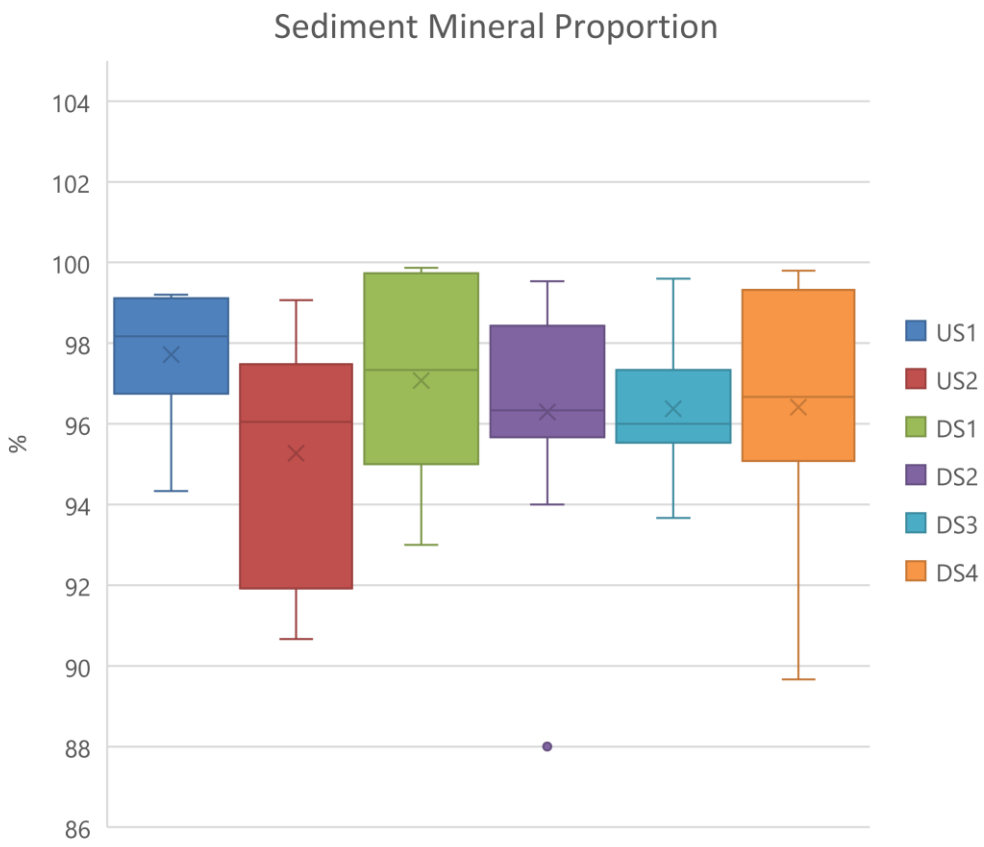

Sediment Char Proportion
2.5
2.0
1.5
1.0
0.5
0.0
%
Sep-16
Oct-16
Nov-16
Dec-16
Feb-17
Feb-17
Mar-17
Jun-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4

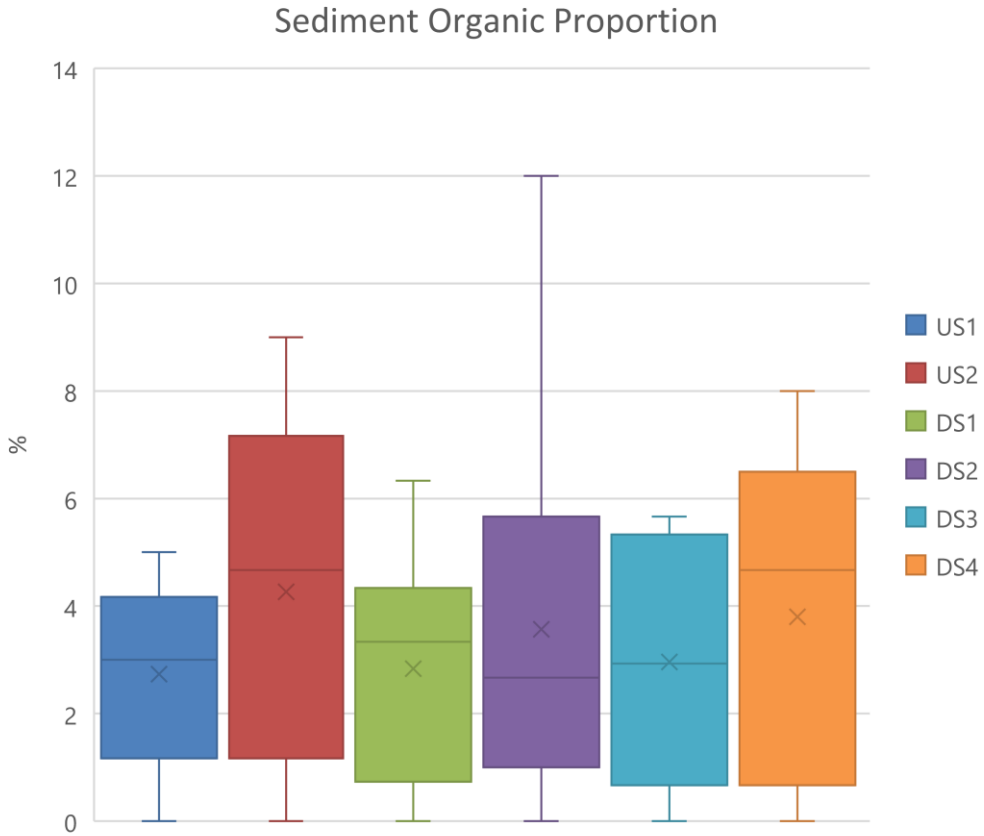

Sediment Mineral Proportion
100
98
96
94
92
90
88
86
%
Sep-16
Oct-16
Nov-16
Dec-16
Feb-17
Feb-17
Mar-17
Jun-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4


Sediment Organic Proportion
14
12
10
8
6
4
2
0
%
Sep-16
Oct-16
Nov-16
Dec-16
Feb-17
Feb-17
Mar-17
Jun-17
Aug-17
Oct-17
Dec-17
Feb-18
Apr-18
Jun-18
Aug-18
Sample month
US1
US2
DS1
DS2
DS3
DS4


Sediment Coal Proportion
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
%
US1
US2
DS1
DS2
DS3
DS4


Sediment Char Proportion
2.5
2.0
1.5
1.0
0.5
0.0
%
US1
US2
DS1
DS2
DS3
DS4


Sediment Mineral Proportion
104
102
100
98
96
94
92
90
88
86
%
US1
US2
DS1
DS2
DS3
DS4


Sediment Organic Proportion
14
12
10
8
6
4
2
0
%
US1
US2
DS1
DS2
DS3
DS4

4.4 Visual Inspections for Coal Fines

As per the sampling schedule shown in Table 1, visual inspections for coal fines accumulations are made at sites DS1 to DS4 on a quartely basis and at DS5 on a six monthly basis.

At each sampling occasion the river sections up- and downstream of the water quality sampling sites (and/or the aquatic ecology sampling reach) are inspected for accumulated sediment drifts and the drifts are inspected for obvious coal fine content. Sediment accumulations when found are photographed, and a selection of photographs of the sediment accumulations up and downstream at sites DS1 to DS5 are appended at **Appendix C1**.

As per the first six-monthly report, at no point were accumulated deposits of coal fines identified for the reporting period covered by this report (March 2018 to August 2018). In places of low flow where there were accumulated sediments, the sandy sediments or cobbles were covered in fine silt or slit-algae matrix cover (see Appendix C1 photographs).

5. AQUATIC ECOLOGY SAMPLING RESULTS

The EMP requires bi-annual sampling for macroinvertebrates at sites US1 to US4, annual sampling for fish using replicate bait traps for 24-hour periods at sites US1 to DS 4 and annual sampling for frogs at sites US1 to DS4.

An initial trial EMP aquatic ecology sampling program was undertaken in Autumn 2016 with the first EMP sampling undertaken in Spring 2016. A report prepared by MPR for these two sampling events was appended to the first six monthly EMP report in March 2017. The Autumn 2017 survey was included I n the second EMP report and the Spring 2017 survey was included in the third EMP report.

The Autumn 2018 aquatic ecology sampling program was undertaken between 16 and 23 April 2018, and the MPR report is appended to this report as **Appendix D**.

5.1 Aquatic Ecology Methods and Data Summary

The Aquatic Ecology program includes the following stream-health sampling components undertaken at all sites (US1 to DS5):

- Site aquatic ecology habitat condition is estimated on each six-monthly sampling occasion using a modified version of the River-Creek-Environment (RCE) stream site condition index.
- A submersible water quality data logger is used to record water depth, temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity at all aquatic ecology sampling sites.
- Aquatic macroinvertebrate assemblages are determined using the standardised National River Process and Management Program River Bio-assessment protocols known as Australian River Assessment System (AusRivAS), and sampling is undertaken at both ‘edge’ and ‘riffle’ sites where these habitats (as defined by AusRivAS) exist at the sites (i.e, sites DS1 to DS5).
- For the upper river sites US1 and US2 there are no riffle sections as defined. Accordingly, only ‘*edge’* sampling is undertaken at these sites.
- Sampling and observations for fish are undertaken every six months at part of the aquatic ecology sampling program. At each aquatic ecology sampling site, four fish bait traps are set at suitable locations, left overnight and collected the next day during macroinvertebrate sampling.
- Frog searches are undertaken every six months at part of the aquatic ecology sampling program. Frog searches are undertaken twice at each site visit (i.e., when fish traps are set, and when the site is revisited to collect fish traps and undertake macroinvertebrate sampling. A dedicated frog call recorder is also deployed for overnight recording at selected sites each season.

Habitat assessment, water quality results, fish trapping and observation results and frog searches plus call results are all tabulated in the **Appendix D** report and the RCE plus water temperature and conductivity variation for the combined sites are also shown graphically.

5.2 Macroinvertebrate Monitoring Data Summary

The period between the last aquatic ecology sampling in October 2017 through to the April 2018 sampling period has been characterised by long dry spells punctuated by short periods of low intensity rainfall and very few heavy rainfall events (the largest being 46mm on 21 October 17 and 32.6mm on 20 February 18). March monthly rainfall (82.2mm) was below average with most (53.2mm) recorded over six days (21-27 March).

There was then only 4.8mm rainfall recorded for the 19 days leading up to the sampling period, with 3.8mm of this recorded over the two days prior to sampling commencing on 16th April. Sampling was then interrupted with 12.4mm recorded on 20th April, and sampling completed on 23rd April.

LDP discharges were also reduced between Spring 17 and Autumn 18. The average daily discharge for 2017 was 13.42 ML/day, and for the March to April 2018 period leading up to sampling, the daily average was reduced to 6.04 ML/day.

The macroinvertebrate assemblage data comprises presence-absence data for taxa identified to the taxonomic levels specified in AusRivAS (generally to Family level). These data are used to compile the following macroinvertebrate indices – compiled for both 'edge' and 'riffle' sample results:

- Site Aquatic Habitat Condition (**RCE Index**)
- Site **Diversity index** (taxa richness).
- **SIGNAL Index** (Stream Invertebrate Grade Number Average Level).
- **EPT index**; the combined number of Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddis-fly) families present per site.

These indices are tabulated and compared to previous seasonal results in cluster bar control graphs and the variation in the indices for the Autumn 2018 survey are also tested against the overall variation in each index for the previous surveys (in this case four surveys – Autumn 2016 & 2017 and Spring 2016 & 2017). Specifically, the test examines whether the value is lower than the range Mean – Standard Deviation (X-SD) of the former data. It should be noted that in this case comparisons against only three previous data sets does not carry much weight and will only become more meaningful once there have been at least two Autumn and two spring surveys (i.e., starting Autumn 2018):

- All site RCE indices were within or above the range X-SD, with the exception of site DS4 which was slightly under the X-SD range.
- Edge Sample Diversity indices for sites US1, DS3 and DS4 were within or above the range X-SD and the rest were below.
- All Edge SIGNAL scores were within or above the range X-SD, with the exception of site US2, DS1 and DS4.
- All Edge EPT scores were within or above the range X-SD, with the exception of site DS1.
- All Riffle Diversity Site results were above the range X-SD except at sites DS3 and DS5. DS1 was well above the X±SD range.
- Riffle SIGNAL scores were all above the range X-SD.
- Riffle EPT scores were within or above the range X-SD with the exception of sites DS4 and DS5. DS1 and DS2 scores were above the X±SD range.

5.3 Vertebrate (Fish and Frog) Monitoring Data Summary

Mountain galaxias were the only fish caught in traps or observed in Autumn 2018 and were caught at four sites. A total of 15 were caught. Mountain galaxias have been found or sighted at all sites and it is concluded that there is no physical barrier for this species to travel between sites.

For the Autumn 2018 survey no tadpoles or frogs were observed during the systematic site searches. From frog call recordings overnight for the Autumn 2018 survey sites, only one call - Red Crowned Toadlet, *Pseudophryne australis* was recorded - at site DS3.

6. DISCUSSION

This is the fourth data report on the implementation and progress of the EMP and reports on monitoring undertaken and completed between March 2018 and August 2018.

For **water quality analysis** the concentrations of the following analytes remained less than detection (<DL) for all sites:

- Hydroxide and Carbonate Alkalinity (DL< 1mg/L) Oil and Grease (DL < 5 mg/L), Total Phenol (DL < 0.05mg/L) and Total Cyanide (DL < 0.004mg/L).
- Beryllium, Boron, Lead and Uranium (DL 0.001mg/L), Selenium (DL 0.01mg/L).
- The concentrations of Antimony, Arsenic, Cadmium, Chromium and Copper have remained less than detection (DL 0.001mg/L) for most sites and for most sampling times to date.

For **sediment total metal analysis,** the concentrations of total Selenium (DL <1 mg/kg), Boron (DL <50mg/kg) and Cadmium (DL < 0.1 mg/kg, except US2 in Feb 18, April 18 & Jun 18) have remained less than their relative detection limit for all sites and for all sampling times to date. Most site Antimony, Arsenic and Beryllium concentrations have remained below detection or just above detection.

For **aquatic ecology monitoring** in Autumn 2018, the period between the last aquatic ecology sampling in October 2017 through to the April 2018 sampling period was characterised by long dry spells punctuated by short periods of low intensity rainfall and a few heavy rainfall events, and for the March to April 2018 period leading up to sampling, the daily average LDP discharge was reduced to around 6ML/day:

- Comparisons of individual site Streamhealth indices against study Mean ± Standard Deviations (X ± SD) indicated the most index results were within the site X ± SD ranges with individual exceptions for all sites except US1.
- Mountain galaxias were recorded at most sites including US1 and Giant Spiny Crayfish were recorded or observed from Site DS1 and downstream to DS5. There were no introduced fish found or observed. Whilst no tadpoles or frogs were found or observed during systematic site searches, a Red Crowned Toadlet was recorded overnight at Site DS3.

The aquatic ecology monitoring results indicate that the Wollamgambe River within the study area provides good aquatic habitat for a range of macroinvertebrate species and provides fish passage and habitat for native fish species.


Centennial Coal