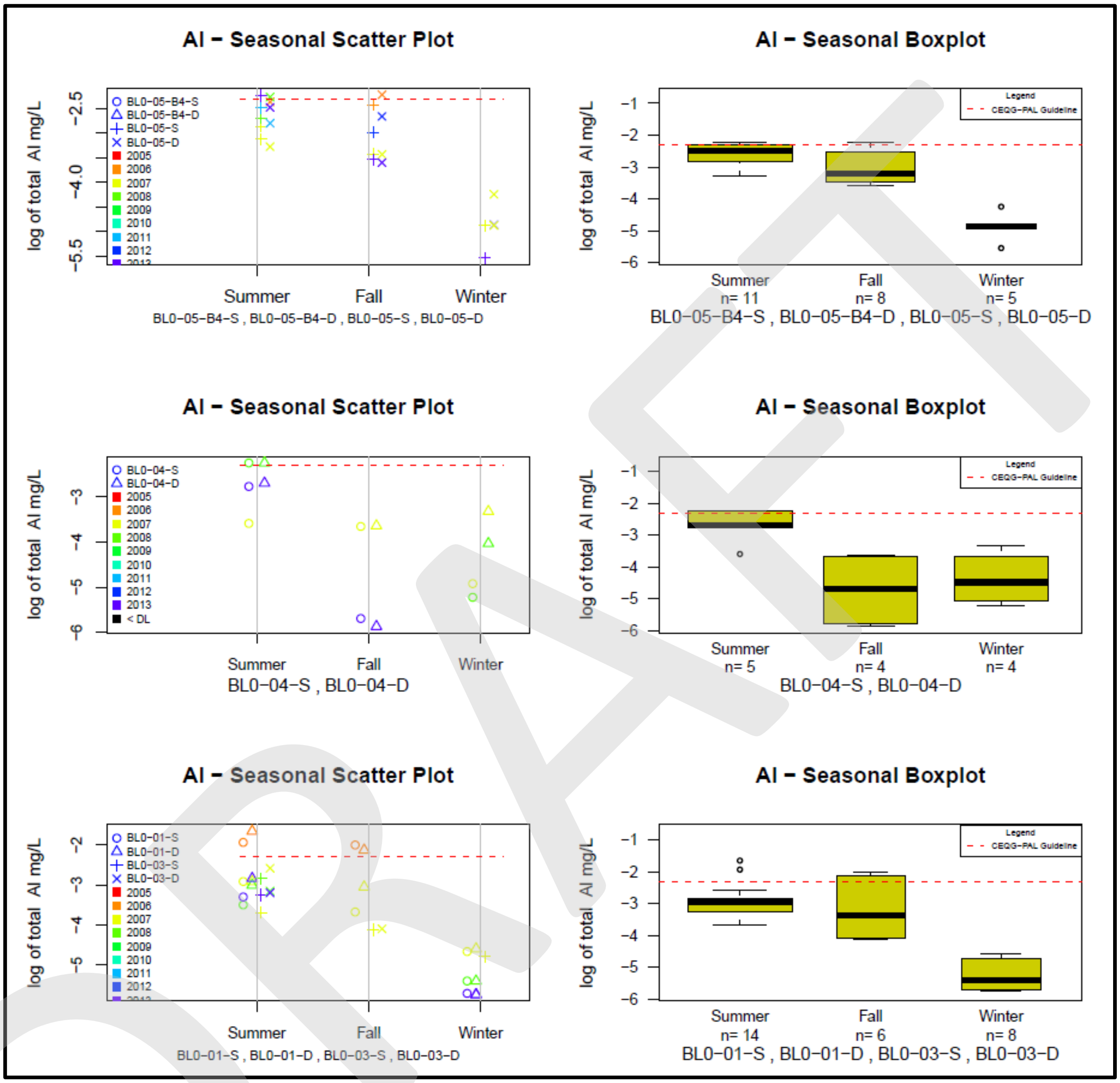


NOTES:

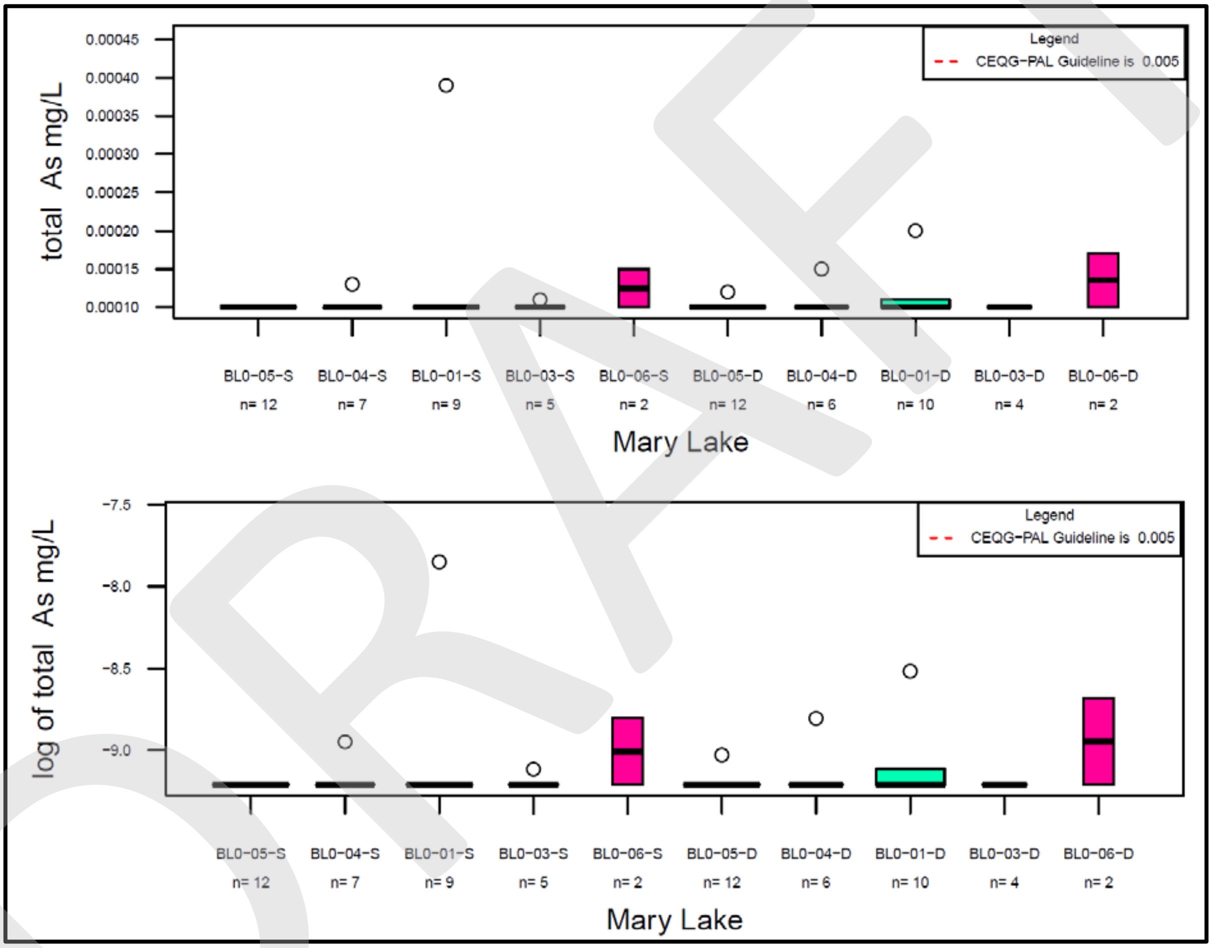
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.59 Mary Lake – Variability of Total Aluminum in Water

Seasonal boxplots show aluminum concentrations tend to be at their maximum in the summer, and decrease to their minimum value in the winter, with fall concentrations occurring somewhere in between. The only stations that do not show this trend are BL0-04-S/D and BL0-06-S/D. These stations show a cluster of low concentration values below 2007-2008 winter data. Similar to other locations within the mine site, seasonal box plots indicate that aluminum concentrations are highest in the winter and lowest in the summer.

Total Arsenic (Figures B.60 and B.61)

Sixty-nine (69) total arsenic concentration samples were collected from Mary Lake over the course of eight years. Arsenic concentrations tend to occur below detection limits, and below the CWQG-PAL limit (0.005 mg/L), with the exception of several outlying values (Figure B.60). All outlying values occur during the fall at BL0-05-S, BL0-04-S/D, and BL0-06-S/D in 2013; and at BL0-01-S/D in 2007. The highest outlying value (~0.0004 mg/L) remains below the CWQG-PAL limit. Samples from BL0-06-S/D, located at the outlet of Mary Lake, have slightly elevated median arsenic concentrations when compared to other stations.

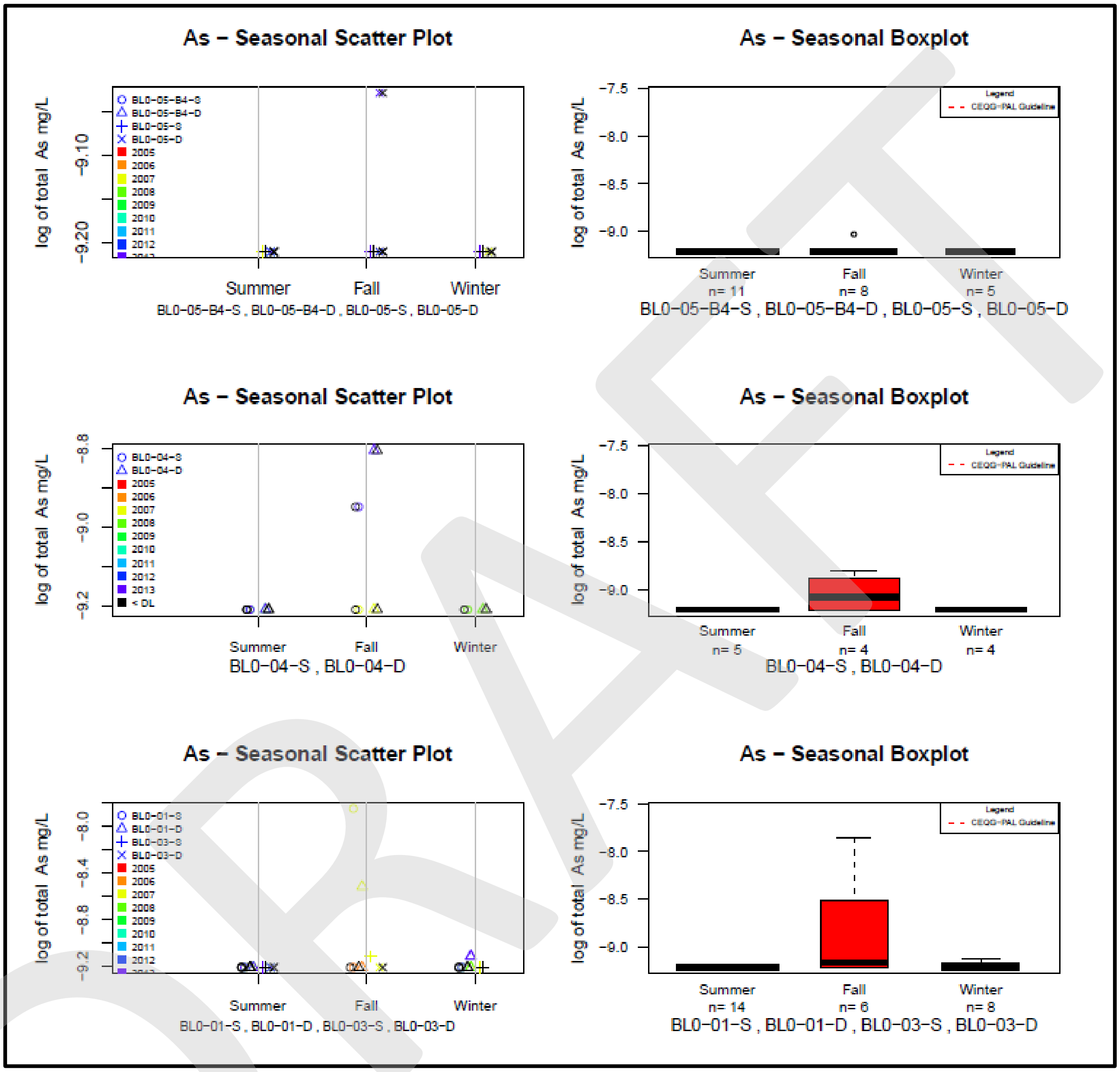


<u>**NOTES:**</u>

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.60 Mary Lake – Total Arsenic Concentrations in Water

Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be utilized together for calculation of benchmarks (Figure B.61). Seasonal boxplots show that all maximum arsenic concentration outliers occur during the fall, while summer and winter concentrations remain depressed in comparison.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

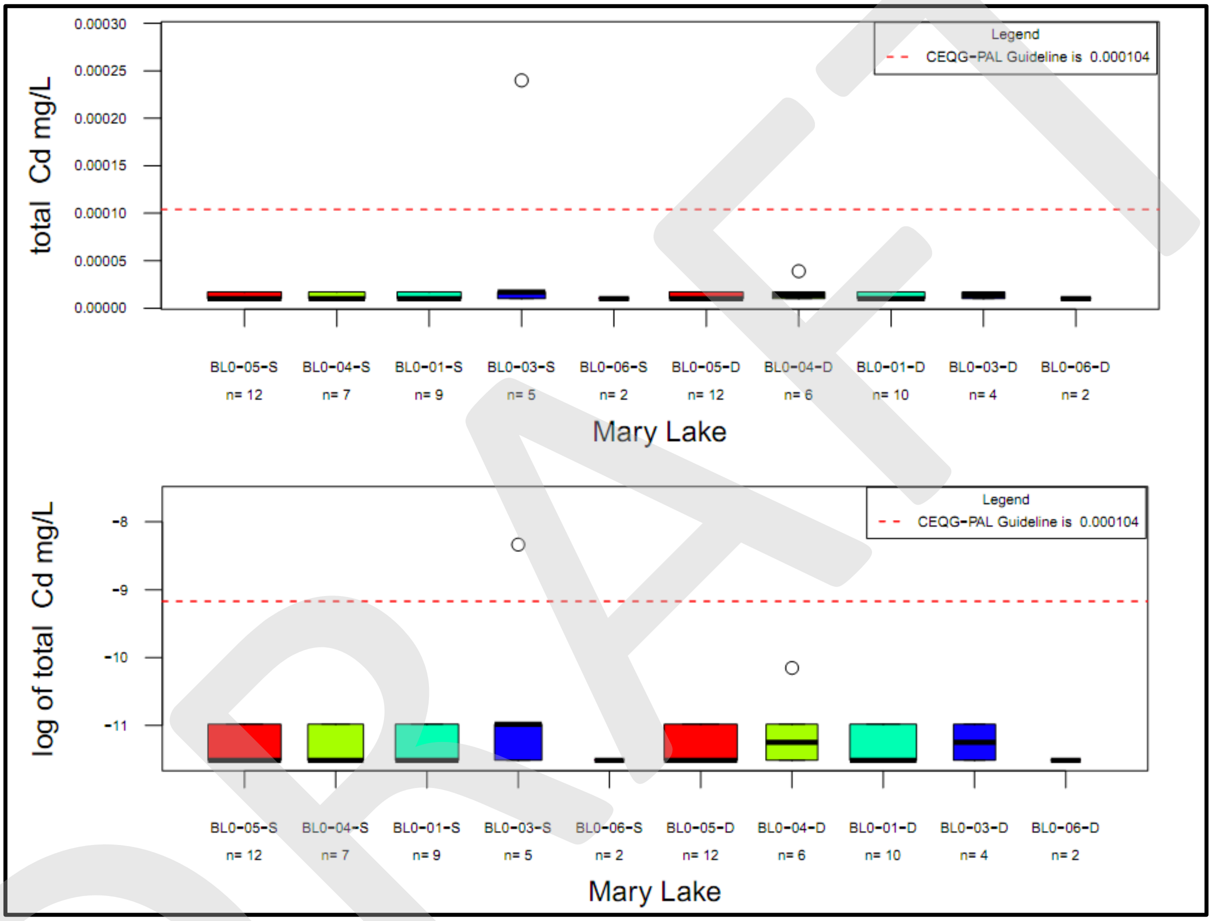
Figure B.61 Mary Lake – Variability of Total Arsenic in Water

Total Cadmium (Figures B.62 and B.63)

Sixty-nine (69) total cadmium concentration samples were collected from Mary Lake over the course of eight years. Cadmium concentrations tend to occur at or below detection limits, and just below the CWQG-PAL limit (0.000018 mg/L), with the exception of several outlying values (Figure B.62). BL0-04-D and BL0-03-S are the only stations where maximum concentrations exceed the

CWQG-PAL limit. All geographically distinct sample locations in Mary Lake have similar median values, with the exception of BL0-04-D and BL0-03-S, which have elevated median values.

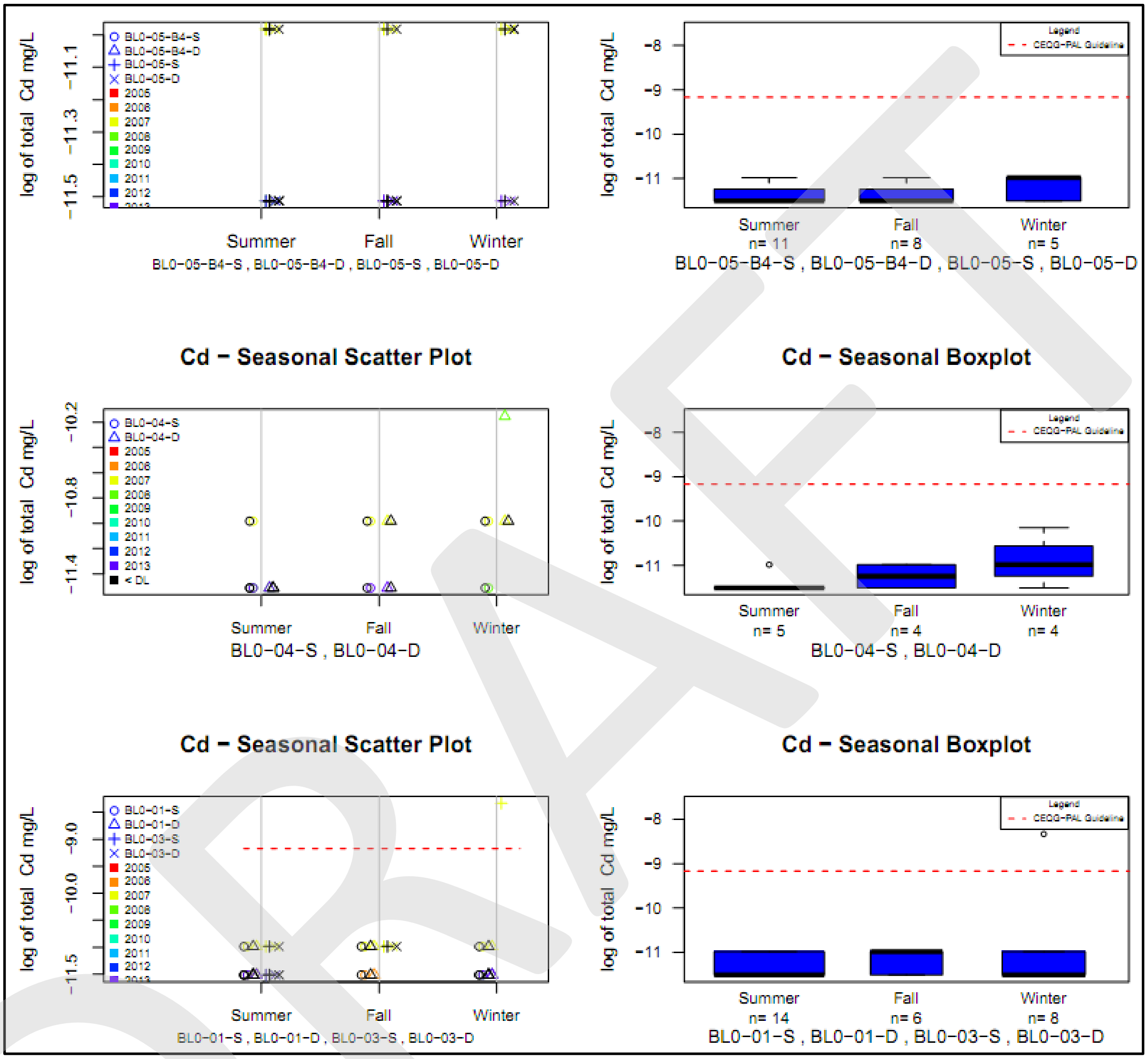
Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be utilized together to determine baseline trends (Figure B.63). Seasonal scatterplots indicate cadmium concentrations are slightly elevated in the winter, when compared to other seasons.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.62 Mary Lake – Total Cadmium Concentrations in Water



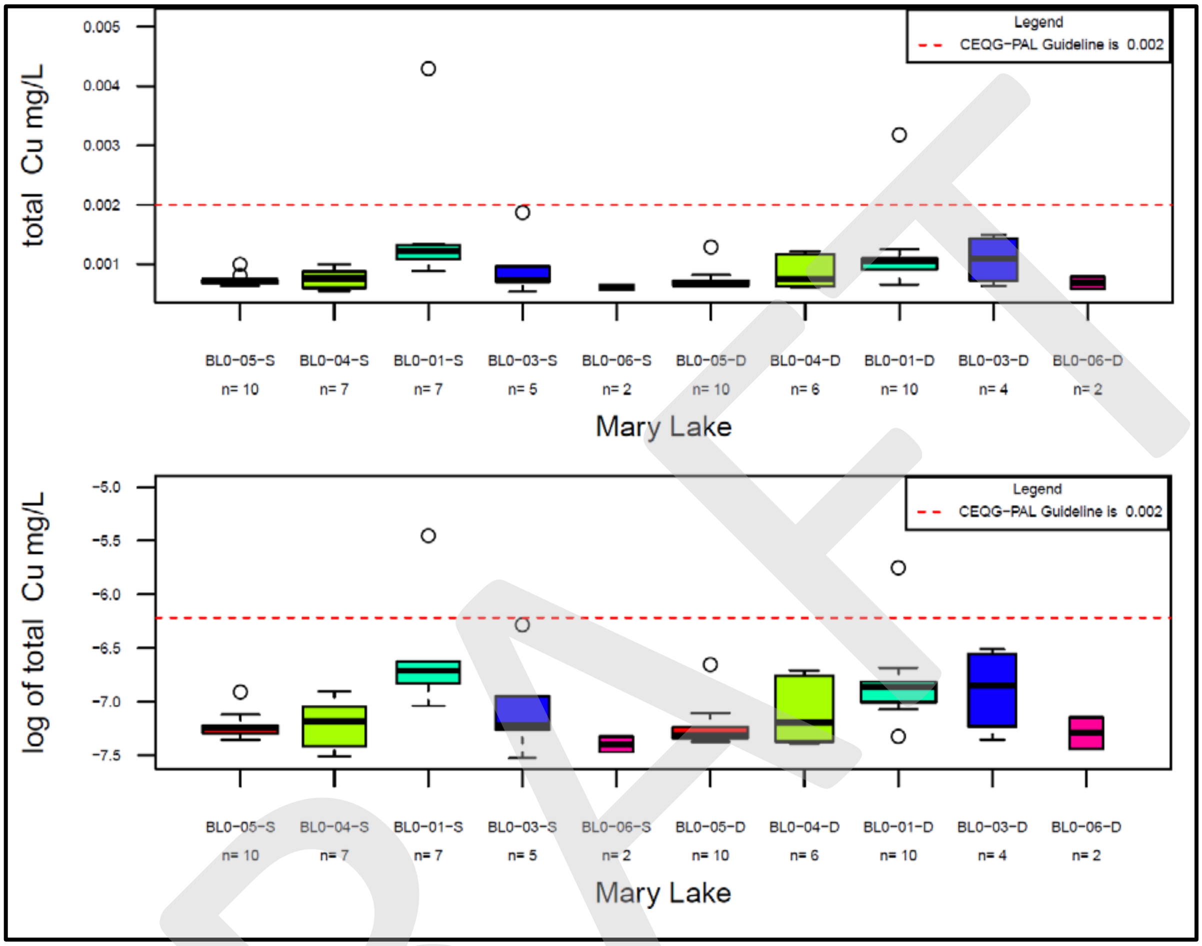
NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.63 Mary Lake – Variability of Total Cadmium in Water

Total Copper (Figures B.64 and B.65)

Sixty-three (63) total copper concentration samples were collected from Mary Lake over the course of eight years. Copper concentrations tend to occur above detection limits, and below the CWQG-PAL limit (0.0002 mg/L), with the exception of two outlying values (Figure B.64). Samples from BL0-01-S/D and BL0-03-D are elevated in comparison to other stations. This indicates possible existing copper loading via inflows from I-tributary or J-tributary.

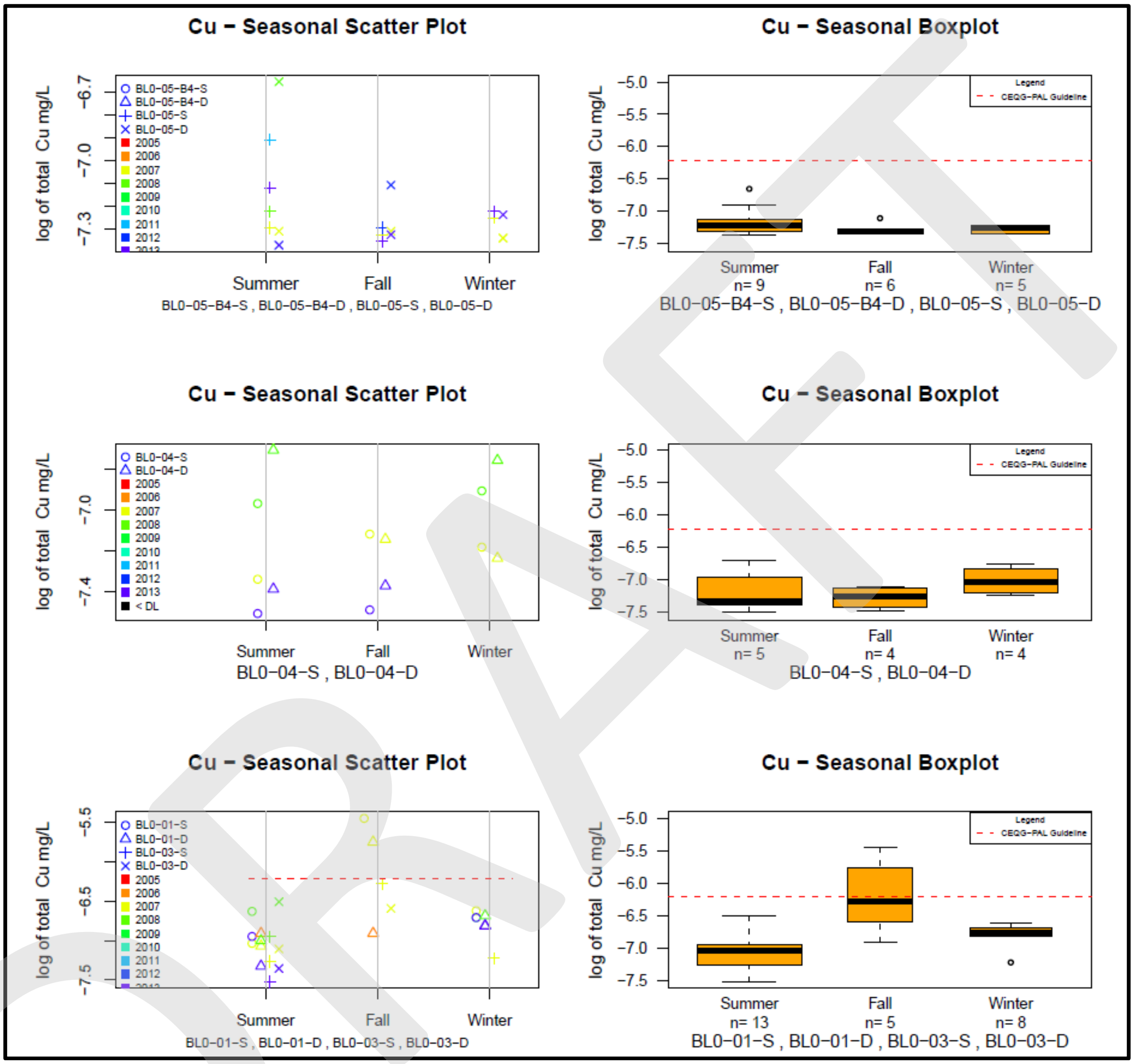


NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.64 Mary Lake – Total Copper Concentrations in Water

Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be utilized together to obtain an understanding of baseline concentrations (Figure B.65). Seasonal boxplots do not reveal a consistent trend among stations.



NOTES:

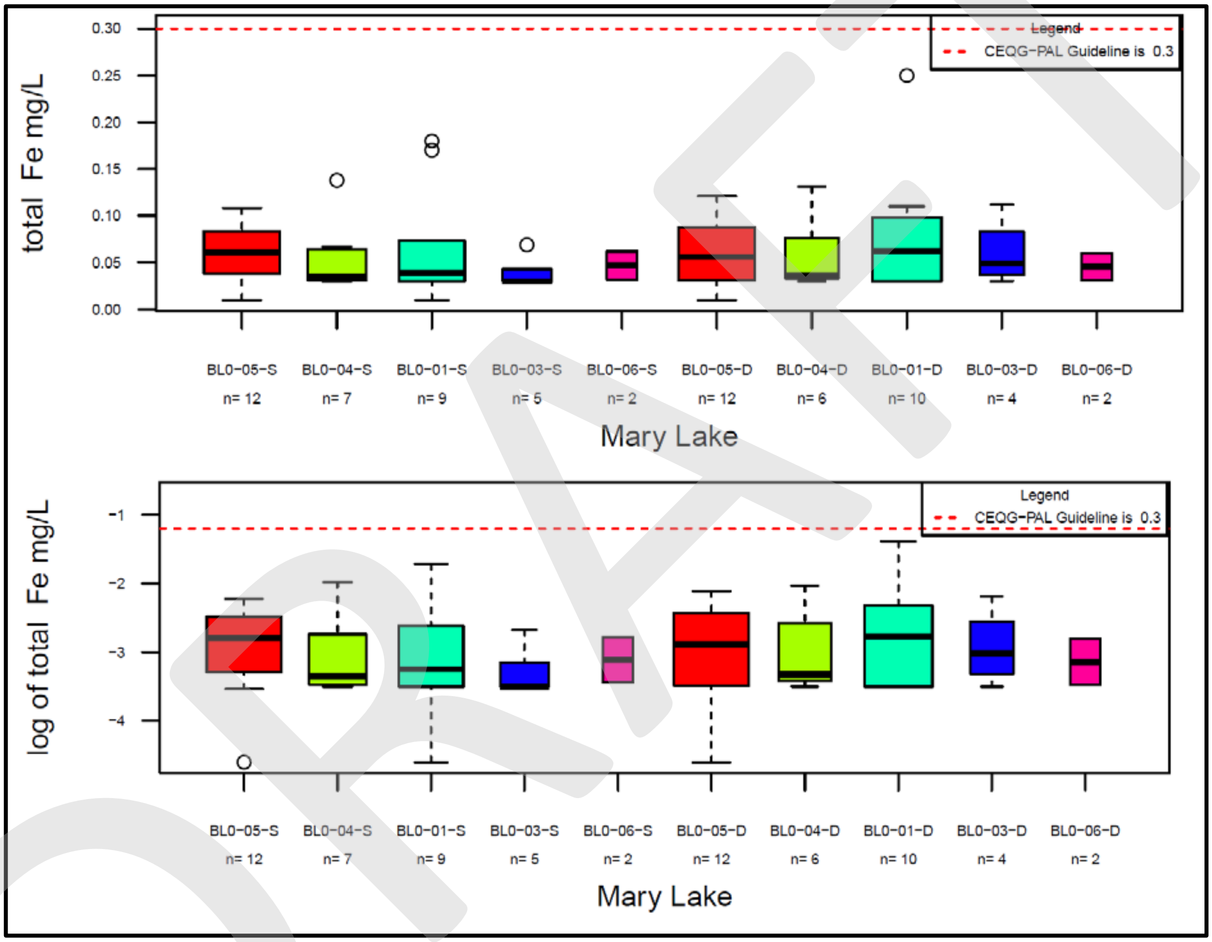
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.65 Mary Lake – Variability of Total Copper in Water

Total Iron (Figures B.66 and B.67)

Sixty-nine (69) total iron concentration samples were collected from Mary Lake over the course of eight years. Iron concentrations tend to occur above detection limits, and well below the CWQG-PAL limit (0.3 mg/L) (Figure B.66). Median iron concentrations range from 0.04 mg/L to 0.06 mg/L. BL0-05-S/D and BL0-01-D, both located at Mary Lake inlet locations, have elevated median iron concentrations. This indicates some amount of existing iron loading may be occurring from upstream sources.

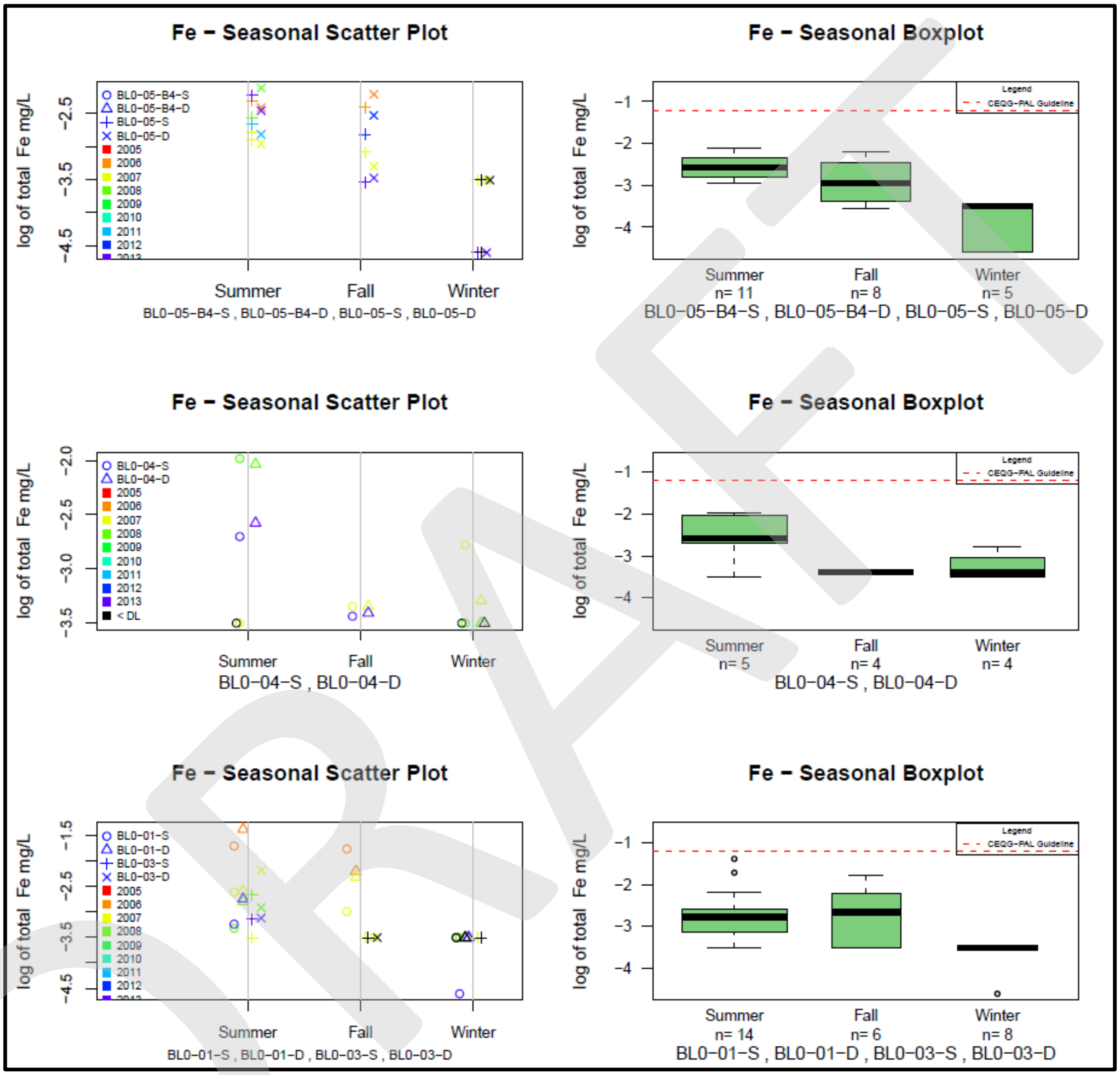
Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be utilized together to gain an understanding of baseline conditions (Figure B.67*)*. Seasonal boxplots indicate summer concentrations are typically elevated, when compared to winter concentrations. Concentration trends for fall data are less consistent.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.66 Mary Lake – Total Iron Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

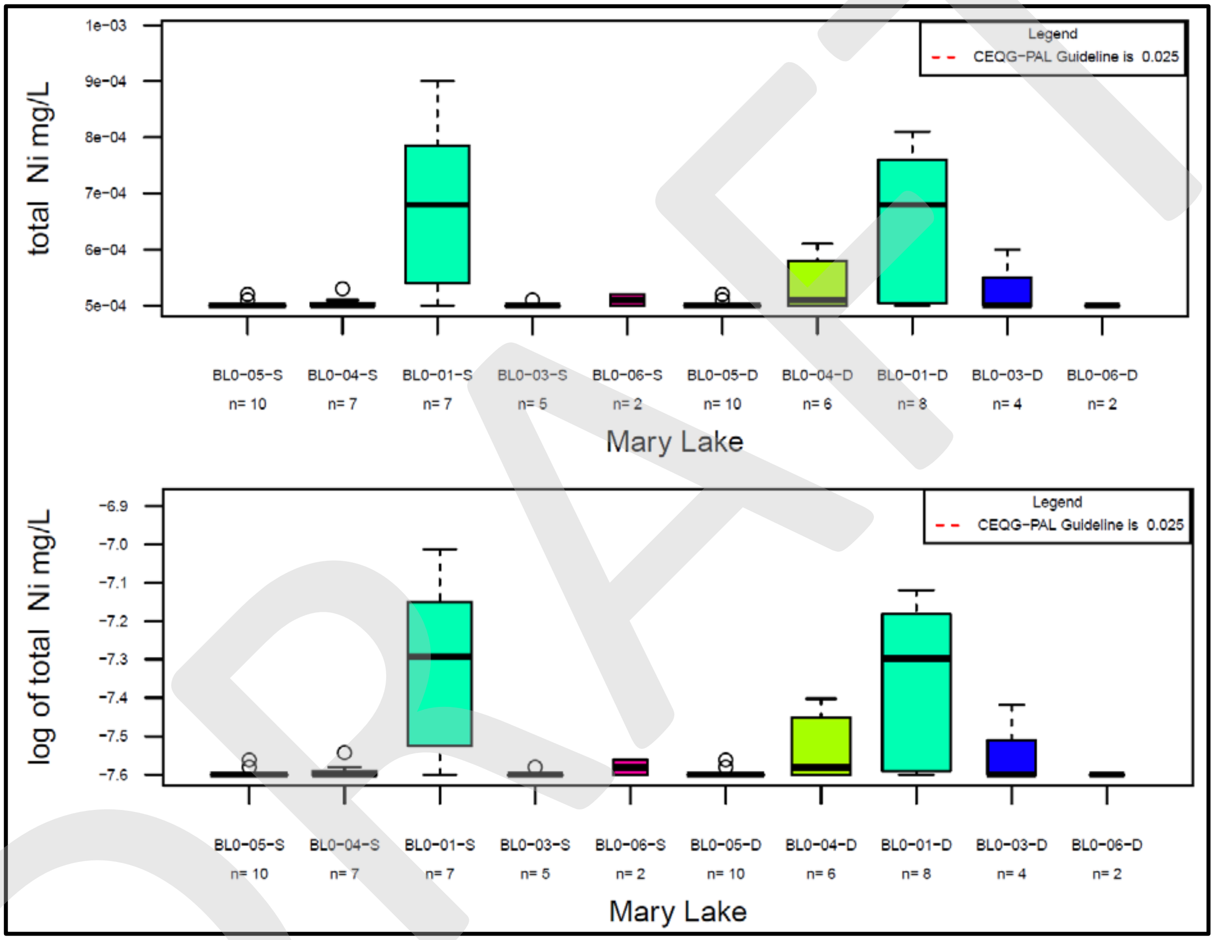
Figure B.67 Mary Lake – Variability of Total Iron in Water

Total Nickel (Figures B.68 and B.69)

Sixty-one (61) total nickel concentration samples were collected from Mary Lake over the course of eight years. Nickel concentrations are low and tend to occur at, below or slightly above detection limits, and well below the CWQG-PAL limit (0.025 mg/L) (Figure B.68). Median nickel concentrations at geographically distinct sampling stations tend to occur around 0.0005 mg/L. Samples from

BL0-01-S/D (north arm near the Camp Lake discharge) are elevated in comparison to other sample stations and have a median concentration ~0.0007 mg/L. This indicates some amount of existing nickel loading may be occurring from upstream sources.

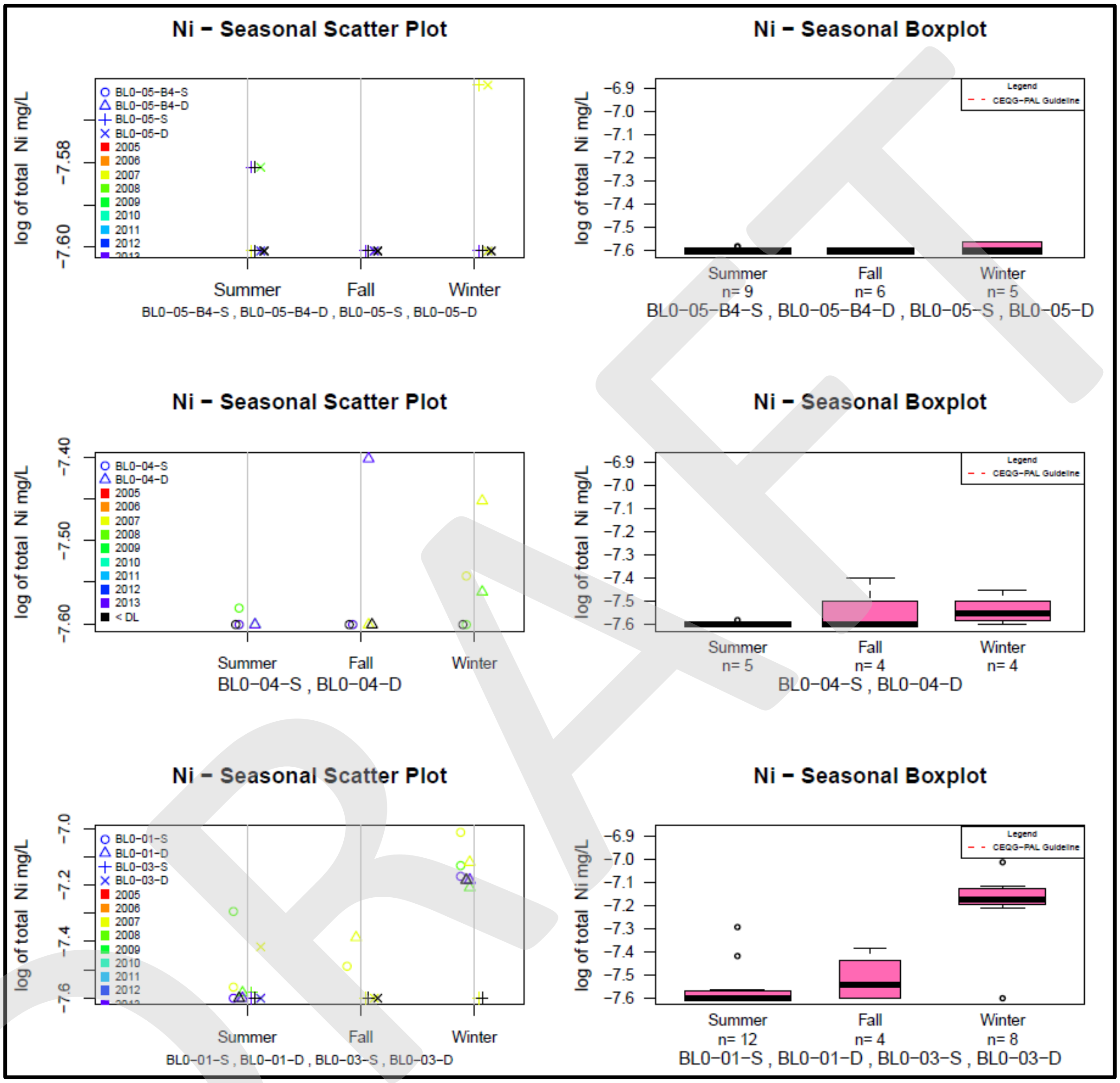
Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be utilized en mass to determine overall baseline trends (Figure B.69). Seasonal boxplots indicate summer concentrations are typically depressed when compared to winter concentrations.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.68 Mary Lake – Total Nickel Concentrations in Water



NOTES:

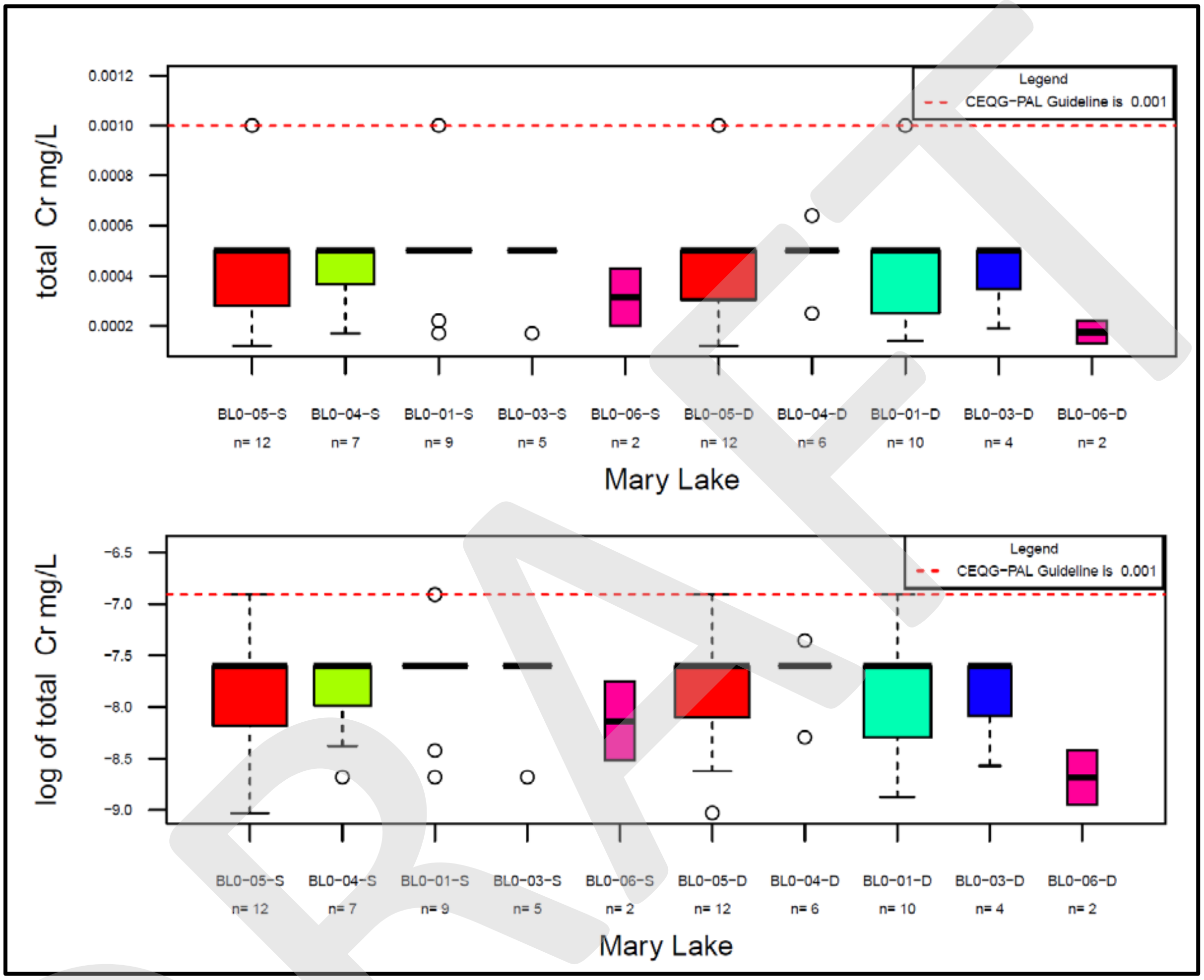
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.69 Mary Lake – Variability of Total Nickel in Water

Total Chromium (Figures B.70 and B.71)

Sixty-nine (69) total chromium concentration samples were collected from Mary Lake over the course of eight years. Total chromium concentrations are low and tend to occur at, below or slightly above detection limits, and well below the CWQG-PAL limit (0.001 mg/L) (Figure B.70). Maximum and outlying concentrations at BL0-05-S/D and BL0-01-S/D reach the guideline limit.

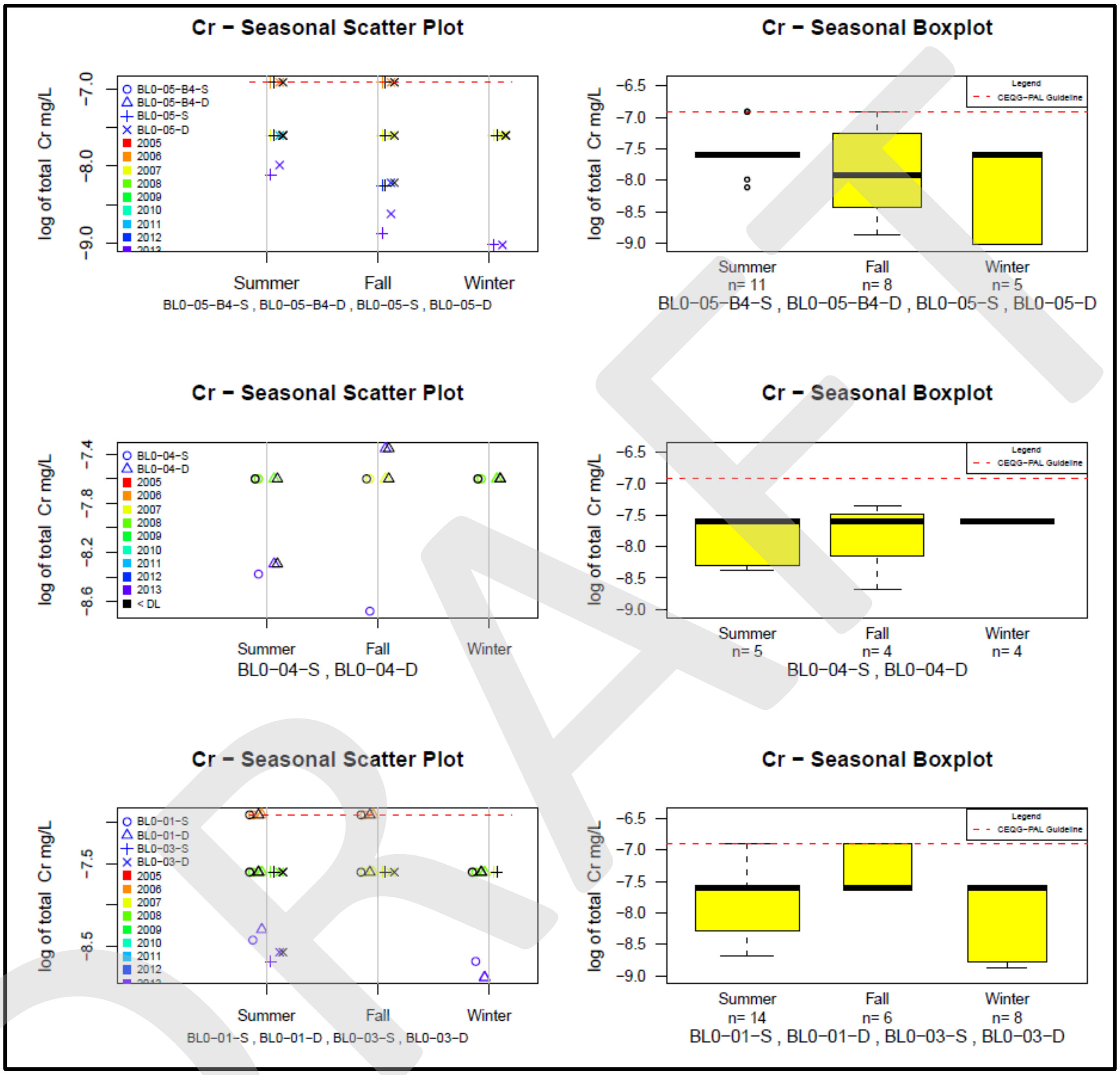
Seasonal scatterplots indicate show that detection limits are defined by applicable years (Figure B.71*)*. Seasonal boxplots do not show any conserved trend throughout sites.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.70 Mary Lake – Total Chromium Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.71 Mary Lake – Variability of Total Chromium in Water

Summary of Mary Lake Water Quality

Summary of trends observed during review of Mary Lake baseline water quality data:

- Distinct depth trends were not observed for any parameters within Mary Lake, which suggests complete mixing of the lake. As a result, both deep and shallow station data has been utilized to inform baseline trends in water quality.

- Inlet sampling shows elevated concentrations for certain samples, such as aluminum, chloride, copper, iron, hardness, chromium and nickel.
- Parameters that occur below MDL or do not show seasonal trends include: cadmium, copper, nitrate, and chromium.
- Parameters with the highest concentrations in the summer include: aluminum and iron.
- Parameters with the highest concentration during the fall include: arsenic.
- Parameters with the highest concentration during the winter: chloride, nickel and cadmium.

B.3 POWER ANALYSIS

B.3.1 Methods

Parameter and station-specific power analyses were completed in order to determine the power of the proposed sampling program to detect statistical changes. As per the Assessment Approach and Response Framework in the CREMP (see Figure 2.12 in the main report), management action is triggered if the mean concentrations of any parameter at selected stations reach benchmark values. Benchmark values have been developed for water quality contaminants of potential concern (COPCs) that consider aquatic toxicology, natural enrichment in the Project area, or low concentrations below MDLs (Intrinsik, 2014; see Section 2.7.3 of the main report). Sufficient statistical power is required to ensure that management action is triggered correctly, and this has necessitated the completion of a power analysis. Inputs to the power analyses include all baseline data sampled to date and the proposed benchmark values, which were calculated using the 97.5th percentile of the baseline data. For all lakes in the sampling program, no pre-mining reference data exists; therefore, a complete Before-After-Control-Impact (BACI) analysis cannot be completed. Instead a before-after (BA) design framework was used (Smith, 2002). Once additional baseline data from 2014 and post-mining data is collected, it is anticipated that a Linear Mixed Effects model will be used to test the differences between concentrations measured for pre-mining impact data, pre-mining baseline data, post-mining impact data and post-mining reference data.

The *a priori* power analysis determines, based on a given sample size, variability and effect size[1], the number of samples required to obtain a certain power at a certain alpha value or Type I error rate. Type I error quantifies the probability that a given statistical test will incorrectly reject the null hypothesis or provide a false positive/false alarm. Conversely, type II error occurs when the null hypothesis is false, but fails to be rejected. In other words, to miss something that is actually occurring. Type I and type II error are inversely related. Since the design of the sampling program is conservative and errs on the side of false alarm vs. miss, a greater alpha value (0.10) has been selected to increase power and consequently decrease the type II error. The power analyses presented here are do not account for multiple testing or use Bonferoni or other correction to adjust for experiment wise error rates. Correcting for multiple testing would result in lower nominal type I errors and reduced power for a given sample size.

The power analyses were run based on two effect sizes: 1) the difference between the station baseline mean and benchmark and 2) halfway between the station baseline mean and benchmark.

---

[1] Effect size is the magnitude of an effect. In a priori power analysis, the effect size quantifies the magnitude difference between two groups that the test will be able to determine.

The following parameters were selected for power analysis as they have a large number of detected values, have elevated concentrations during baseline conditions, are expected to be the most affected parameters during mine operation and are expected to require the largest sample sizes to detect change:

- Aluminum
- Arsenic
- Copper
- Iron
- Cadmium

A short list of sites was compiled from key sites in the proposed CREMP program. The following sites were selected for targeted power analysis:

- Camp Lake:
  - JL0-02-S
  - JL0-09-S
- Sheardown Lake NW:
  - DL0-01-1-S
  - DL0-01-5-S
- Sheardown Lake SE:
  - DL0-02-3-S
- Mary Lake:
  - BL0-01-S
  - BL0-05-S

Two different types of power analysis were run, depending on the proportion of data above MDL. Several modifications to each approach were taken, depending on availability of data at a specific site.

1) The power to detect a change in means was assessed for parameters with sufficient data above MDL (<15% of non-detected data). A before-after (BA) design was used when control data was not available and power analysis was carried out using a two sample t-test to compare means. This approach is less rigorous when compared to the BACI design and does not control for natural temporal changes.

   For the purposes of analysis, for parameters with <15% non-detected data, only detected data was analyzed. This method was selected due to a variety of detection limits present in the historic data. In some cases, imputation of detection limits occurred, as discussed in Section 2.2. Although all imputation assumptions were conservative; analysis of the detected data removes the possibility that data analysis was affected by imputation or elevated detection limits. To verify the use of the detected data to inform mean values for the power analysis, the mean values estimated with detected data are compared to the mean values estimated via Regression on Order (ROS) method. The Regression on Order (ROS) statistics method is recommended by the BC Ministry of Environment as a method to calculate statistics in data sets including non-detects and especially those affected by left-censored data (Huston and Juarez-Colunga, 2009). Both of these values are provided for each key parameter examined for the sake of comparison. In general, the mean estimate based on detected data is larger than the ROS estimate. This is conservative for the power analysis as a higher baseline mean corresponds to a smaller change to be detected post mining.

2) The power to detect a change in the proportion of values above MDL was assessed for parameters with a large proportion of values below MDL (>15% of non-detected data). For some parameters the baseline dataset is represented predominantly by values below MDL. This occurred for arsenic and cadmium at all stations. For these parameters, the exact magnitude of the parameters under baseline conditions is unknown. Although a full BACI analysis will be carried out for data analysis purposes, simplified designs were assumed for the power analysis. Two approaches were utilized for the test of proportions:

    a. BA designs were assessed using a test for two independent proportions (Agresti, 1990).

    b. McNemar's test (Agresti, 1990) was used to assess the power to detect a difference between the paired proportions at impact and control stations. As for continuous data, pairing allows exploitation of the fact that the variance of the difference between paired data is smaller than the variance of the difference between independent samples (Agresti, 1990). Under a full BACI design, the baseline and post-mining paired proportions can be compared to assess whether a change is mine related.

McNemar test for the equivalence of paired proportions (each impact sample paired with a correlated control sample collected at a comparable time) is carried out using the off-diagonal elements (p01 and p10) of a 2x2 contingency table. It is helpful to reference Table B.5 for discussions related to the analysis of proportions. This is a novel approach that enables the use of data highly affected by censored data, where a meaningful comparison of means is not possible and the utility of left-censored methods is limited. To our knowledge, this approach has not been used in other projects, but is supported within scientific literature as a valid method to deal with left-censored data (Agresti, 1990).

Table B.5 Proportion Labels for 2x2 Contingency Table

Impact	Control		
	<MDL	>MDL	Total
<MDL	p_{00}	p_{01}	p_{0+}
>MDL	p_{10}	p_{11}	p_{1+}
Total	p_{+0}	p_{+1}	p_{++}

For lakes, both shallow and deep sites were sampled at the same location at the same time. Although baseline results did not indicate stratification occurs in any of the lakes, the sampling program will continue to sample deep and shallow stations separately, with the hypothesis that mine-related effects could have different depth affects. Data from two depths will be analyzed separately. The power analysis presented here considers shallow stations. Sample size, median, mean, standard deviation and power were compared power between sites for a variety of lake sites. In general, sample sets that have a lower sample size, higher variability and a small difference from station baseline mean and benchmark have low power.

B.3.2 Results

Since the power analysis was completed on a site-specific and parameter-specific basis, the results were interpreted by identifying the sites and parameters that are most constraining. Table B.6 highlights the sites and parameters that are expected to constrain analysis. It is not unexpected that aluminum is a constraining factor across a number of sites since aluminum is the most enriched metal during baseline conditions. Analysis of Figure B.3 shows that sites identified as constraining factors for aluminum concentrations are those sites where the distribution of aluminum data occurs close to the benchmark. Subsequent discussion of each parameter follows individually in Section B.3.2.1 through Section B.3.2.3.

Table B.6 Lake Power Analysis – Constraining Sites and Parameters

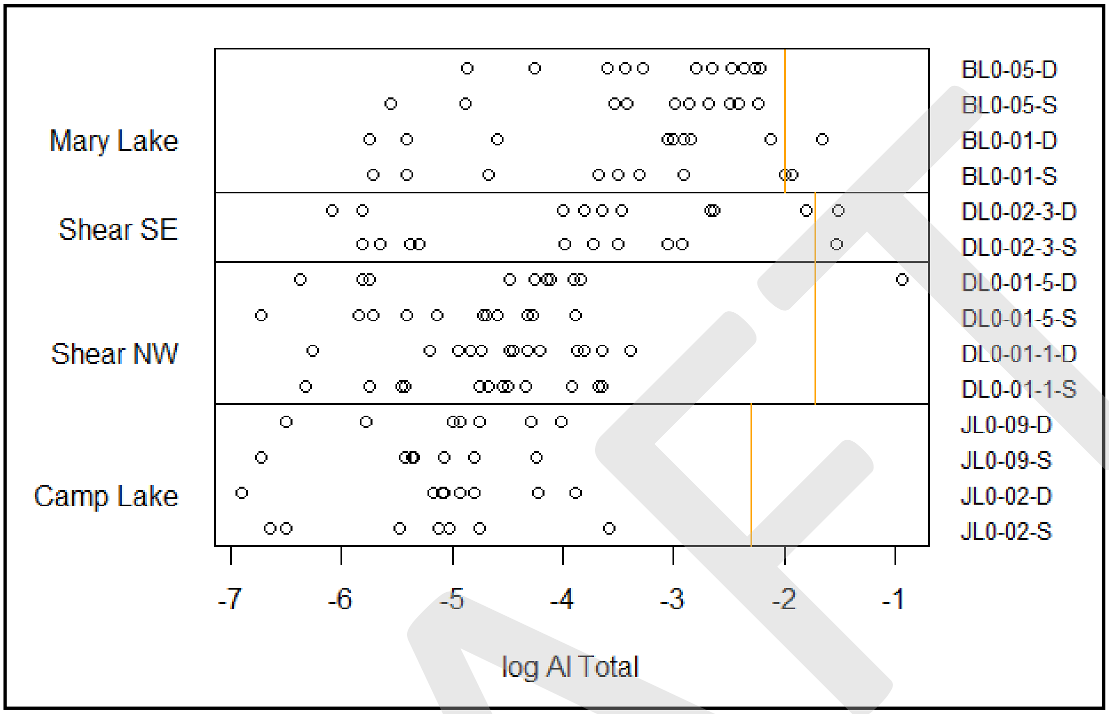
Parameter	Site	Waterbody	Power (given sample size of 10, alpha of 0.1)	Power (given sample size of 50)
Aluminum	DL0-02-3-S	Sheardown Lake SE	50%	78%
	BL0-01-S	Mary Lake	38%	58%
	BL0-05-S	Mary Lake	30%	58%
Copper	BL0-01-S	Mary Lake	30%	38%
Iron	BL0-01-S	Mary Lake	50%	75%

NOTES:

1. POWER IS CALCULATED BASED ON AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION BASELINE MEAN AND BENCHMARK.

B.3.2.1 Aluminum

Total aluminum values are elevated throughout the mine-site area and are noticeably elevated at sites within Sheardown Lake SE and Mary Lake (median aluminum ranges from 0.024 mg/L to 0.061 mg/L between individual sites) when compared to values in Camp Lake and Sheardown Lake NW (median aluminum ranges from 0.0059 mg/L to 0.0093 mg/L between individual sites). Sufficient power is expected to be obtained for sites examined within Camp Lake (JL0-1-S/D, JL0-2-S/D, JL0-09-S/D) and Sheardown Lake (DL0-01-1-S/D and DL0-01-5-S/D) with 5 samples. In contrast, approximately fifty (50) samples are expected to be required within Sheardown Lake SE and Mary Lake. Figure B.72 demonstrates that sites within Sheardown Lake and Mary Lake have a distribution of aluminum values very close to the benchmark. In contrast, Camp Lake and Sheardown Lake SW have a distribution of aluminum values further from the benchmark. Values in Table B.7 show that a higher standard deviation also characterizes data from Sheardown Lake SE and Mary Lake.



NOTES:

1. THE CAMP LAKE BENCHMARK FOR ALUMINUM IS 0.1 mg/L (LOG VALUE = -2.3).
2. THE SHEARDOWN LAKE BENCHMARK FOR ALUMINUM IS 0.179 mg/L (LOG VALUE = -1.72).
3. THE MARY LAKE BENCHMARK FOR ALUMINUM IS 0.137 mg/L (LOG VALUE = -1.99).

Figure B.72 Baseline Aluminum Values with Respect to the Benchmark

Table B.7 Results of Aluminum Power Analysis - Lakes

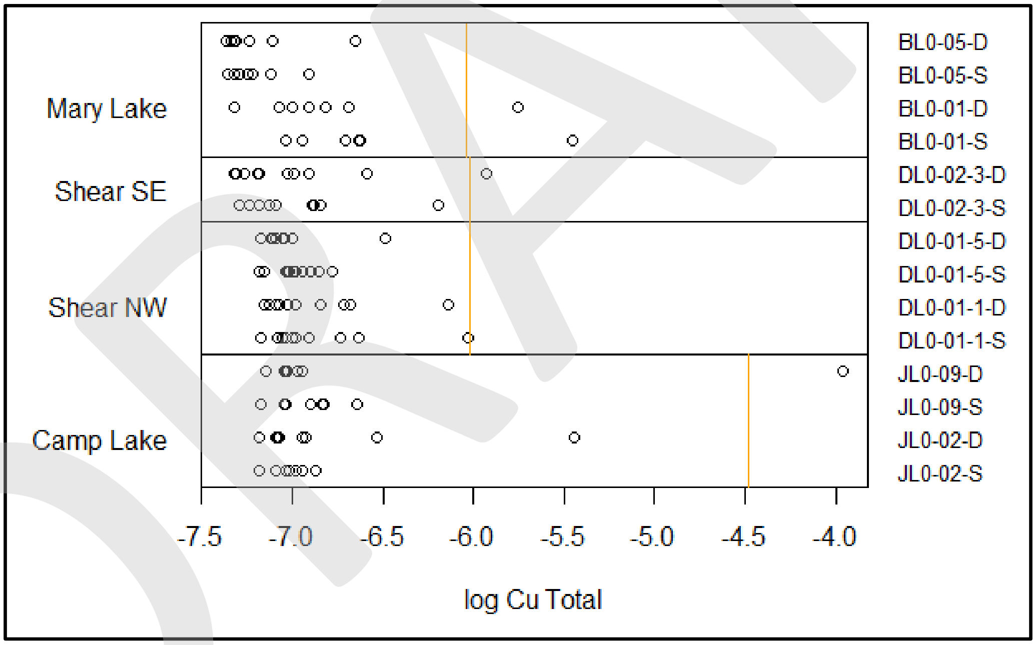
Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Benchmark Value (mg/L)	N Required	N Required (half benchmark)[1]
Camp Lake											
JL0-02-S	8	8	0.0063	0.01	-5.23	1.00	-5.23	0.1	-2.30	2.93	5
JL0-02-D	9	8	0.0068	0.01	-4.79	0.48	-4.91	0.1	-2.30	2.49	5
JL0-09-S	7	7	0.0048	0.00	-5.28	0.76	-5.28	0.1	-2.30	2.98	5
JL0-09-D	7	7	0.0072	0.01	-5.04	0.86	-5.04	0.1	-2.30	2.73	5
Sheardown Lake NW											
DL0-01-1-S	13	13	0.0093	0.01	-4.80	0.82	-4.8	0.18	-1.72	3.08	5
DL0-01-1-D	13	13	0.012	0.01	-4.47	0.76	-4.47	0.18	-1.72	2.75	5[2]
DL0-01-5-S	11	11	0.0089	0.01	-5.03	0.83	-5.03	0.18	-1.72	3.31	5
DL0-01-5-D	11	10	0.015	0.12	-4.20	1.42	-4.22	0.18	-1.72	2.48	5[2]
Sheardown Lake SE											
DL0-02-3-S	10	9	0.024	0.07	-3.89	1.36	-4.23	0.18	-1.72	2.17	50
DL0-02-3-D	10	9	0.031	0.07	-3.29	1.36	-3.40	0.18	-1.72	1.57	50[2]
Mary Lake											
BL0-01-S	9	9	0.030	0.05	-3.68	1.36	-3.68	0.14	-1.99	1.69	50
BL0-01-D	10	10	0.048	0.06	-3.71	1.53	-3.71	0.14	-1.99	1.72	50[2]
BL0-05-S	11	11	0.057	0.04	-3.21	1.09	-3.21	0.14	-1.99	1.22	50
BL0-05-D	11	11	0.061	0.04	-3.11	0.87	-3.11	0.14	-1.99	1.12	50[2]

NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR SITES.

B.3.2.2 Copper

Total copper values are observed to be elevated site-wide and are particularly elevated within Mary River and Camp Lake tributary. Although total copper concentrations are reduced in lake sites compared to stream sites, certain sites remain elevated. The copper benchmark in Sheardown Lake and Mary is the same (0.0024 mg/L) and the Camp Lake benchmark is slightly higher (0.011 mg/L). Based on the existing baseline data, five baseline samples are expected to provide sufficient power to detect changes between baseline mean and halfway between baseline mean and the benchmark value (comparisons on log scale) at all sites within Camp Lake, at DL0-01-5-/S/D (Sheardown Lake NW) and DL0-02-3-S/D (Sheardown Lake SE) and BL0-05-S/D (Mary Lake). Ten post-mining samples are expected to be sufficient at DL0-01-1-S/D. As show on Figure B.73, the BL0-01-S/D site has a distribution of data which falls on either side of the benchmark. Due to the elevated median values and high variability, with the current baseline data it is estimated 50 samples would be required to show significance for the sites examined in Mary Lake; however, even with collection of 50 samples the power to detect change would only be 38%. With collection of additional baseline data in 2014, the power to detect change for copper is expected to increase.



NOTES:

1. THE CAMP LAKE BENCHMARK FOR COPPER IS 0.011 mg/L (LOG VALUE = -4.5).
2. THE SHEARDOWN LAKE BENCHMARK FOR COPPER IS 0.0024 mg/L (LOG VALUE = -6.0).
3. THE MARY LAKE BENCHMARK FOR COPPER IS 0.0024 mg/L (LOG VALUE = -6.0).

Figure B.73 Baseline Copper Values with respect to the Benchmark

Table B.8 Results of Copper Power Analysis - Lakes

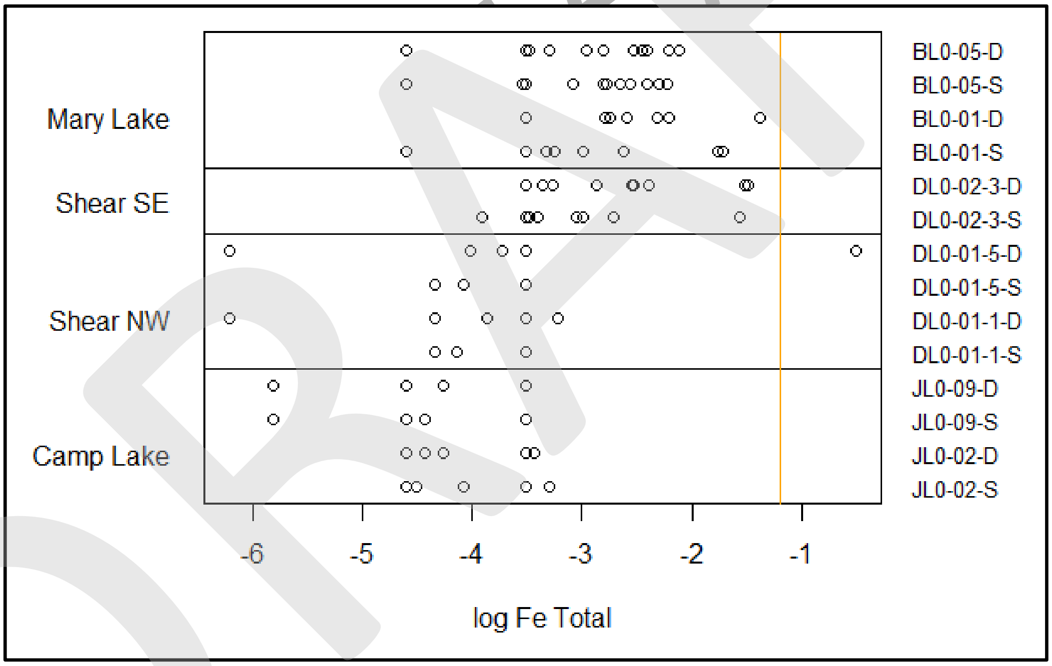
Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	Benchmark Value (mg/L)	Log <Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
JL0-01-S	12	10	0	0.00076	-6.8	0.44	0.011	-4.5	2.3	5[2]
JL0-01-D	10	8	0	0.0043	-6.6	0.94	0.011	-4.5	2.1	5[2]
JL0-02-S	8	8	0	0.00008	-7.0	0.09	0.011	-4.5	2.5	5
JL0-02-D	9	9	0	0.0011	-6.8	0.55	0.011	-4.5	2.3	5[2]
JL0-09-S	7	7	0	0.00018	-6.9	0.18	0.011	-4.5	2.4	5
JL0-09-D	7	7	0	0.0068	-6.6	1.2	0.011	-4.5	2.1	5[2]
DL0-01-1-S	11	11	0	0.00046	-6.9	0.32	0.0024	-6.0	0.85	10
DL0-01-1-D	11	11	0	0.00040	-6.9	0.30	0.0024	-6.0	0.88	10[2]
DL0-01-5-S	11	11	0	0.00011	-7.0	0.12	0.0024	-6.0	0.97	5
DL0-01-5-D	11	11	0	0.00021	-7.0	0.18	0.0024	-6.0	0.99	5[2]
DL0-02-3-S	10	10	0	0.00040	-7.0	0.32	0.0024	-6.0	0.97	5
DL0-02-3-D	10	10	0	0.00061	-7.0	0.43	0.0024	-6.0	0.95	5[2]
BL0-01-S	7	7	0	0.0012	-6.6	0.53	0.0024	-6.0	0.55	50[6]
BL0-01-D	10	10	0	0.00071	-6.8	0.41	0.0024	-6.0	0.77	NA
BL0-05-S	9	9	0	0.00011	-7.2	0.13	0.0024	-6.0	1.2	5
BL0-05-D	9	9	0	0.00021	-7.2	0.23	0.0024	-6.0	1.2	5

NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR SITES.
3. NA SITES WERE NOT ASSESSED.
4. TOTAL SAMPLE SIZE REPRESENTS THE NUMBER OF MEASURED SAMPLES AT EACH SITE (EXCLUDING NON-DETECTS).
5. THERE ARE NO NON-DETECT VALUES AT THIS SITE; THEREFORE, THE ROS LOG MEAN IS THE SAME AS THE LOG MEAN CALCULATED AND IS NOT PRESENTED.
6. SAMPLE SIZE REQUIRED FOR BL0-01-S IS AFFECTED BY OUTLIER VISIBLE IN FIGURE B.73.

B.3.2.3 Iron

Total iron concentrations are slightly elevated site-wide, but greater iron concentrations were observed in streams than rivers. There is a significant deficit of detection iron data at Camp Lake and Sheardown Lake NW. Due to the low numbers of detected samples, sample size cannot be estimated for Camp Lake and Sheardown Lake NW. Baseline sampling during 2014 is recommended to increase the sample size at these sites, or, alternately, an approach that considers non-detects is required. Approximately ten post-mining samples are expected to be sufficient to determine significant differences between baseline impact and post-mining impact sites within Sheardown Lake SE. The recommended sample size for Mary Lake is problematic, particularly for the BL0-01-S site. This site has among the highest mean and median iron values, in addition to elevated variability and relatively small sample size. Even with collection of fifty samples at BL0-01-S, power at this station does not exceed 75%. Similar to other parameters, additional baseline data from 2014 is expected to increase power for iron at this site.



NOTES:

1. THE BENCHMARK FOR IRON IN ALL LAKES IS 0.3 mg/L (LOG VALUE = -1.2).

Figure B.74 Baseline Iron Values with Respect to the Benchmark

Table B.9 Results of Iron Power Analysis - Lakes

Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
Camp Lake											
JL0-02-S	8	3	0.017	0.014	-4.0	0.61	-4.5	0.3	-1.2	2.8	-
JL0-02-D	9	3	0.014	0.011	-4.0	0.53	-4.6	0.3	-1.2	2.8	-
JL0-09-S	7	1	0.012	NA	-4.4	NA	-4.4	0.3	-1.2	3.2	-
JL0-09-D	7	1	0.014	NA	-4.3	NA	-4.2	0.3	-1.2	3.1	-
Sheardown Lake NW											
DL0-01-1-S	13	5	0.030	0.009	-3.8	0.41	NA	0.3	-1.2	2.6	-
DL0-01-1-D	13	4	0.017	0.016	-4.4	1.3	-4.4	0.3	-1.2	3.2	-
DL0-01-5-S	11	4	0.024	0.009	-3.9	0.42	NA	0.3	-1.2	2.7	-
DL0-01-5-D	11	6	0.027	0.236	-3.6	1.8	NA	0.3	-1.2	2.4	-
Sheardown Lake SE											
DL0-02-3-S	10	7	0.047	0.066	-3.0	0.75	NA	0.3	-1.2	1.8	10
DL0-02-3-D	10	8	0.079	0.076	-2.5	0.70	-2.8	0.3	-1.2	1.3	10[2]
Mary Lake											
BL0-01-S	9	7	0.050	0.068	-2.9	1.00	NA	0.3	-1.2	1.7	50
BL0-01-D	10	8	0.070	0.071	-2.6	0.70	-3.0	0.3	-1.2	1.4	-
BL0-05-S	11	9	0.070	0.025	-2.7	0.41	-2.9	0.3	-1.2	1.5	5
BL0-05-D	11	11	0.060	0.036	-2.9	0.74	-2.9	0.3	-1.2	1.7	5[2]

NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR SITES.
3. IF INSUFFICIENT SAMPLE SIZE IS AVAILABLE, NO VALUE FOR N WAS PROVIDED.

B.3.2.4 Cadmium, Arsenic and Iron Proportions

The proportion of data below MDL was determined for each of the target parameters at selected stations. Cadmium, Arsenic and iron were identified as requiring analysis of proportions (Figure B.10). A normal approximation has been used to estimate the width of the confidence interval on the proportion of values below (above) MDL for given sample sizes (Table B.10). For analysis purposes, when the proportion of non-detects is close to 100%, an exact test will be used.

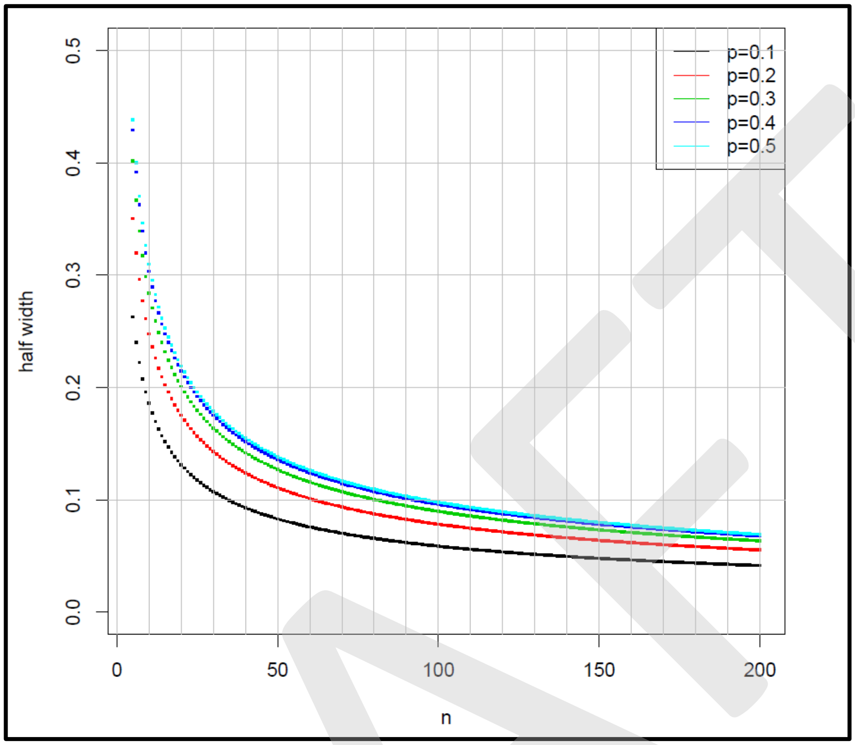
In order to assess statistical power to detect a change in the proportion of values below (or above) MDL from baseline to post-mining, we present a table of the sample sizes required. We see that a sample size of 12 is sufficient to show a change from 30% to 80%; a sample size of 8 is sufficient to show a difference between 20% and 80%.

Table B.10 Sample Size Required to Obtain 80% Power

	Proportion Above (below) MDL Post Mining				
Baseline Proportion Above (below) MDL	0.4	0.5	0.6	0.7	0.8
0.2	64	31	18	12	8
0.3	281	74	33	19	12
0.4	NA	305	77	33	18

NOTE:

1. Sample size required for baseline and post-mining to obtain 80% power with a two-sided type I error of 0.05 (or one-sided type I error of 0.05.



NOTES:

2. FOR THIS GRAPH, P = PROPORTION OF VALUES BELOW MDL/NON-DETECT.
3. THE CONFIDENCE INTERVAL WIDTHS ARE SYMMETRIC AROUND P=0.5. THERFORE P=0.1 AND 0.9; P=0.2 AND 0.8; P=0.3 AND 0.7; P=0.4 AND 0.6.

Figure B.75 Half 95% Confidence Interval Width

B.3.3 Recommendations

Power analysis completed for a subset of parameters at select areas is expected to be used to detect change at critical locations for most parameters. Parameters used here are indicator parameters, which are expected to have small effects sizes and represent the most number of samples required to be collected. There are two major factors that evidently constrain the power analysis for the lake samples. First, elevated aluminum concentrations create difficulties obtaining sufficient power, especially within Mary Lake and one site in Sheardown Lake SE. Second, the BL0-01-S site has high concentrations of aluminum, copper and iron, in addition to high variability. This site is predicted to have very low power, even with sample sizes as great as fifty.

As a result of these analyses, the following are recommended to augment the study design:

1. Increase the amount of baseline data (this will occur during the 2014 season of baseline data collection that will occur concurrently with mine construction but prior to mine effluent or dust emission);
2. Collect data at one more station within Sheardown Lake SE (recommend DL0-02-6)
3. Add two sites at the inlet location of Mary Lake near BL0-01 to ensure sufficient power to detect changes at this key location.

4. Add one additional site to the inlet location of Mary Lake near BL0-05 to ensure sufficient power to detect changes at this key location.
5. Add two to three lake reference sites for post-mining data collected. Ideally these sites should be consistent with the EEM reference sites.
6. Ensure that samples collected at all locations are collected as close to the same day and time as possible.
7. Three yearly samples are recommended to be collected during the first three-years of mine operation.

B.4 CONCLUSIONS

The only distinct depth trends are noted in Sheardown Lake for aluminum. The rest of the lake data gathered a lake stations suggests aggregations of deep and shallow stations is appropriate.

Table B.11 summarizes the trends observed in the data.

B.5 REFERENCES

Agresti, A, 1990. *Categorical Data Analysis*. Wiley Series, New York.

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Intrinsik Environmental Sciences Inc., 2014. *Development of Water and Sediment Quality Benchmarks for Application in Aquatic Effects Monitoring at the Mary River Project.* Intrinsik Project No. 30-30300.

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Table B.11 Summary of Trend Analysis in Area Lakes

Trend	Camp Lake	Mary Lake	Sheardown Lake NW	Sheardown Lake SE
Distinct depth trends	Not observed, suggest lake completely mixed; utilization of both depth and shallow sites to calculate benchmarks deemed appropriate	Not observed, suggest lake completely mixed; utilization of both depth and shallow sites to calculate benchmarks deemed appropriate	Al slightly elevated in deeper samples, suggest lake completely mixed; aggregation of depth and shallow sites appropriate for all parameters except Al	Not observed, suggest lake completely mixed; utilization of both depth and shallow sites to calculate benchmarks deemed appropriate
Geographic trends between discrete sampling sites	Not observed	Slightly elevated concentrations of Al, Cl, Cu, Cr, Fe, hardness and Ni observed at inlet; elevated As concentrations observed at outlet	Little variability	Cu, Fe and Ni (slightly elevated concentrations at DL0-02-4)
Distinct inter annual trends	Chloride and Cr (2011 to 2013 concentrations elevated compared early data)	Fe (2013 data slightly lower concentration than previous years) , Cd (detection limits decreased over course of sampling), Ni (elevated during 2007 winter)	Cd and Fe (decrease in detection limits over years)	Cu and Ni (early data from 2007-2008 elevated compared to more recent data)
Parameters below MDLs and / or do not show seasonal trends	Cl, Cd, As, Fe, nitrate	Cd, Cu, Cr, nitrate	As, Cd, Cl, Cr, Cu, nitrate, Fe	As, Cd, nitrate, Cr and Cu.
Parameters with maximum concentrations during summer	Al, nitrate	Al, Fe		Al (and fall), Fe
Parameters with maximum concentrations during fall	Cr	As	Al	
Parameters with maximum concentrations during winter	Cu (and summer), Ni (and summer)	Cl, Ni, Cd	Ni	Cl, Ni

ATTACHMENT C

DETAILED REVIEW OF BASELINE STREAM WATER QUALITY

(Pages C-1 to C-70)

ATTACHMENT C

DETAILED REVIEW OF BASELINE STREAM WATER QUALITY

(Pages C-1 to C-70)

ISO 9001 - FS 64925
ISO 14001 - EMS 550121
OHSAS 18001 - OHS 550122

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DETAILED REVIEW OF BASELINE STREAM WATER QUALITY
NB102-181/33-1C

Rev	Description	Date
1	Issued in Final	May 30, 2014

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CONSULTING

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C – STREAM WATER QUALITY REVIEW

C.1 OVERVIEW

A detailed review of water quality within the mine site streams was undertaken to facilitate the development of the Core Receiving Environment Monitoring Program (CREMP) for water and sediment quality. The review adopted the same approach applied to the detailed review of lake water quality presented in Appendix B. As stated in Section 1.2 of the main report, the objectives of the baseline review were as follows:

- Identify data quality issues
- Determine whether or not mineral exploration and bulk sampling activities conducted since 2004 have affected water quality in the mine site area
- Understand the seasonal and inter-annual variability of water quality
- Understand natural enrichment of the mine site area waters
- Determine the potential to pool data from multiple sample stations to increase the statistical power of the baseline water quality dataset
- Develop study designs for monitoring water quality in mine site streams and lakes
- Determine if changes to the existing water quality monitoring program are required to meet monitoring objectives

The focus of this review of stream water quality is the two main receiving waters of mine effluent, which are also close to the Project mining area that will be exposed to ore dust deposition: Camp Lake Tributary 1 (CLT-1) and the Mary River.

Parameters of interest in the baseline review included water quality stressors of potential concern (SOPCs) identified on the basis of the existence of an established water quality guideline, as well as other factors such as Exposure Toxicity Modifying Factors (ETMF): pH, water hardness, dissolved organic carbon, etc., and indicator parameters (alkalinity, chloride, nitrate). Baseline water quality data was compared to Canadian Council of Ministers of the Environment (CCME) – Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CWQG-PAL). The focus was on total concentrations (versus dissolved) since CWQG-PAL guidelines are developed for total concentrations. The parameters of interest are displayed graphically in box plots. The box plots are used to portray natural ranges of selected parameters. Concentration data measured for the parameters of interest has been log transformed and further analyzed to investigate the possibility of aggregating data, bearing in mind:

- Seasonal variability (between spring, summer and fall samples)
- Inter-annual variability (from 2006 through 2008 and 2011 through 2013)

To assist in the development of study designs, parameter and station-specific a priori power analyses were completed in order to determine the power of the proposed sampling program to detect statistical changes. As per the Assessment Approach and Response Framework in the CREMP (see Figure 2.12 in the main report), management action is triggered if the mean concentrations of any parameter at selected stations reach benchmark values. Benchmark values were developed for the identified SOPCs that consider aquatic toxicology, natural enrichment in the Project area, or low concentrations below MDLs (Intrinsik, 2014; see Section 2.7.3 of the main report). Draft benchmarks were applied in the power analysis of the baseline presented in this detailed review.

The resultant study design for the monitoring of Project-related effects to water quality is presented in Section 2.7 of the main report.

C.2 STREAM FLOW CHARACTERISTICS

Stream water quality sampling was completed within the drainages, streams and rivers in vicinity to the mine station from 2005 through 2008 and 2011 through 2013. The most comprehensive sampling was conducted in 2007.

The streams and rivers in the study area typically flow in early June and stop flowing in the second half of September. The hydrograph developed from the H6 stream gauge on the Mary River is presented as Figure C.1. Smaller creeks typically run dry and/or freeze earlier than the Mary River. Only the largest rivers in the area such as the Ravn River or the Rowley River flow during the winter.

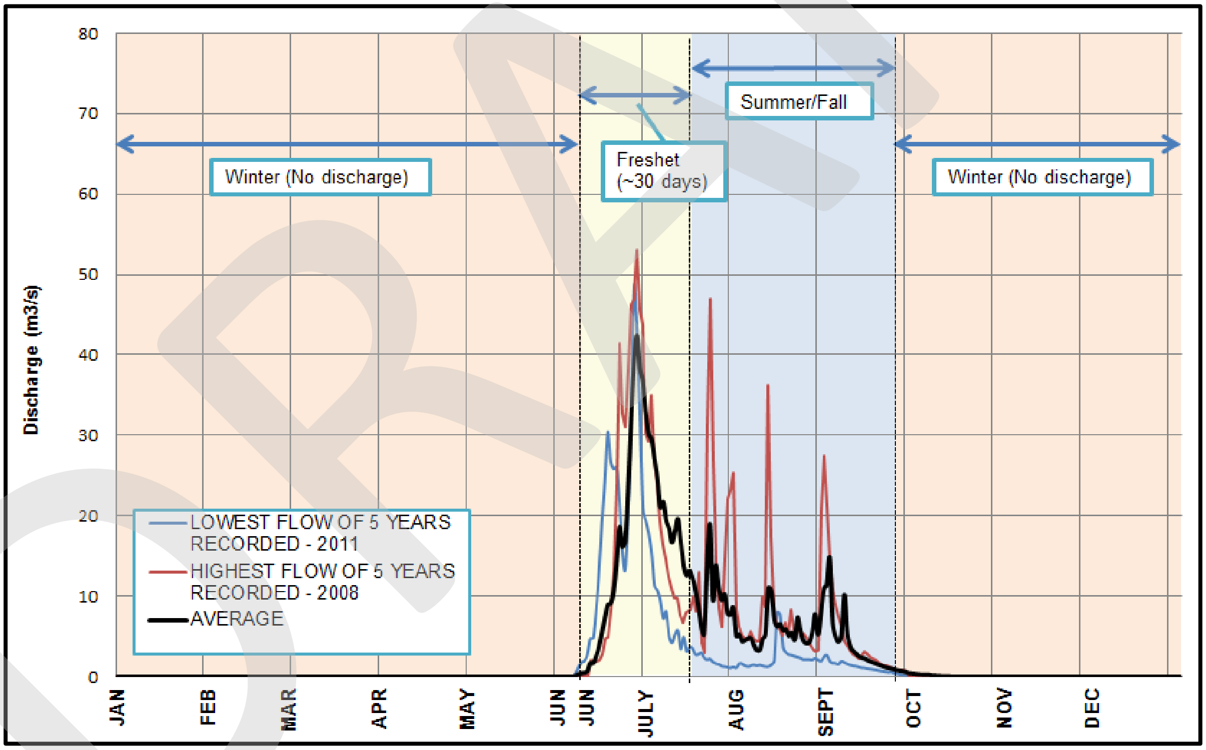


Figure C.1 Hydrograph of Stream Gauge H6 on the Mary River (2008-2011)

Understanding the flow regime at the station is an important backdrop to understanding the seasonal differences.

A review of the baseline data for each of the streams in vicinity to the mine site is provided below.

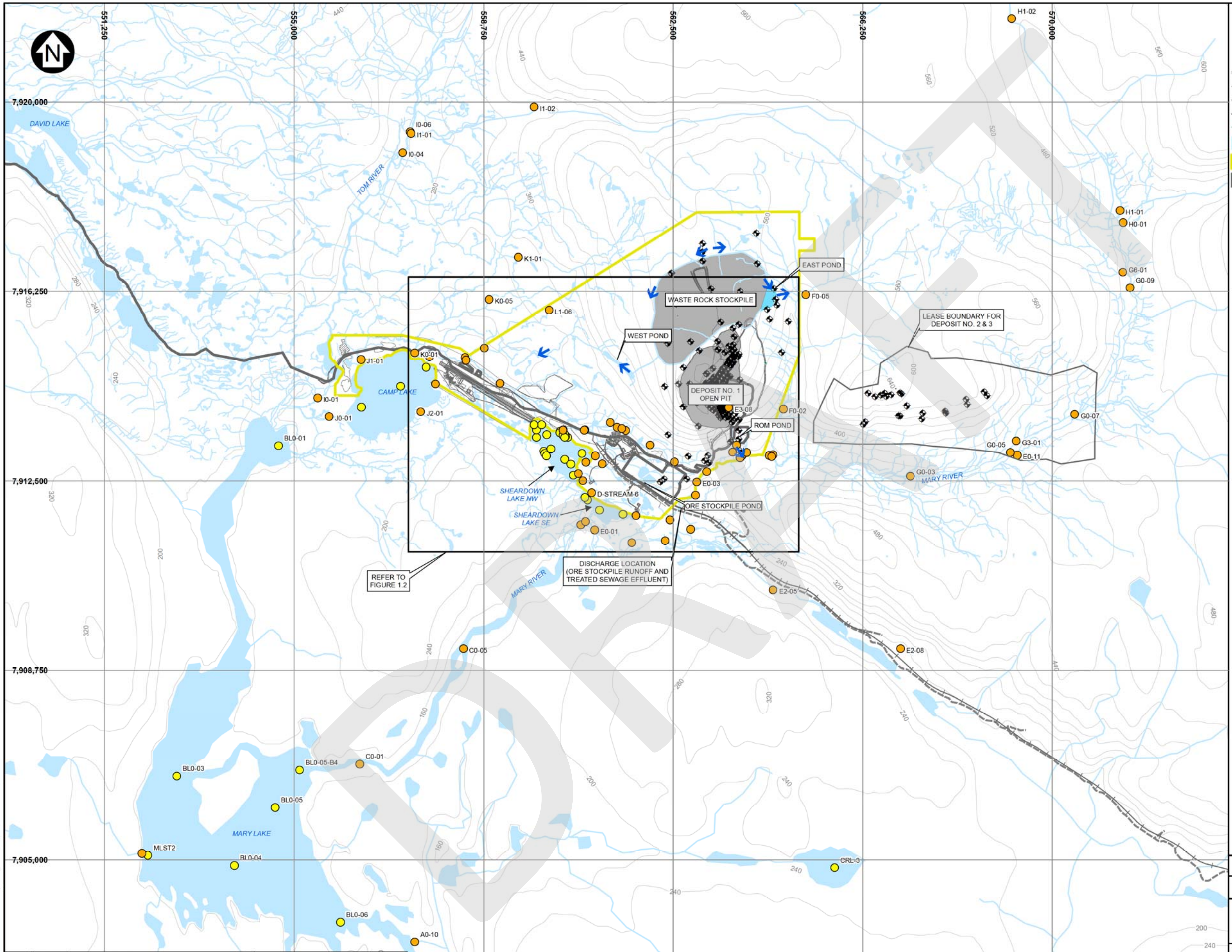
C.3 BASELINE SUMMARY

C.3.1 Mary River

Water quality samples within Mary River have been collected from 2005 through 2013, at a number of stations along the Mary River. The following 11 stations were selected as applicable for future CREMP monitoring and are discussed in detail below. A total of 351 samples from these 11 stations on Mary River were collected. Most sampling was completed during the summer season, from July through August. The greatest number of samples was collected during 2007 and 2008. Starting upstream of the mine station working downstream to Mary Lake, the sample stations are described below (Figures C.2 and C.3):

- G0-09: This is the most upstream station on the mainstem of the Mary River. This station will remain an upstream control station that will remain unaffected by mine-affected seepage or mine-affected dust particulate.
- G0-03: This station is on Mary River mainstem, downstream from G0-09, but upstream of any mine-related effluent effects.
- G0-01: This station is located on Mary River mainstem, immediately upstream of the confluence with the F-Tributary to which the east waste rock stormwater pond will discharge.
- E0-10: This station is located on the Mary River mainstem, immediately downstream of the F-tributary confluence. During operation of the proposed mine, seepage effects from the East Pond could potentially affect water quality at this station.
- E0-03: This station is located on the Mary River mainstem, downstream of the proposed ROM Pond discharge.
- E0-04: This station is located on the Mary River mainstem, downstream of the proposed ROM Pond discharge and immediately downstream of E0-03.
- E0-21: This station is located on the Mary River mainstem and is located downstream of all potential mine effects and is being considered as a “near-field” exposure station for the EEM program.
- E0-20: This station is located on the Mary River mainstem and is located downstream of all potential mine effects. The station is also located immediately downstream of station E0-21.
- C0-10: This station is located on the Mary River mainstem and is located downstream of all potential mine effects.
- C0-05: This station is located on the Mary River mainstem and is located downstream of all potential mine effects and is being considered as a “far-field” exposure station for the EEM program.
- C0-01: This station is located on the Mary River mainstem near the mouth, downstream of all potential mine effects. The station is being considered as an alternate “far-field” exposure station for the EEM program.

To simplify discussion and determine whether data aggregation would be appropriate, the stations above have been discussed in regard to seasonal and inter-annual variability, due to very similar water quality characteristics:



LEGEND:

- ● LAKE SAMPLE LOCATION
- ● STREAM SAMPLE LOCATION
- DRILLHOLE LOCATION
- EXISTING TOTE ROAD
- PROPOSED RAILWAY ALIGNMENT
- PROPOSED CONSTRUCTION ACCESS ROAD
- PROPOSED SITE INFRASTRUCTURE
- RIVER/STREAM/DRAINAGE
- ▇ WATER
- ▢ POTENTIAL DEVELOPMENT AREA (PDA)
- ▇ PROPOSED MINE INFRASTRUCTURE

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 1 0.5 0 1 2 3 4 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

HISTORIC WATER QUALITY STATIONS
MINE SITE AREA

Knight Piésold
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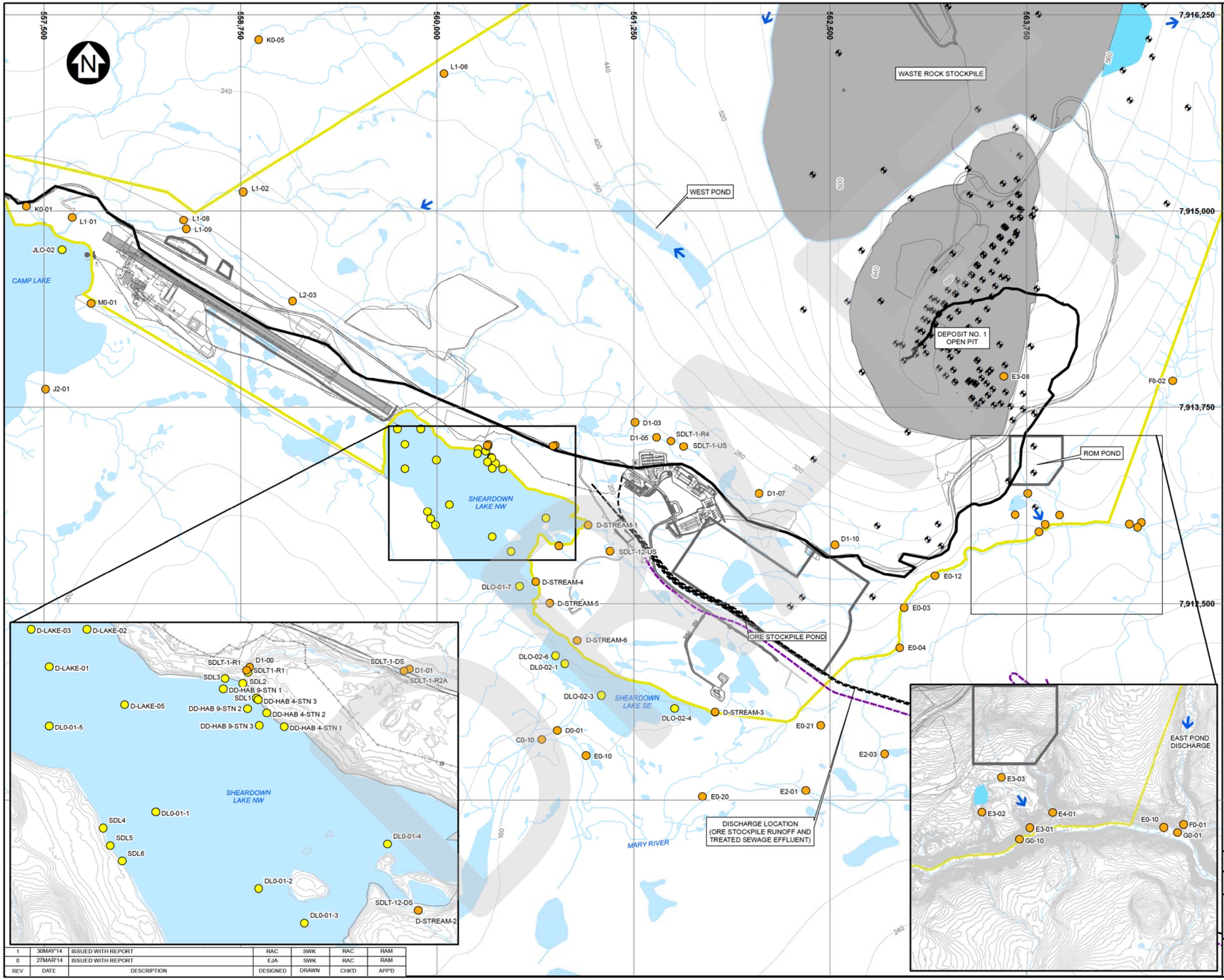
P/A NO.	REF NO.
NB102-181/33	1

FIGURE C.2 REV 1

1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D

SAVED: I:\1102\00181\33\A\GIS\Figs\B42_r1.mxd; May 30, 2014 1:15 PM; skozmick



1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	EJA	SWK	RAC	RAM
REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D

SAVED: I:\1\02\00181\33\A\GIS\Figs\B43_r1.mxd; May 30, 2014 1:21 PM; skozmick

LEGEND:

🟡	LAKE SAMPLE LOCATION
🟠	STREAM SAMPLE LOCATION
⊕	DRILLHOLE LOCATION
▬	EXISTING TOTE ROAD
┼	PROPOSED RAILWAY ALIGNMENT
- - -	PROPOSED CONSTRUCTION ACCESS ROAD
—	PROPOSED SITE INFRASTRUCTURE
—	RIVER/STREAM/DRAINAGE
🟦	WATER
🟨	POTENTIAL DEVELOPMENT AREA (PDA)
⬛	PROPOSED MINE INFRASTRUCTURE

NOTES:

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2. COORDINATE GRID IS IN METRES.
   COORDINATE SYSTEM: NAD 1983 UTM ZONE 17N.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL VARIES.
4. LAKE SAMPLE LOCATIONS VARY SLIGHTLY DURING WINTER MONTHS DUE TO ICE CONDITIONS.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 250 125 0 250 500 750 1,000 1,250 m

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

HISTORIC WATER QUALITY STATIONS
IMMEDIATE MINE SITE AREA

Knight Piésold
CONSULTING

P/A NO.	REF NO.
NB102-181/33	1

FIGURE C.3	REV 1

- G0-09, G0-03, E0-10 and G0-01: These stations represent upstream control stations that are expected to remain relatively unaffected by mine development (except perhaps by dust deposition). All stations, except E0-10 will also act as control stations once the proposed mine commences operation.
- E0-03, E0-21, E0-20: These stations have similar water quality and represent near-field exposure stations during operation of the proposed mine.
- C0-10, C0-05, C0-01: These stations have similar water quality and represent far-field exposure stations during operation of the proposed mine.

A summary of the data collected during each season, with respect to year and station are included in Table C.1. A graphical representation of the sampling events is provided in Figure C.4.

Table C.1 Mary River Sample Size

Year	Summer	Fall	Winter
2005	5	5	5
2006	16	31	17
2007	12	39	32
2008	6	50	33
2009	5	14	10
2010	0	4	4
2011	0	5	7
2012	8	9	8
2013	8	9	9
Station	**Summer**	**Fall**	**Winter**
G0-09	8	26	18
G0-03	7	16	13
G0-01	6	23	16
E0-10	7	26	15
Station	**Summer**	**Fall**	**Winter**
E0-03	10	28	21
E0-04	0	1	1
E0-21	2	2	3
E0-20	2	2	3
C0-10	10	27	21
C0-05	2	3	4
C0-01	6	12	10

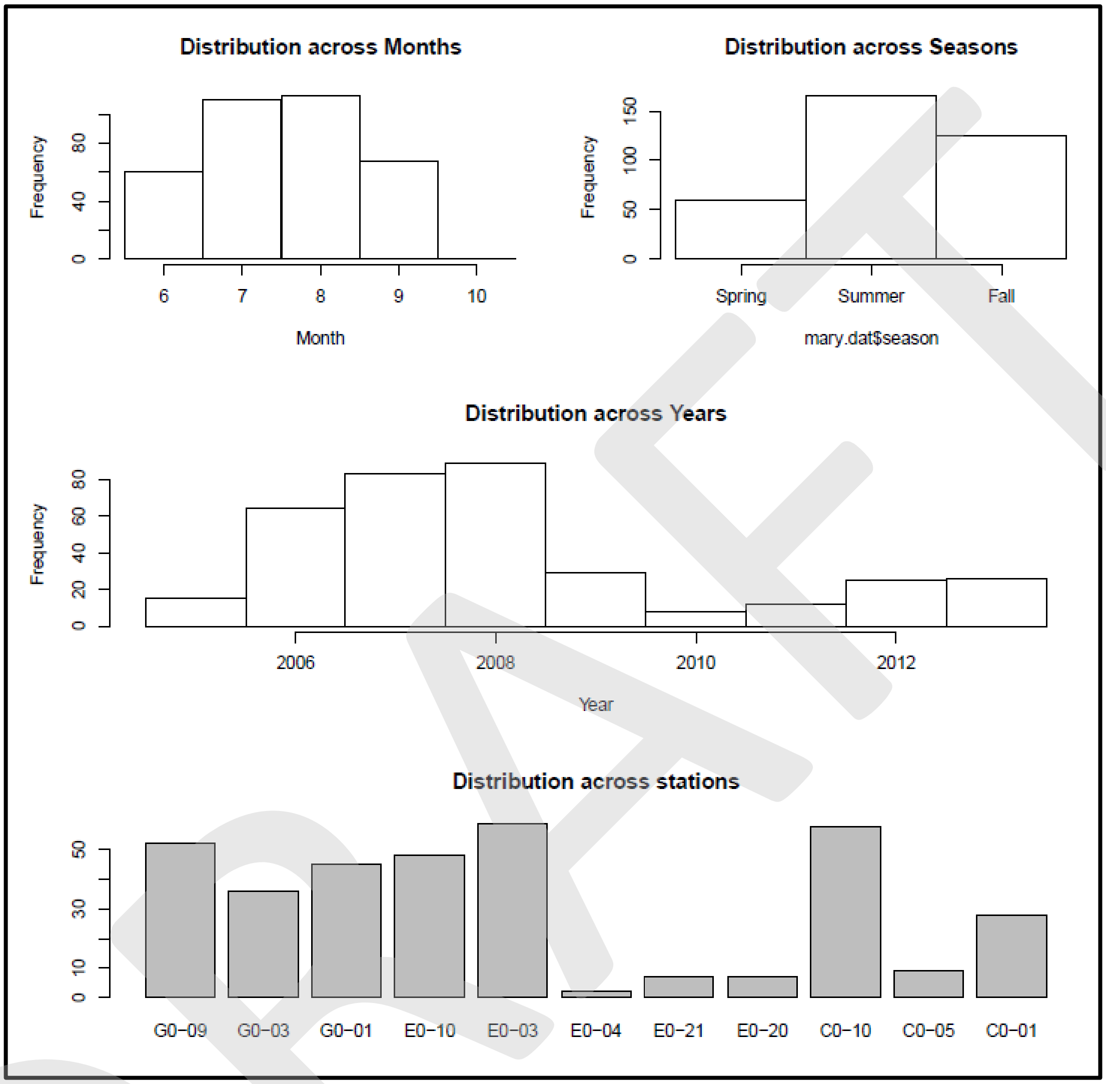


Figure C.4 **Mary River – Graphical Summary of Sampling Events**

The following summarizes the data review observations for the of the physical parameter data. Box plots that follow present upstream on the far left, moving downstream towards the right.

pH (Figure C.5)

- Mary River is slightly alkaline, with total median pH of 7.87 (range from 6.26 to 8.5).
- No distinct geographic trends were noted.

Alkalinity (Figure C.6)

- Mary River stations have uniformly high median alkalinity values that range from 40 to 50 mg/L $CaCO_3$, with maximum alkalinity values reaching close to 120 mg/L $CaCO_3$, classifying the lake water as having low sensitivity to acidic inputs.
- No distinct geographic trends were noted.

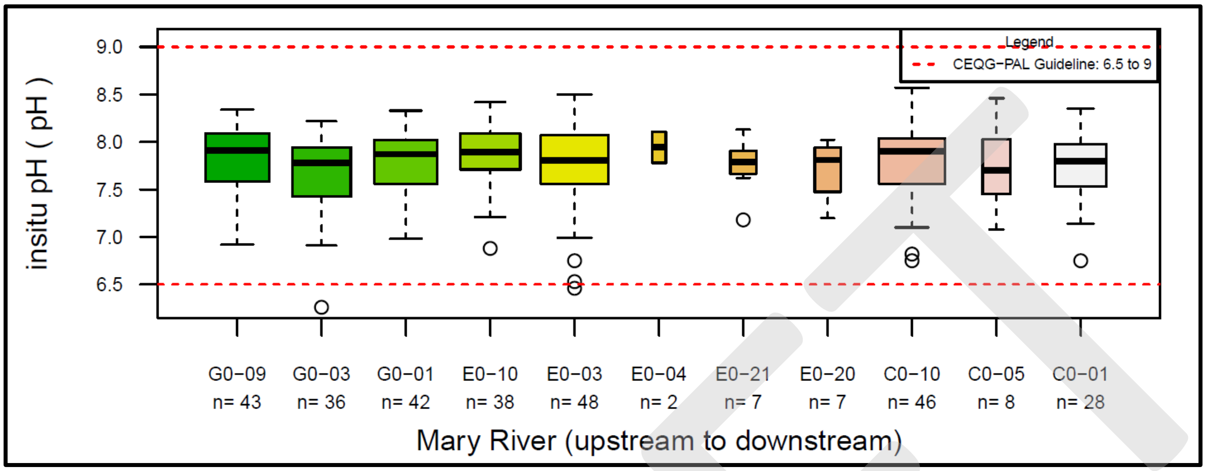


Figure C.5 **Mary River – In Situ pH**

Hardness (Figure C.6)

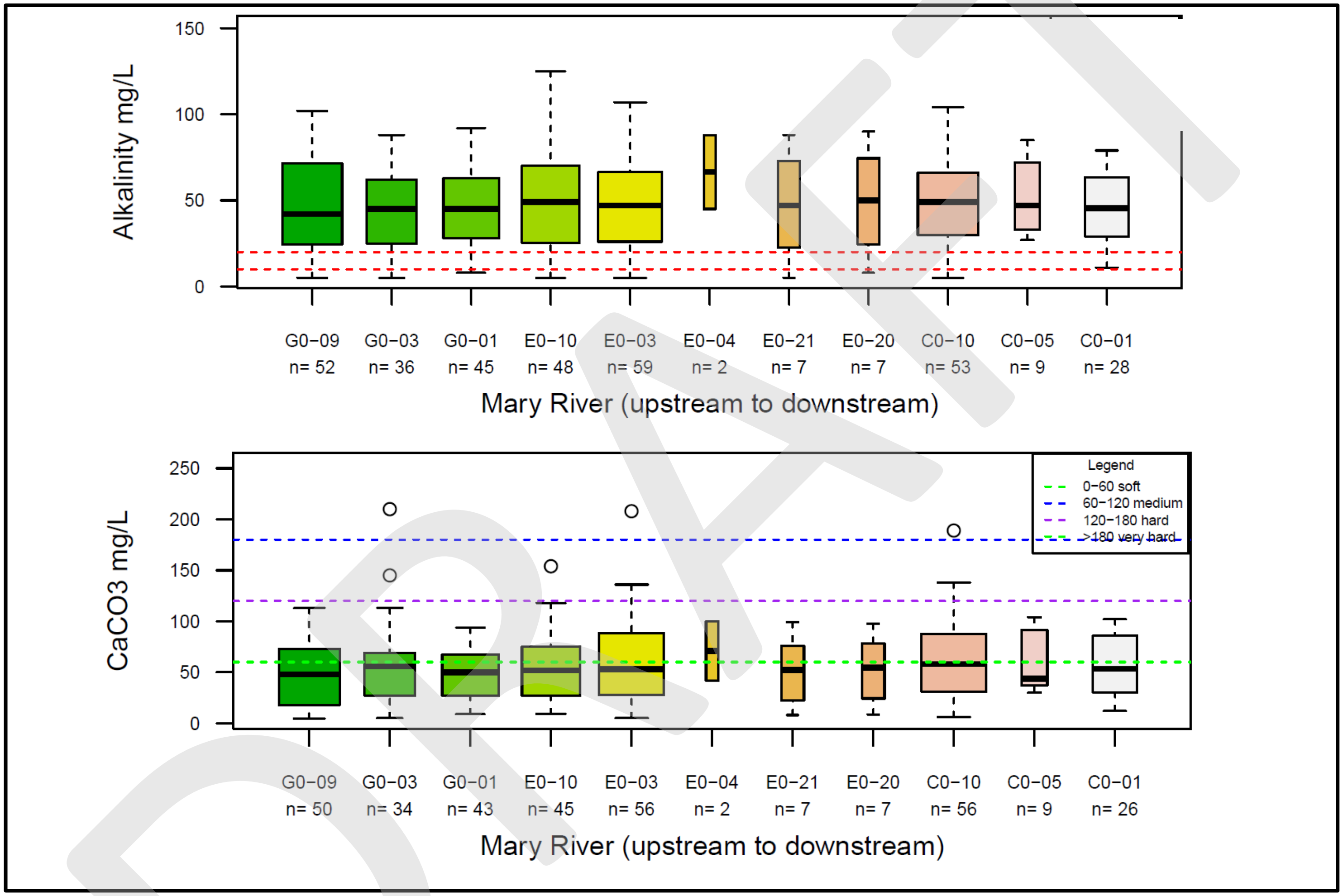
- Median hardness values at the stations in Mary River between 50 mg/L to 60 mg/L, classifying the river water as “soft”. Only one station (E0-04) had median hardness values greater than 60 mg/L.
- Hardness portrayed trends very similar to alkalinity, although elevated values at E0-21 and E0-20 were reduced when compared with the alkalinity values.
- The close range between hardness and alkalinity suggest that the hardness is almost entirely carbonate hardness with little to no non-carbonate contributions to hardness.

The following sections summarize the results for the non-metallic inorganic parameters of interest: chloride and nitrate.

Chloride (Figures C.7 and C.8)

The total sample size for chloride concentration samples collected in Mary River is 315, with between 2 and 51 samples collected at each geographically distinct station. Chloride concentrations are low and range from maximum values of 8 mg/L to detection limit values of 1 mg/L (Figure C.7). These concentrations are far below the CWQG-PAL guideline of 120 mg/L. Distinct geographic trends for chloride are not observed; however, measured chloride concentrations from upstream stations (G0-09, G0-03, G0-01 and E0-10) are slightly lower than concentrations observed at stations downstream of E0-10. This is expected to be the result of drilling salts that have been used during exploration in areas in vicinity to the open pit. Log transformed data has far fewer outliers and depicts geographic trends more clearly than the normal data.

Seasonal scatterplots and boxplots show a fairly conserved seasonal trend among different stations aggregated together: lowest measured concentrations occur in the spring (with the exception of C0-10, C0-05 and C0-01 data), slightly higher measured concentrations occur in the summer and the highest measured concentrations occur during the fall (Figure C.8). Seasonal scatter plots do not show consistent temporal trends over the years sampled, although seasonal scatterplots indicate the presence of one detection limit at ~1 mg/L.



NOTES:

1. ALKALINITY VALUES BELOW 10 mg/L ARE HIGHLY SENSITIVE TO ACIDIC INPUTS; ALKALINITY VLAUES BETWEEN 10 – 20 mg/L ARE MODERATELY SENSITIVE TO ACIDIC INPUTS AND ALKALINITY VALUES ABOVE 20 mg/L HAVE LOW SENSITIVITY TO ACIDIC INPUTS.

Figure C.6 Mary River – Alkalinity and Hardness

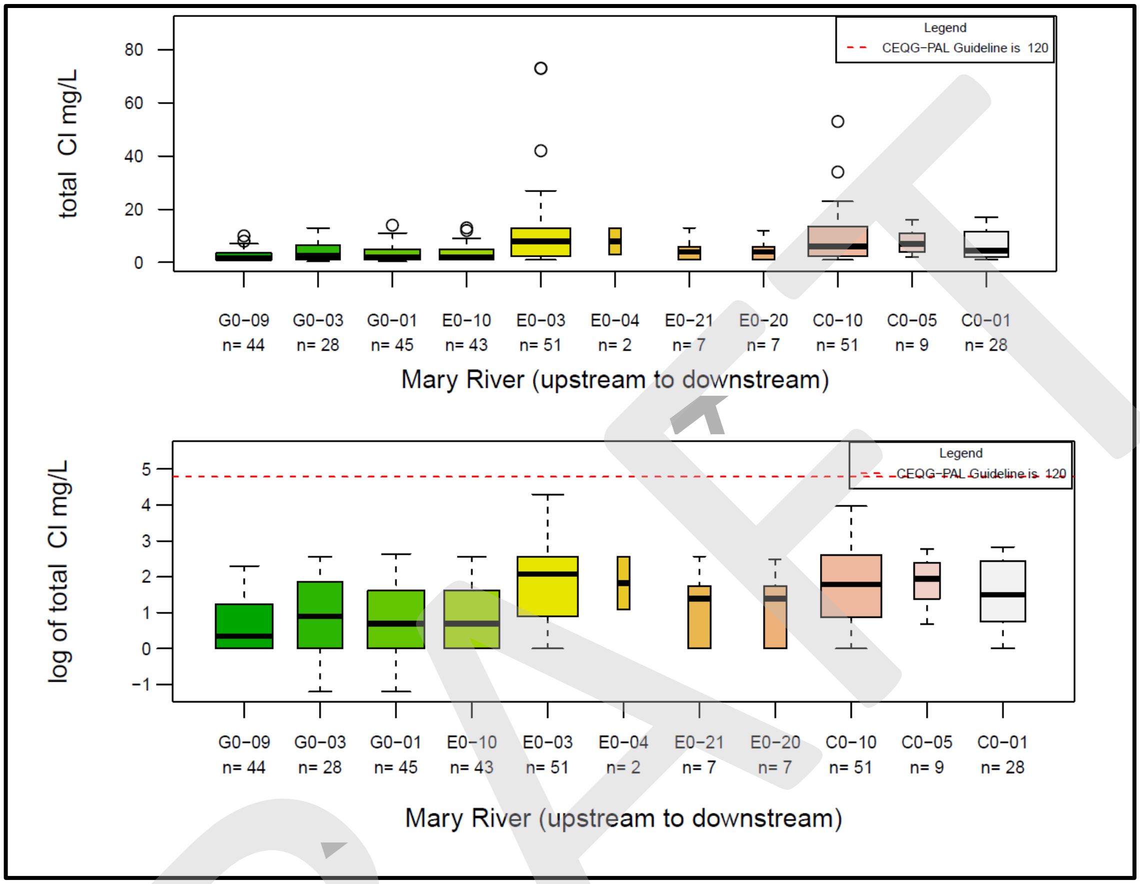
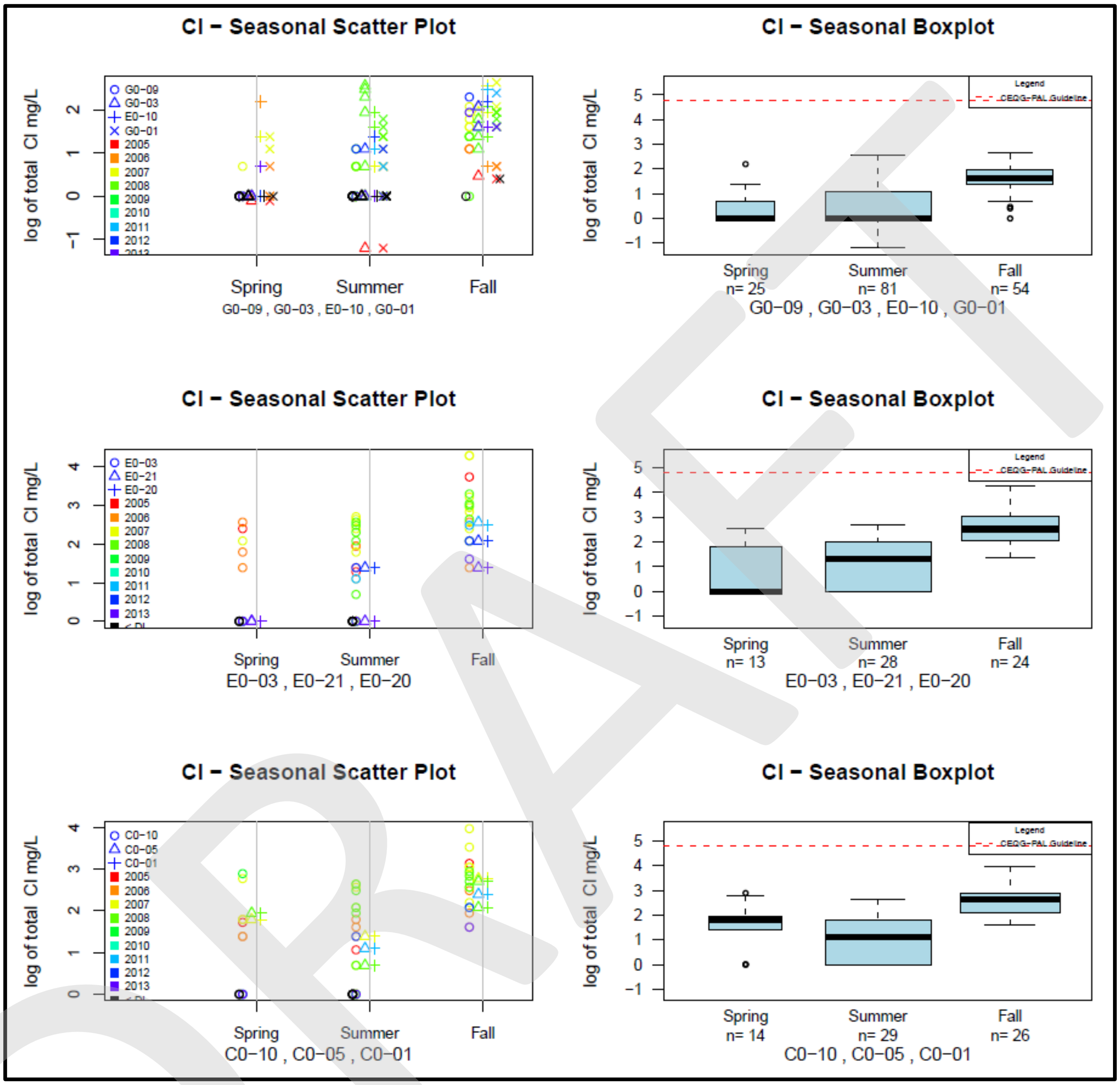


Figure C.7 Mary River – Chloride Concentrations in Water



NOTES:

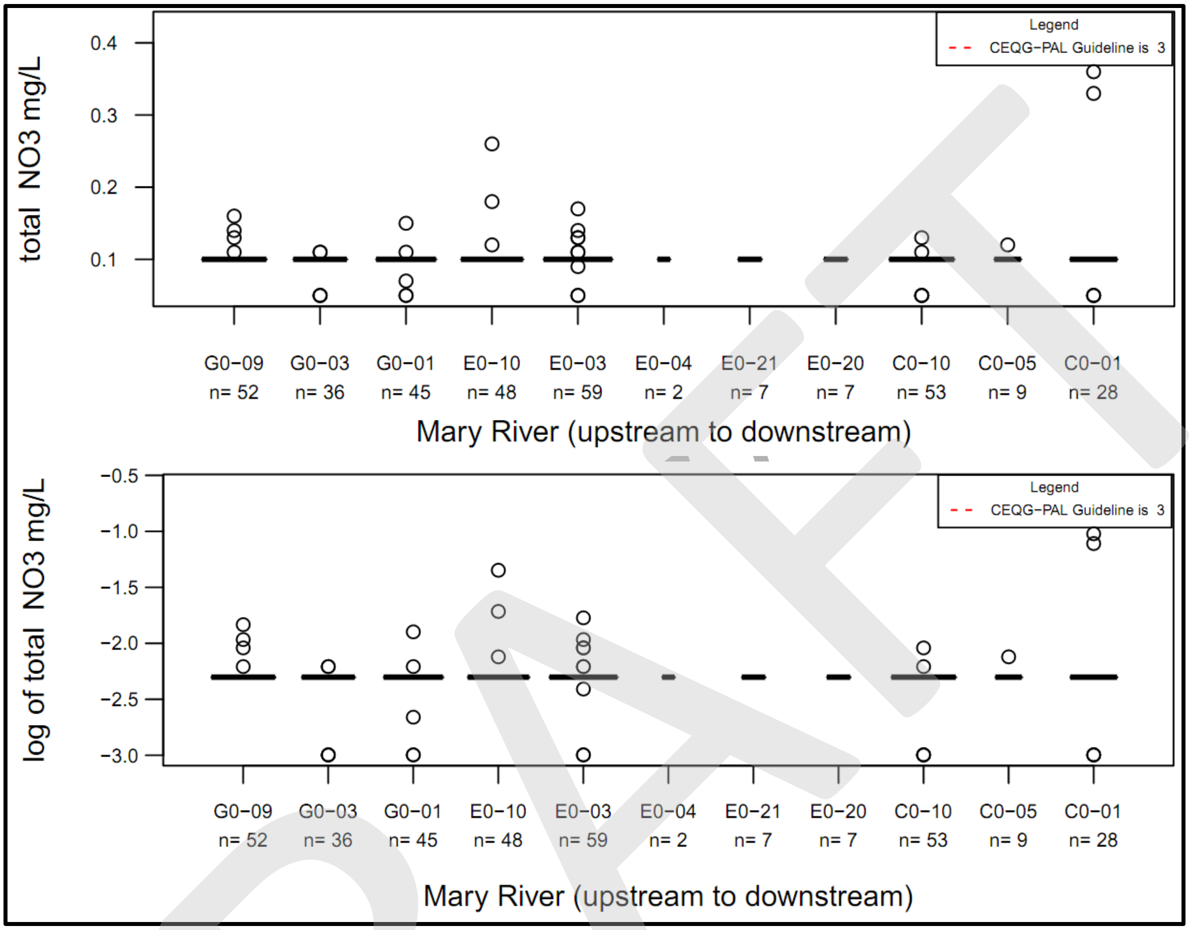
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure C.8 Mary River – Variability of Chloride in Water

Nitrate (Figures C.9 and C.10)

The total sample size for nitrate samples collected in Mary River is 346, with between 2 and 59 samples collected at each geographically distinct station on the Mary River. Nitrate concentrations generally occur at MDL level, and well below the CWQG-PAL guideline (3 mg/L), although, frequent outliers are noted (Figure C.9).

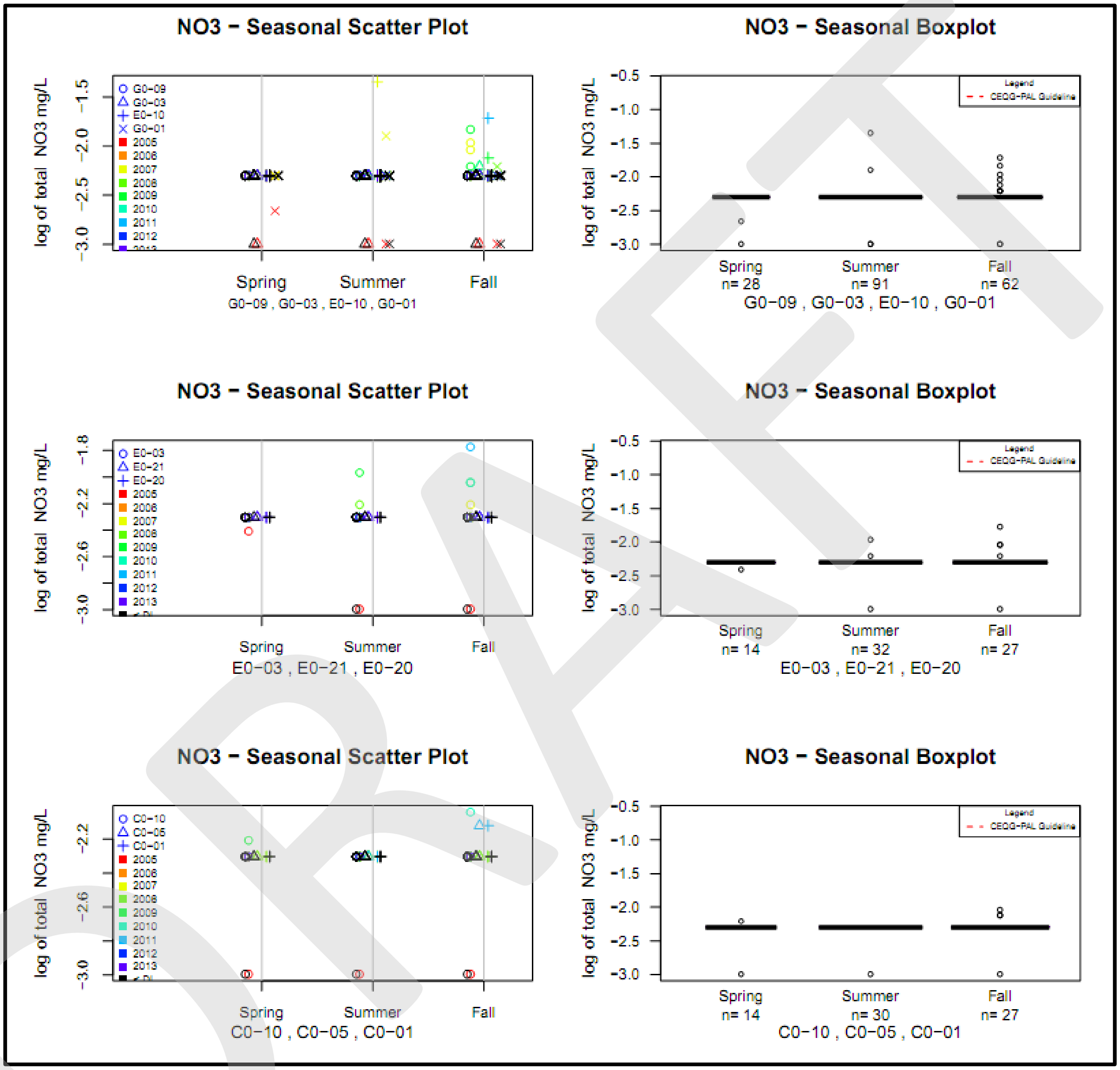
Seasonal scatterplots and boxplots show that the majority of outliers occur in the fall, and that data is subject to MDL interference. Seasonal scatterplots indicate that earlier data, from 2005, actually had a lower MDL than more recently collected data in 2012 (Figure C.10).



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.9 Mary River – Nitrate Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

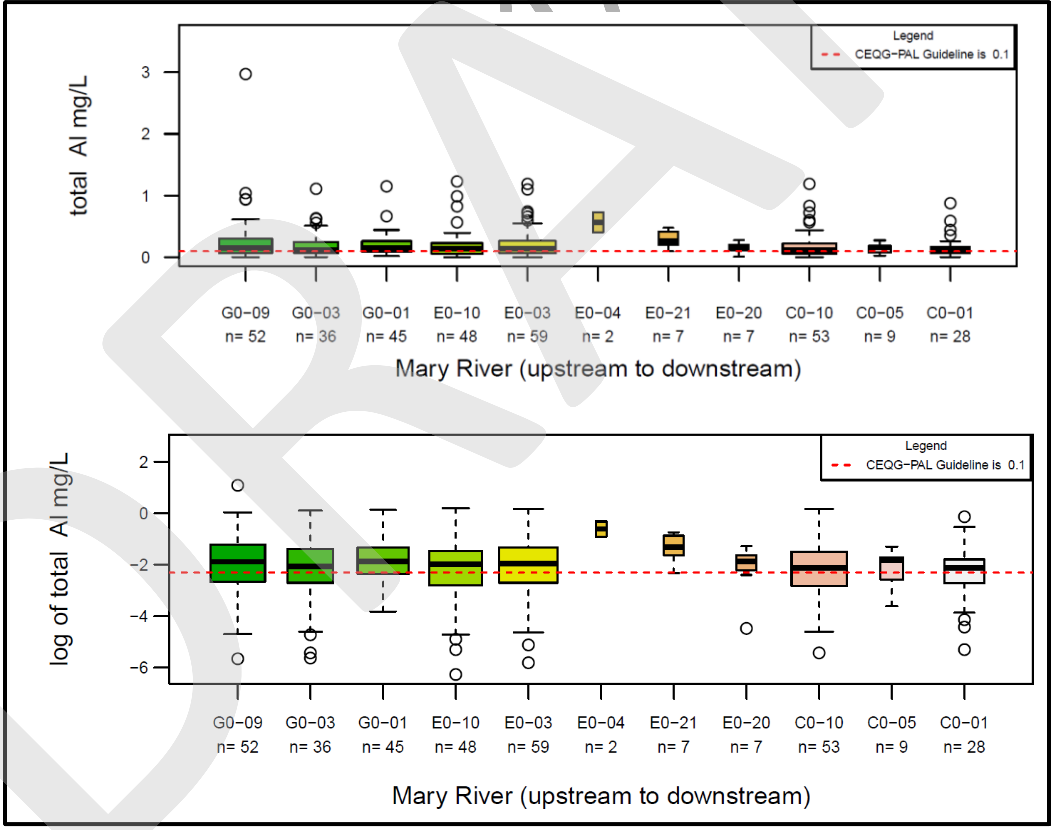
Figure C.10 Mary River – Variability of Nitrate in Water

The following sections summarize the results for the metal parameters of interest: aluminum, arsenic, cadmium, copper, iron, and nickel. All metals are discussed as total concentrations instead of dissolved concentrations, to reflect both the total dissolved and particulate metal loading.

Total Aluminum (Figures C.11 and C.12)

The total sample size for aluminum samples collected in Mary River is 346, with between one through 59 samples collected at each geographically distinct station on the Mary River (Figure C.11). Baseline total aluminum concentrations are elevated, and all stations sampled have median values greater than the CWQG-PAL guideline (0.1 mg/L) but below the Interim SSWQO[1] of 0.94 mg/L). The highest outlying value is 3 mg/L. Many outlying values are noted when box plots are created with raw data; however, when values are log transformed, fewer outliers are noted, and all occur below the calculated median value. Distinct geographic trends for aluminum are not observed, although slightly higher concentrations are noted at E0-04, E0-21 and E0-20. These observations are reliant are small amounts of data, and are therefore, not conclusive.

Seasonal scatterplots and boxplots do not show temporal effects during the eight year sampling program; however, seasonal trends are noted that are consistent between distinct Mary River stations (Figure C.12). Samples collected during summer show slightly higher seasonal concentrations, followed closely by fall concentrations, while spring concentrations occur at the lowest magnitudes.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.11 Mary River – Total Aluminum Concentrations in Water

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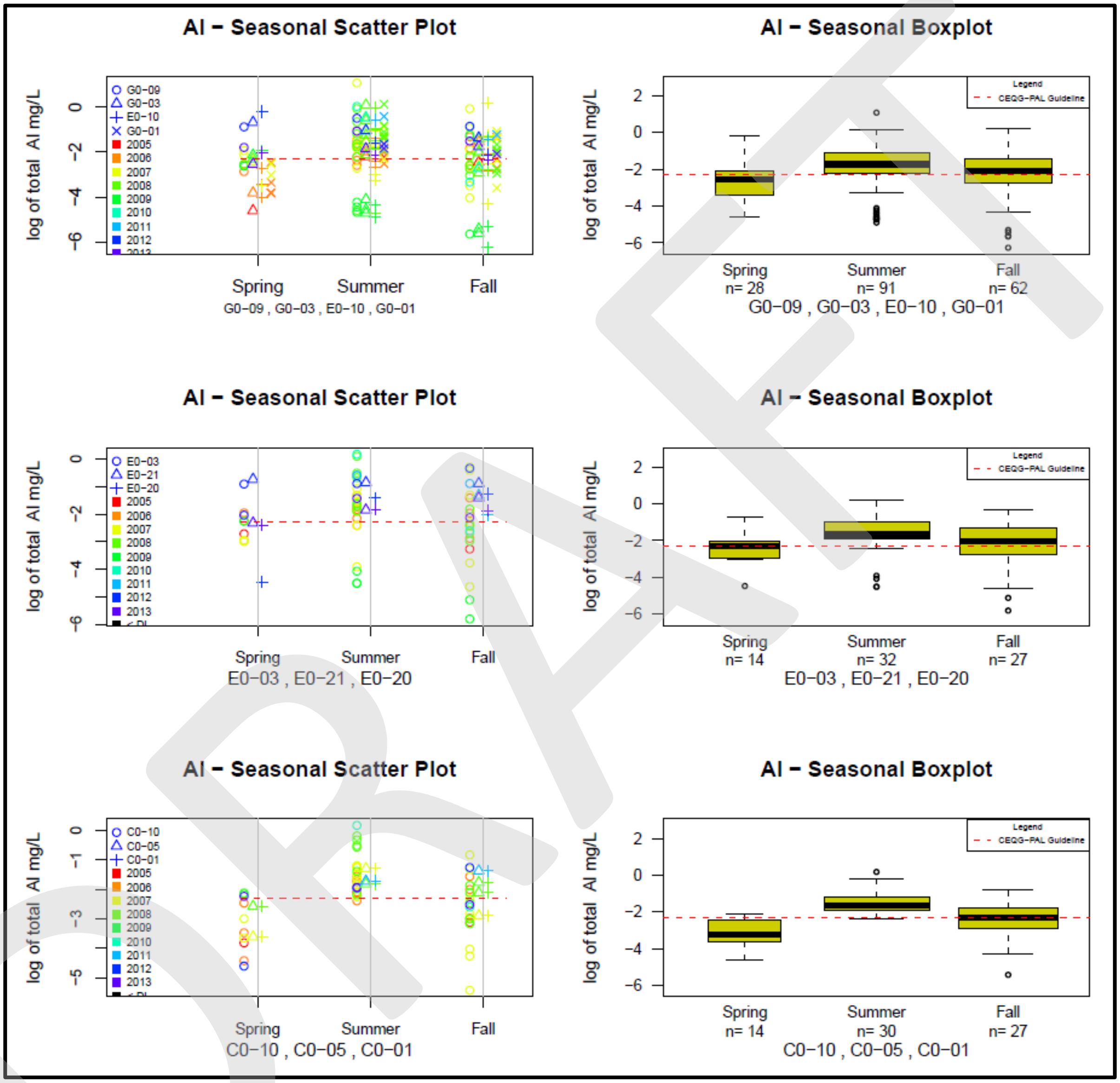
[1] The SSWQO was based on the 95th percentile of G0-09.



NOTES:

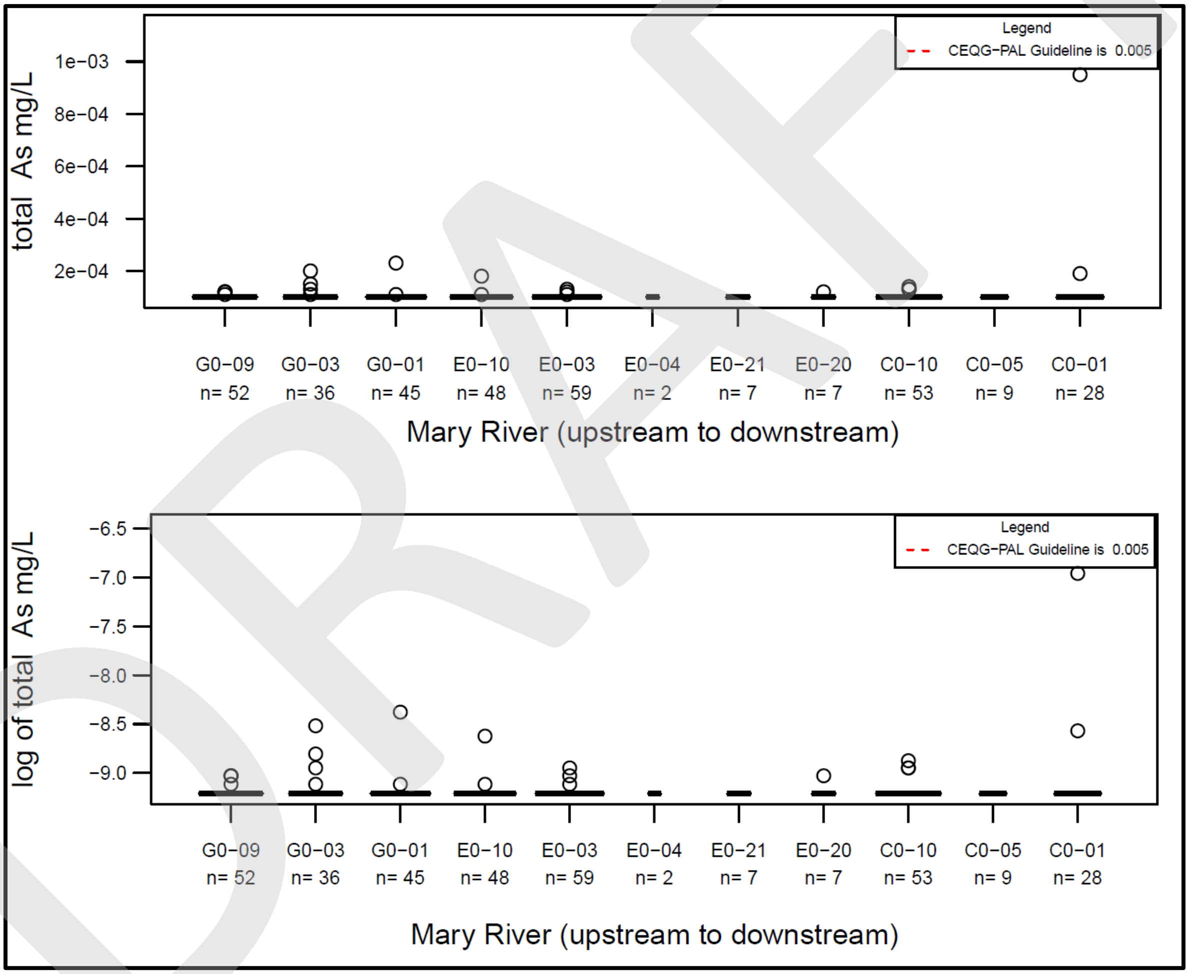
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.12 Mary River – Variability of Total Aluminum in Water

Total Arsenic (Figure C.13)

Total arsenic concentrations throughout Mary River generally occur at very low values or at the the laboratory MDLs, with the exception of some outlying values. Outlying values have been recorded at all stations except E0-04, E0-21 and C0-01, which all have smaller sample sizes than other stations (Figure C.13).

Median arsenic concentrations range from 0.0001 mg/L to 0.0002 mg/L. On average, 93% of data falls below the laboratory MDL. Station E0-03 has a median concentration slightly above MDL, with the 75th percentile concentration equal to approximately 0.001 mg/L. Ninety-five percent of data points occur below MDL. Station G0-01 also has the highest outlying value, recorded at ~0.0025 mg/L.



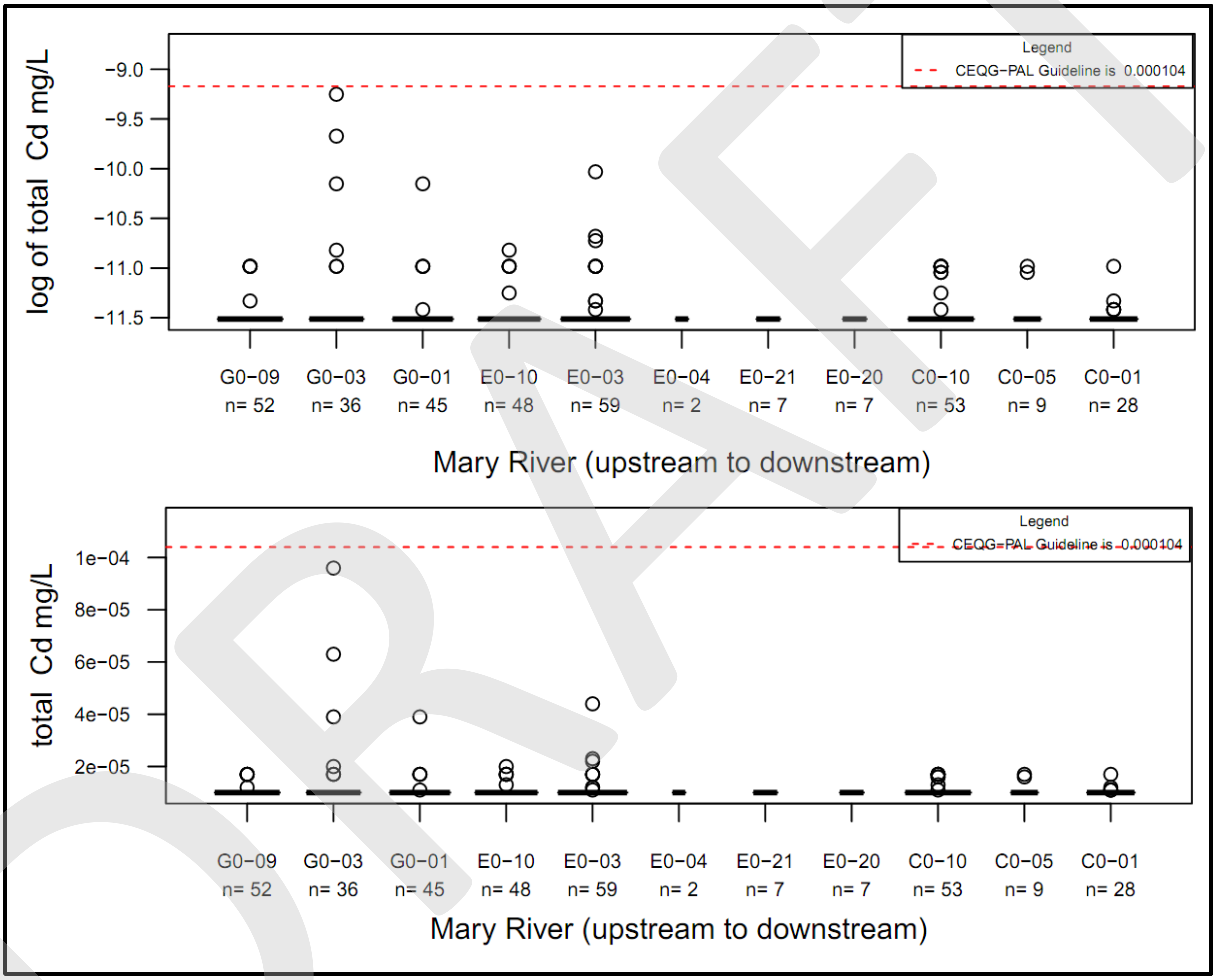
NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.13 Mary River – Total Arsenic Concentrations in Water

Total Cadmium (Figure C.14)

The total sample size for cadmium samples collected in Mary River is 346, with between two through 59 samples collected at each geographically distinct station on the Mary River. Similar to arsenic, cadmium concentrations remain low or below the laboratory MDLs at most stations (Figure C.14). Median cadmium concentrations range from 0.00001 mg/L to 0.0001 mg/L. Based on all samples in Mary River, approximately 92% of samples fall below the laboratory MDLs.



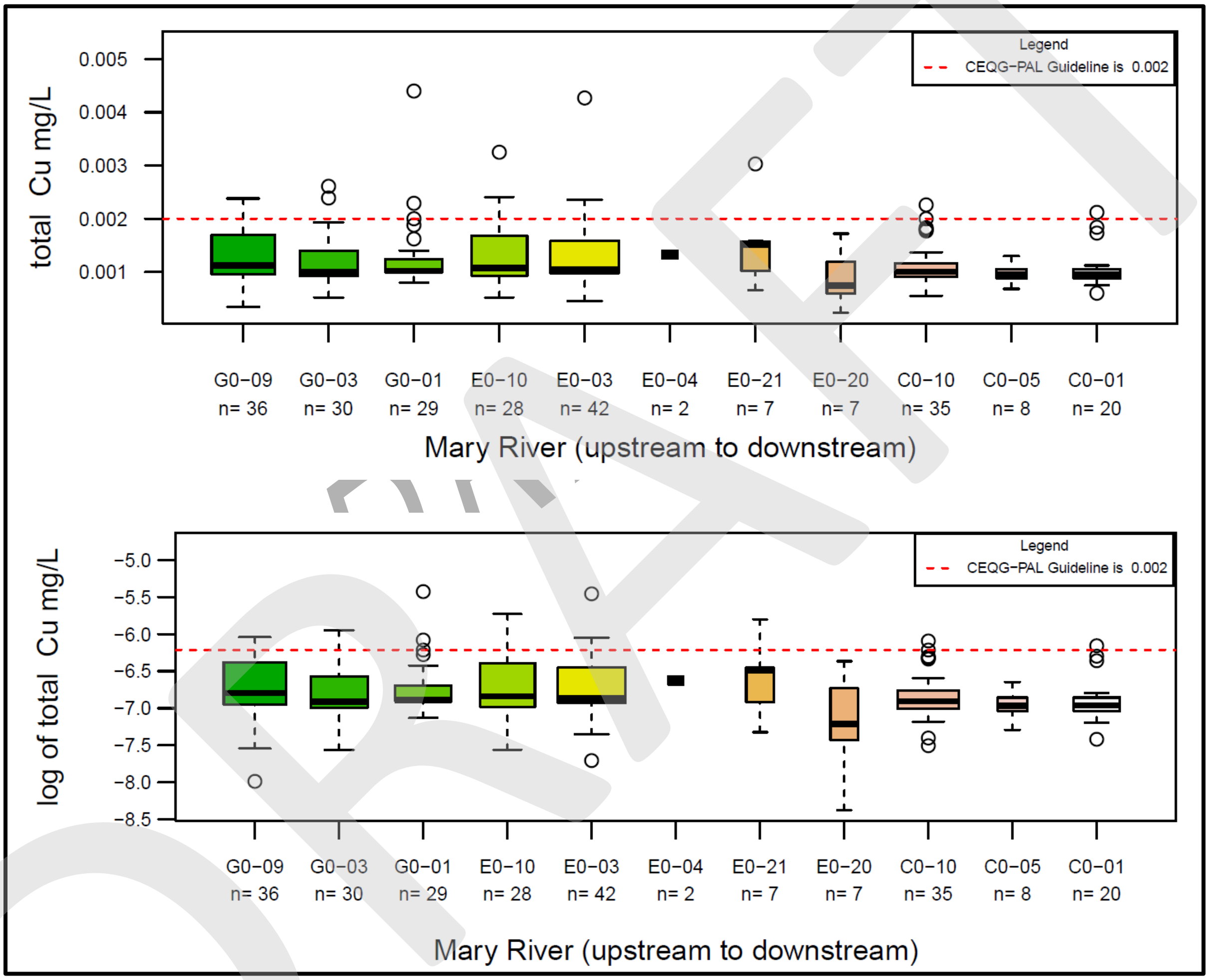
NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.14 Mary River – Total Cadmium Concentrations in Water

Total Copper (Figures C.15 and C.16)

Between two through 59 total copper samples were collected at each geographically distinct station on the Mary River, for a total of 244 copper samplesa collected from the Mary River. Baseline total copper concentrations are slightly elevated. Although no median copper concentrations surpass the CWQG-PAL guideline (0.002 mg/L), naturally occuring maximum concentrations and 75th precentile concentrations do exceed this guideline (Figure C.15). The maximum copper concentration recorded within Mary River was slightly above 0.004 mg/L, which is twice that of the CWQG-PAL guideline limit. Distinct geographic trends are not noted within Mary River, as all stations have median values that are quite similar. Log transformed data shows slightly fewer outliers, but the data transformation does not affect the spread of data to a large extent.

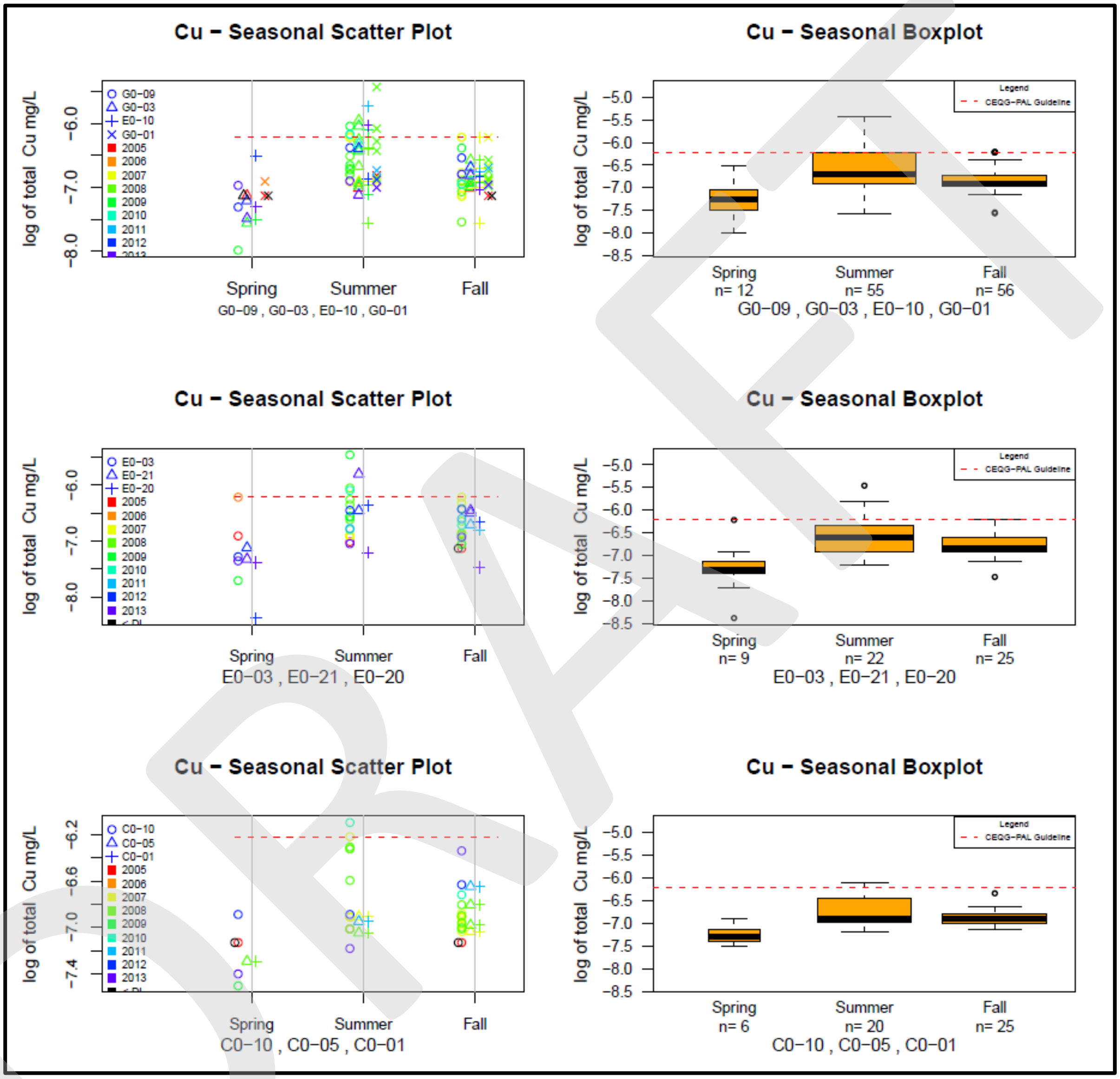


NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.15 Mary River – Total Copper Concentrations in Water

Seasonal scatterplots do not reveal a temporal trend over the eight year sampling history (Figure C.16). Seasonal scatterplots and boxplots do show, however, that all stations on Mary River show a consistent seasonal trend: with elevated, but similar concentrations occurring in summer and fall, and slightly lower concentrations occurring during spring. This trend is unique to copper.



NOTES:

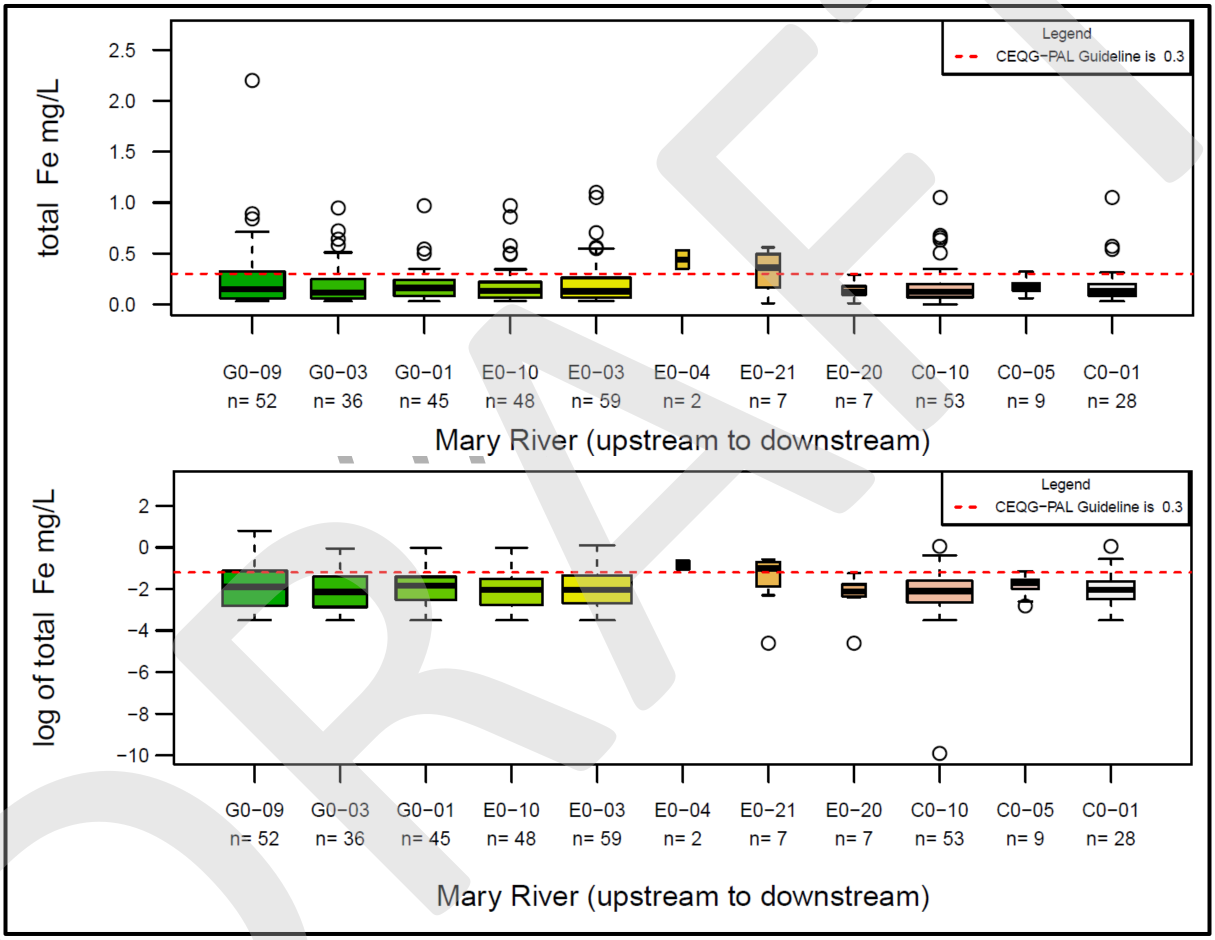
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.16 Mary River – Variability of Total Copper in Water

Total Iron (Figures C.17 and C.18)

The total sample size for total iron samples collected in Mary River is 346, with between two through 53 samples collected at each geographically distinct station on the Mary River. Baseline total iron concentrations are slightly elevated (Figure C.17).

Stations E0-21 and E0-04 have median iron concentrations that exceed the CWQG-PAL guideline (0.3 mg/L), but are based on a small sample size and are therefore inconclusive. The rest of the stations on Mary River have median values that fall below this guideline. Naturally occuring maximum concentrations and 75th percentile concentrations, however, do exceed the CWQG-PAL guideline and occur at a maximum, approximately six times the gudieline value. Plots of the log data indicate reduce the frequency of outliers significantly.

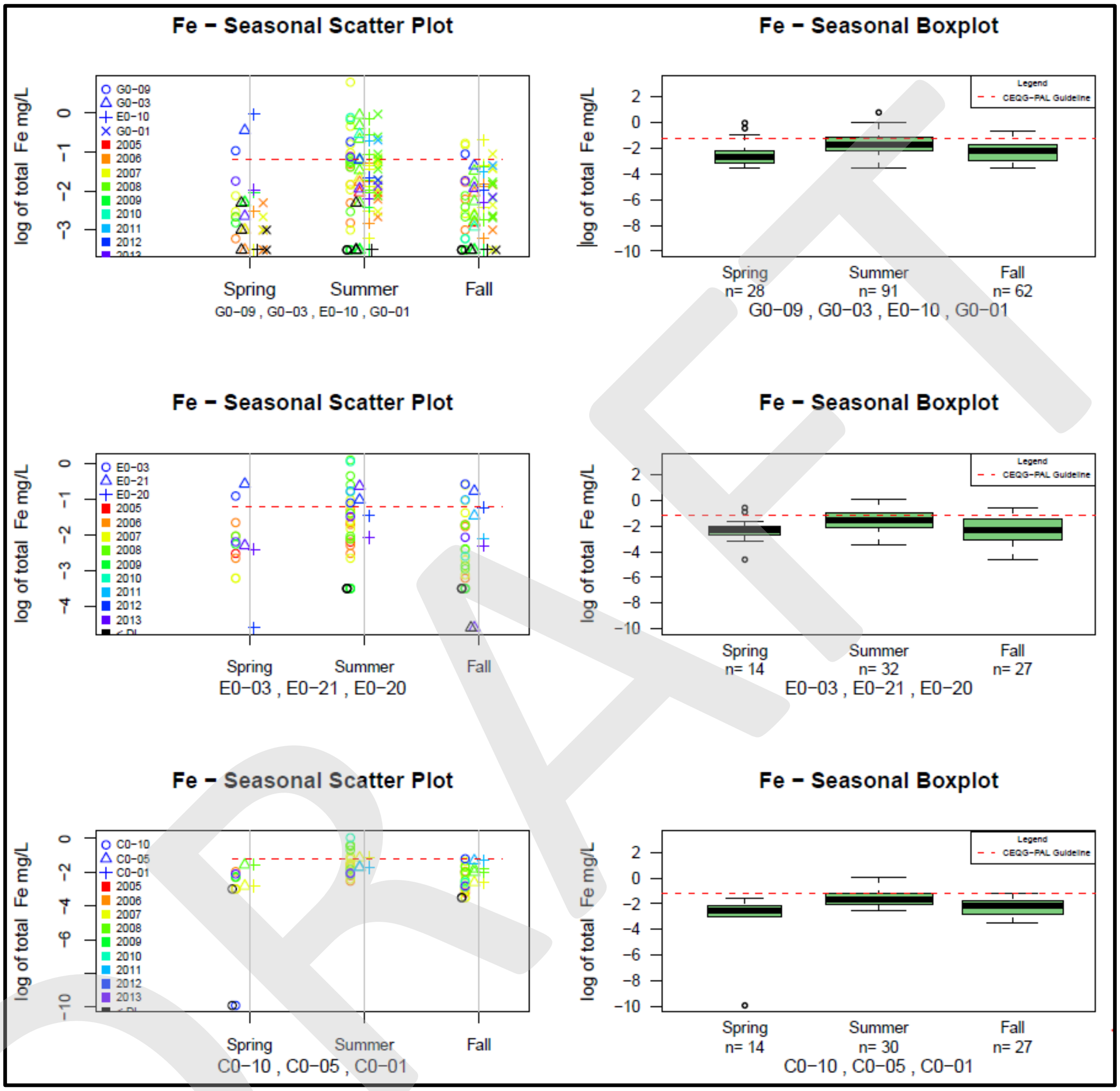


NOTES:

1. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.17 Mary River – Total Iron Concentrations in Water

Seasonal scatterplots do not reveal a temporal trend over the eight year sampling history (Figure C.18). Seasonal scatterplots and boxplots do show, however, that all stations on Mary River show a muted seasonal trend similar to the seasonal trend observed for aluminum. Summer total iron concentrations occur at slightly higher concentrations, with fall concentrations reporting slightly below summer concentrations, but above median spring concentrations.



NOTES:

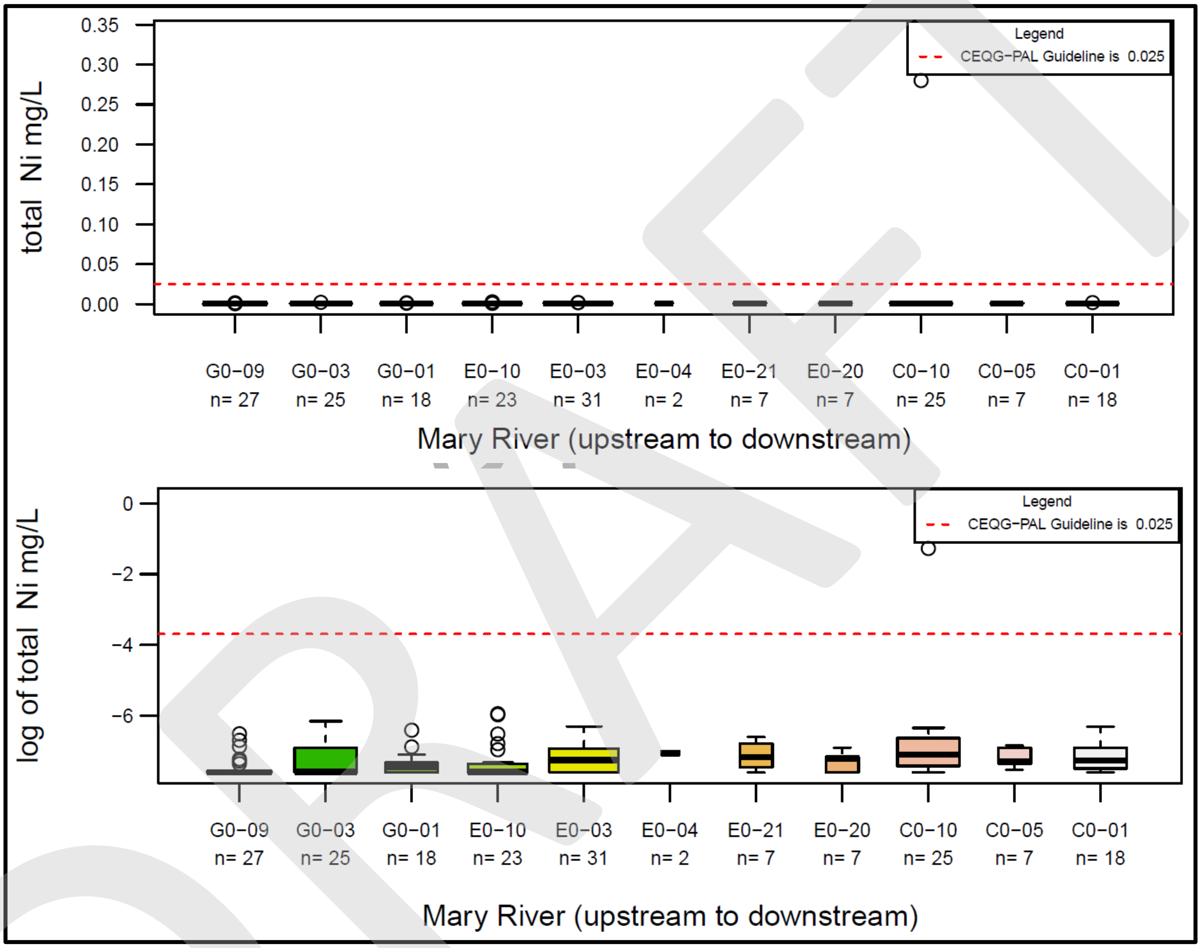
1. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.18 Mary River – Variability of Total Iron in Water

Total Nickel (Figures C.19 and C.20)

The total sample size for total nickel samples collected in Mary River is 190, with between two through 31 samples collected at each geographically distinct station on the Mary River. Baseline total nickel concentrations are low and occur consistently below the CWQG-PAL guideline (0.025 mg/L) (Figure C.19). Median values vary only slightly between stations, but do not appear to indicate any kind of geographic trend.

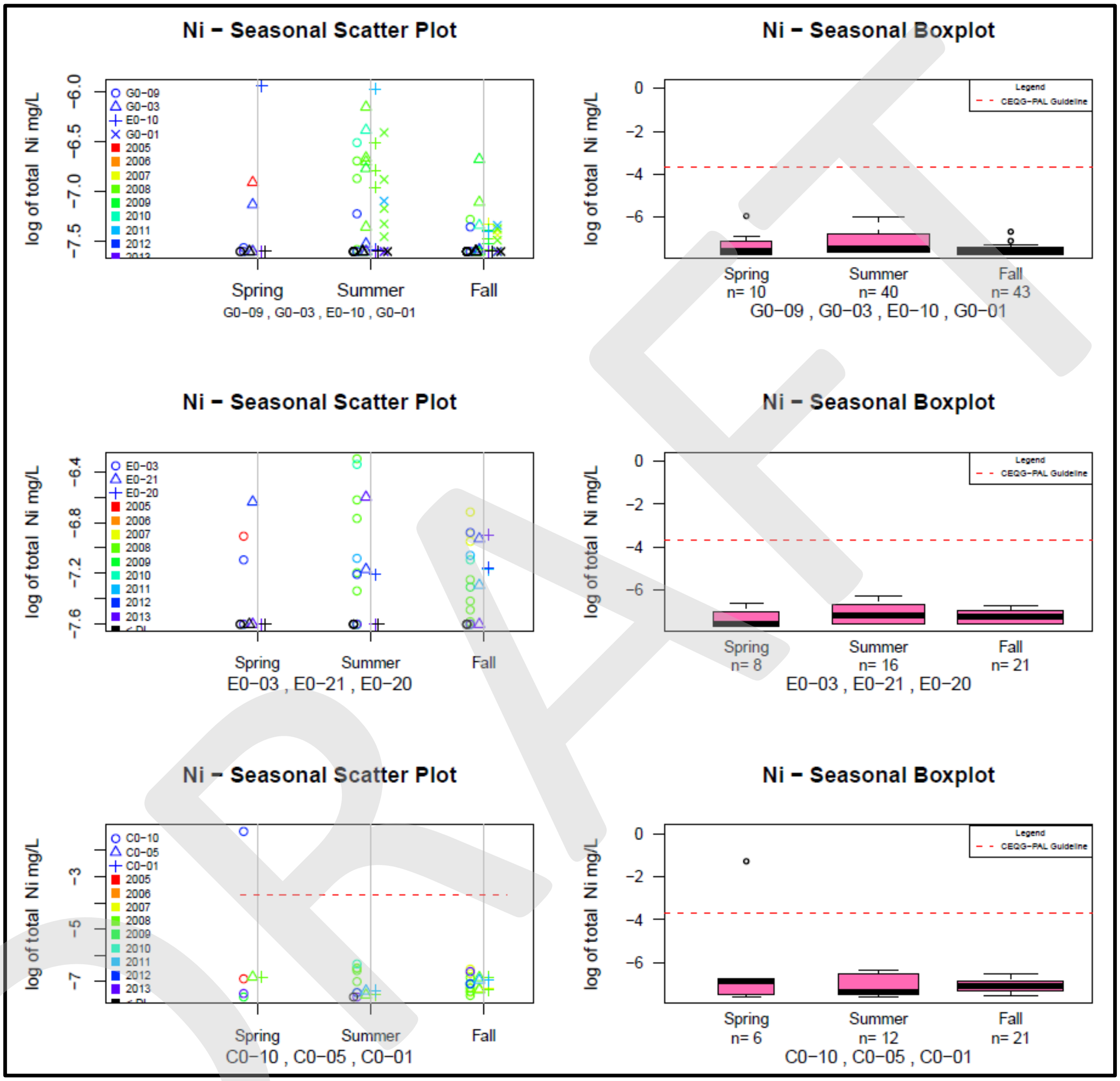
Seasonal scatterplots indicate data from 2008 and 2009 is slightly elevated compared to other data collected during the eight year sampling history (Figure C.20). Seasonal scatterplots and boxplots do not show any discernable seasonal trend, although it is possible summer concentrations are slightly higher than fall and spring concentrations.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.19 Mary River – Total Nickel Concentrations in Water



NOTES:

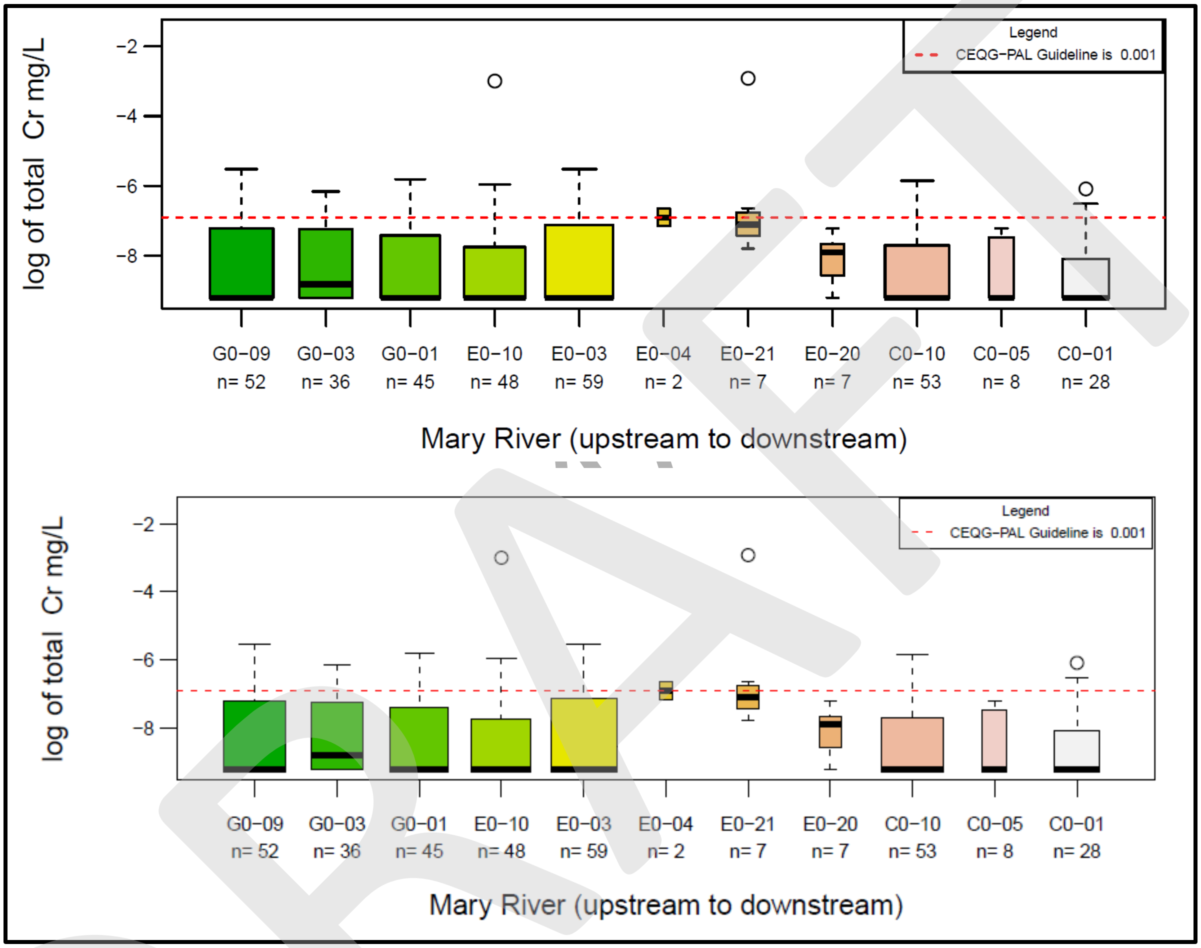
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.20 Mary River – Variability of Total Nickel in Water

Total Chromium (Figure C.21 and Figure C.22*)*

The total sample size for total chromium, samples collected in Mary River is 347, with between two through 59 samples collected at each geographically distinct station on the Mary River. Baseline total chromium concentrations are generally low but occur above the CWQG-PAL guideline (0.001 mg/L) at some stations (Figure C.21). Stations E0-04, E0-21 and E0-20 have elevated median concentrations compared to other stations.

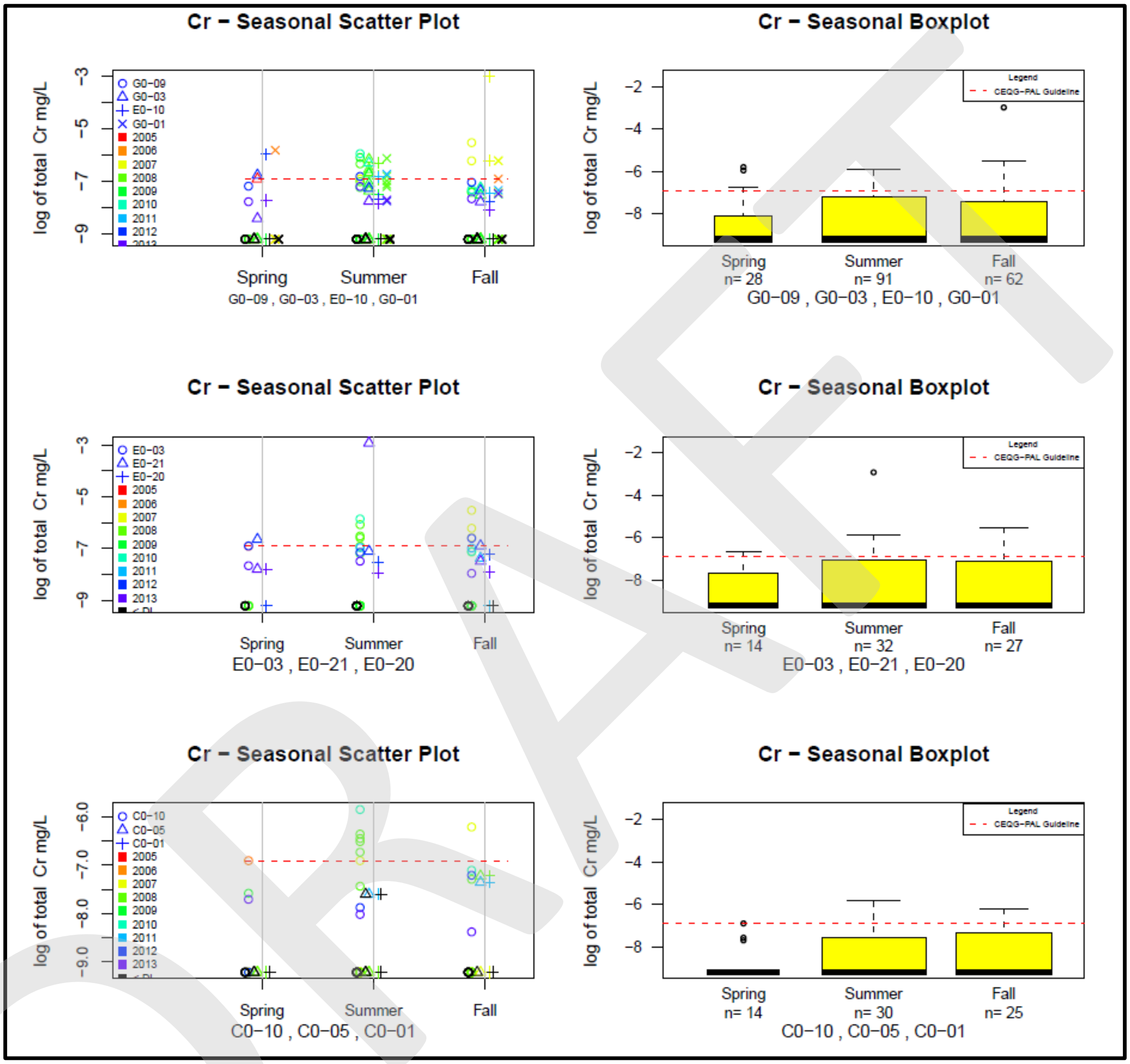
Seasonal scatterplots indicate data from summer of 2008 is slightly elevated compared to other data collected during the eight year sampling history (Figure C.22). Seasonal scatterplots and boxplots do not show any discernable seasonal trend.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.21 Mary River – Total Chromium Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.22 Mary River – Variability of Total Chromium in Water

Summary of trends observed during review of Mary River baseline data:

- Geographic trends between discrete sampling stations were not observed for any parameters, with the exception of chloride, which showed slightly lower upstream concentrations. Concentrations at E0-04, E0-20 and E0-21 were often slightly elevated, but due to small sample size, this is not a conclusive trend.
- With the exception of nitrate and nickel, parameters did not show any distinct temporal trends over the sampling period.
- No seasonal trends were noted for nitrate, arsenic and cadmium due to detection limit interference. Although detection limit interference did not occur for nickel and chromium, these parameters do not also show consistent seasonal trends between sample stations.
- Aluminum, copper and iron (and muted trends observed for nickel) historically have their highest concentrations occurring during the summer.

C.3.2 Camp Lake Tributary

Water quality samples at five stations within the Camp Lake Tributary were collected from 2005 through 2013. A total of eighty-seven (87) samples were collected from the Camp Lake Tributary L0/L1 (Table C.2). Most sampling was completed during the spring and summer season, from June through August. The most number of samples were collected during 2007 and 2008. Variability in the Camp Lake Tributary samples is larger than variation observed within the other lakes samples. Although variability may be influenced by the relatively low sample size at all stations (15 to 22, with the exception of L0), variability is expected to also be as a result of sampling different tributaries.

- L0-01: Located on Tributary L0, this is the most downstream station on the Camp Lake Tributary, prior to discharge into Camp Lake and represents the most downstream point of entry of discharge from West Pond.
- L1-02: Located on Tributary L1, located immediately downstream of L1-08, prior to the confluence of Tributary L1 and L2.
- L1-08: Located on Tributary L1, within fish-bearing water, immediately below the West Pond discharge station and a large falls.
- L1-09: Located on Tributary L0, immediately downstream of the confluence of the L2 Tributary and the L1 tributary.
- L2-03: Located on Tributary L2, adjacent to the existing air strip. Tributary L2 converges with Tributary L1 to form Tributary L0.

Sampling locations are shown on Figures C.2 and C.3. A summary of the data collected during each season, with respect to year and station are included in Table C.2. A graphical representation of the sampling events is provided in Figure C.23.

Table C.2 Camp Lake Tributary Sample Size

Year	Summer	Fall	Winter
2005	4	3	3
2006	3	6	3
2007	2	7	5
2008	2	8	5
2011	0	3	3
2012	5	5	5
2013	5	5	5
Station	**Summer**	**Fall**	**Winter**
L0-01	9	23	15
L1-02	3	3	3
L1-08	4	4	4
L1-09	2	3	3
L2-03	3	4	4

The following summarizes the data review observations for the physical parameter data collected for the Camp Lake Tributary.

pH (Figure C.24)

- *In situ* pH values in the Camp Lake Tributary do not vary greatly, and slightly alkaline, with total median pH ~ 8.
- *In situ* pH is observed to increase slightly from upstream to downstream stations.

Alkalinity (Figure C.24)

- All Camp Lake Tributary stations have high alkalinity and are considered to have low sensitivity to acidic inputs. Median hardness is equal to 73 mg/L.
- The lowest alkalinity values are recorded at L1-08, the station located furthest upstream, and values increase to a maximum of approximately 95 mg/L at L2-03. This indicates the possibility that inputs may have occurred during exploration activities.

Hardness (Figure C.24)

- Median hardness for all stations within the Camp Lake tributary is 79 mg/L, classifying the river water as “moderately soft”; although, median hardness values at L1-08 and L1-02 are classified as “soft”.
- Hardness portrayed trends very similar to alkalinity, with the lowest measured concentration occurring at L1-08 (~48 mg/L) and increasing to a maximum value at L2-03 (~100 mg/L).
- The close range between hardness and alkalinity suggest that the hardness is almost entirely carbonate hardness with little to no non-carbonate contributions to hardness.

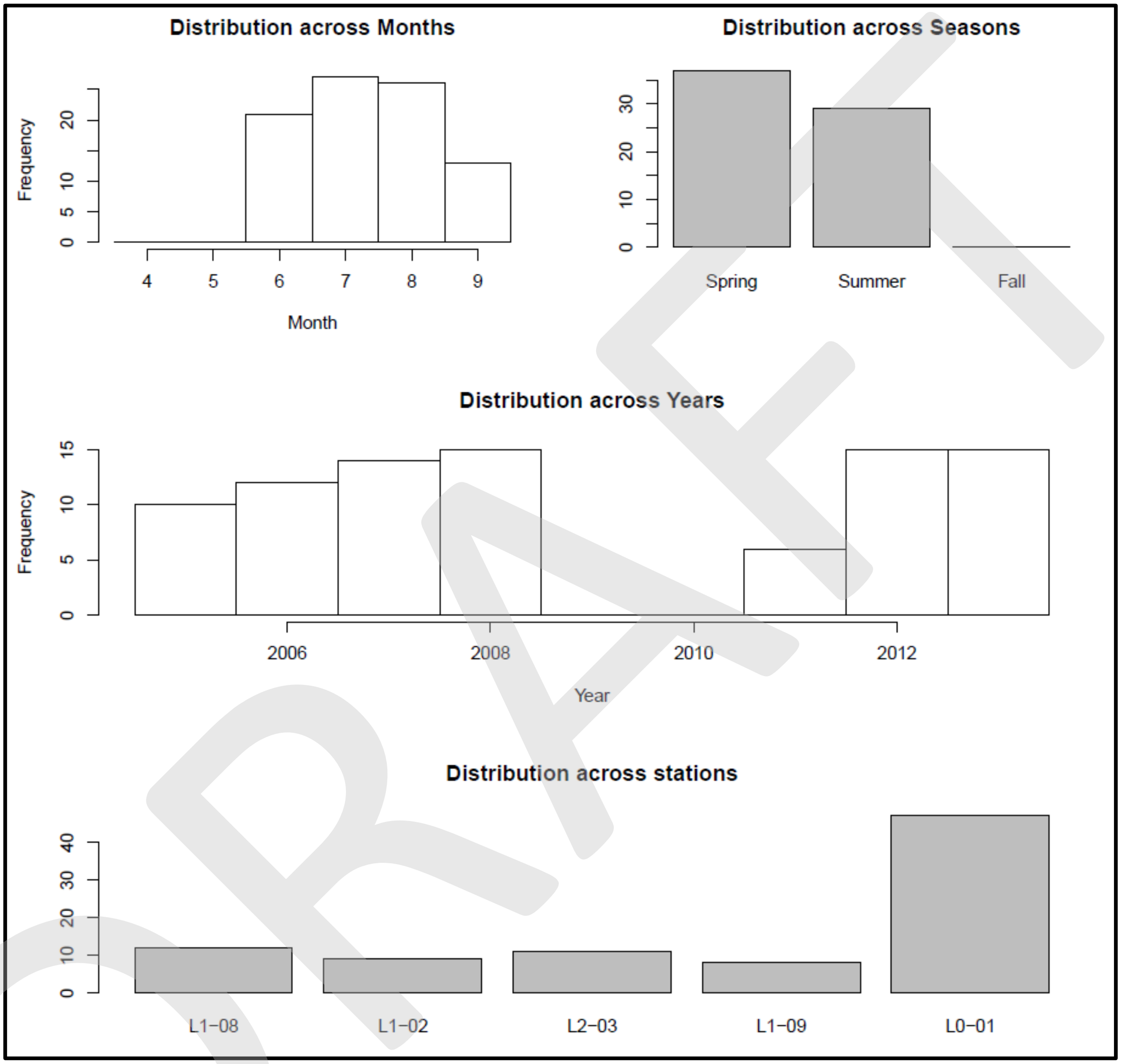
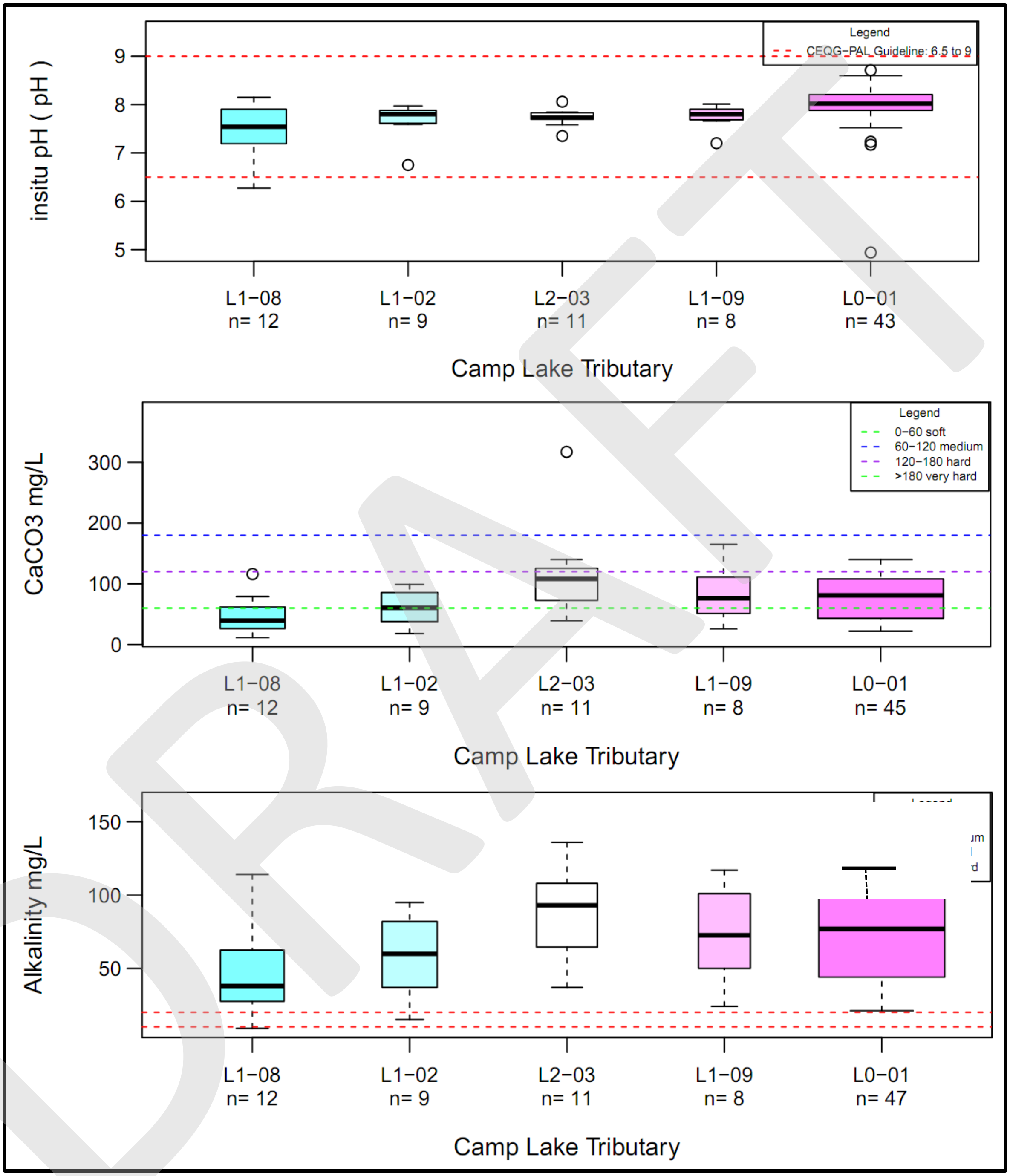


Figure C.23 **Camp Lake Tributary – Graphical Summary of Sampling Events**

The following sections summarize the results for the non-metallic inorganic parameters of interest: chloride and nitrate.

Chloride (Figures C.25 and C.26)

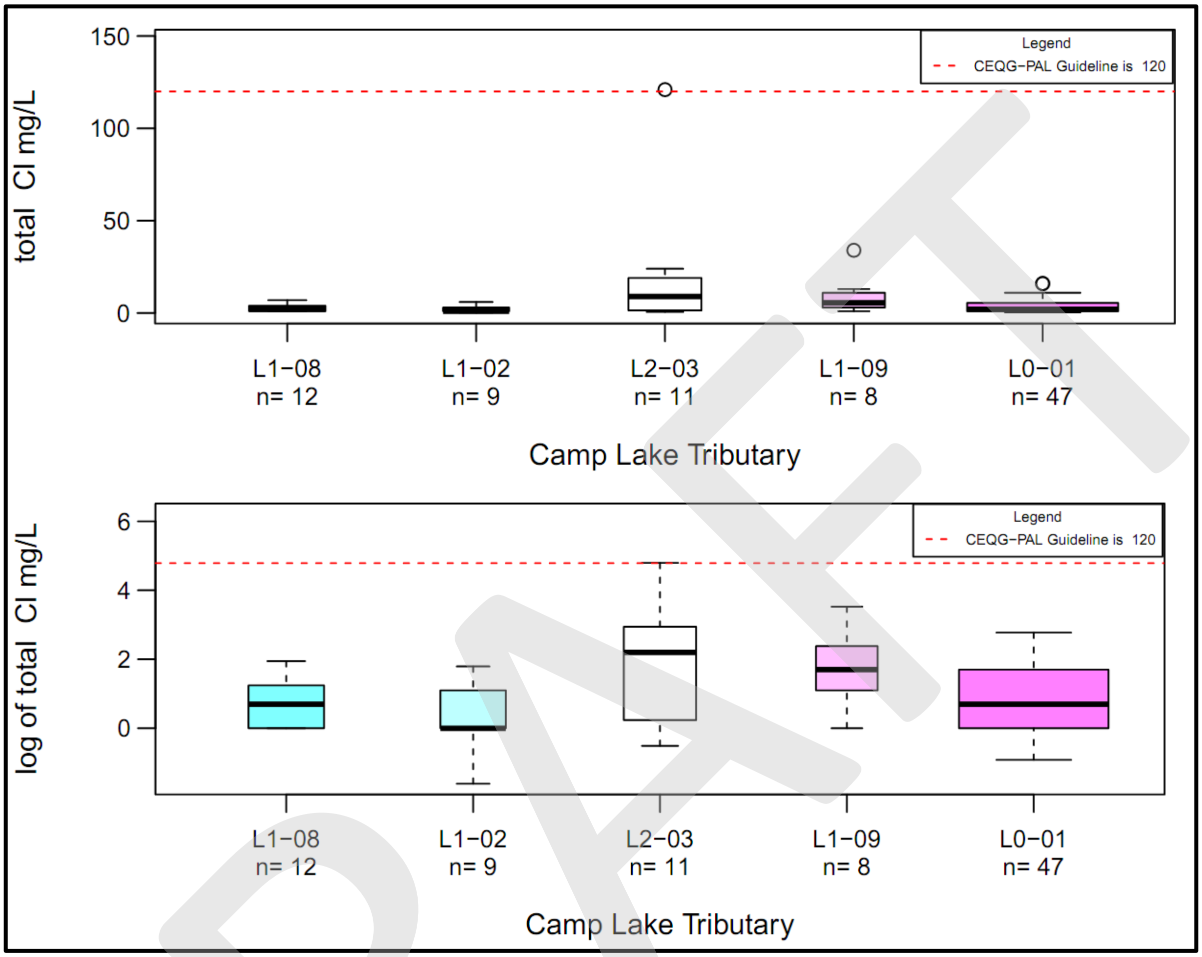
The total sample size for chloride concentration samples collected in the Camp Lake Tributary is eighty-seven (87) with 8 to 47 samples collected at each geographically distinct sampling station (Figure C.25). Chloride concentrations are low, with the exception of one outlier recorded at L2-03. Chloride concentrations generally range from the MDL to 20 mg/L, with the exception of one outlier recorded at 120 mg/L (at the CWQG limit). Chloride concentrations are marginally higher at L2-03, which samples a tributary adjcaent to the existing air strip, and are marginally lower at sampling point



NOTES:

1. ALKALINITY VALUES BELOW 10 mg/L ARE HIGHLY SENSITIVE TO ACIDIC INPUTS; ALKALINITY VLAUES BETWEEN 10 – 20 mg/L ARE MODERATELY SENSITIVE TO ACIDIC INPUTS AND ALKALINITY VALUES ABOVE 20 mg/L HAVE LOW SENSITIVITY TO ACIDIC INPUTS.

Figure C.24 Camp Lake Tributary – In-Situ pH, Alkalinity and Hardness



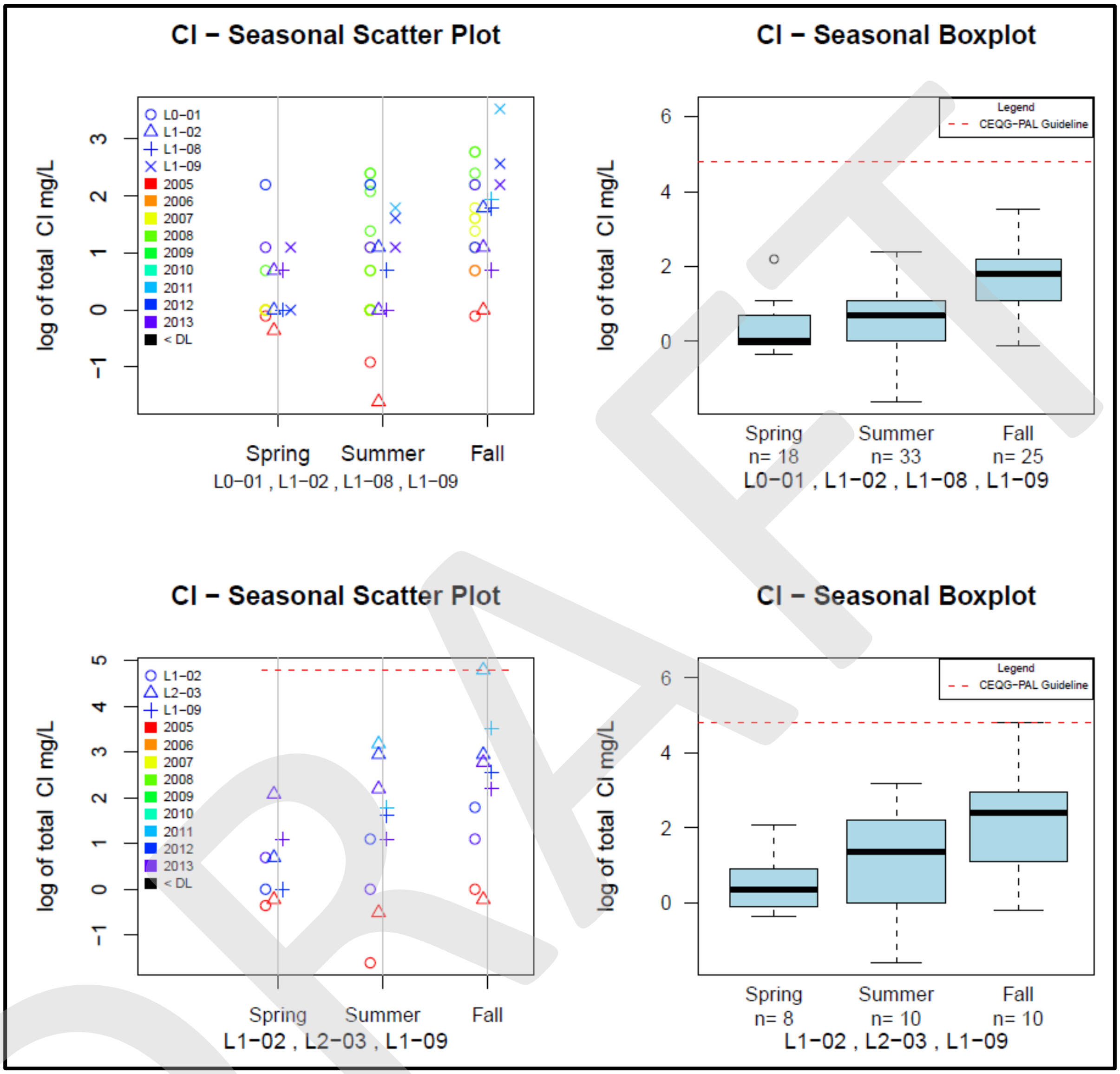
NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure C.25 Camp Lake Tributary – Chloride Concentrations in Water

higher upstream in the catchment: L1-08 and L1-02. The small magnitude of this change is not conclusive enough to attribute significant change to this parameter as a result of exploration activities.

Temporal trends were not observed to have occurred within the seasonal scatter plots (Figure C.26). Seasonal boxplots for data within the Camp Lake Tributary show a conserved trend of: lower spring concentrations, slightly elevated summer concentrations, and highest seasonal concentrations occurring in the fall.



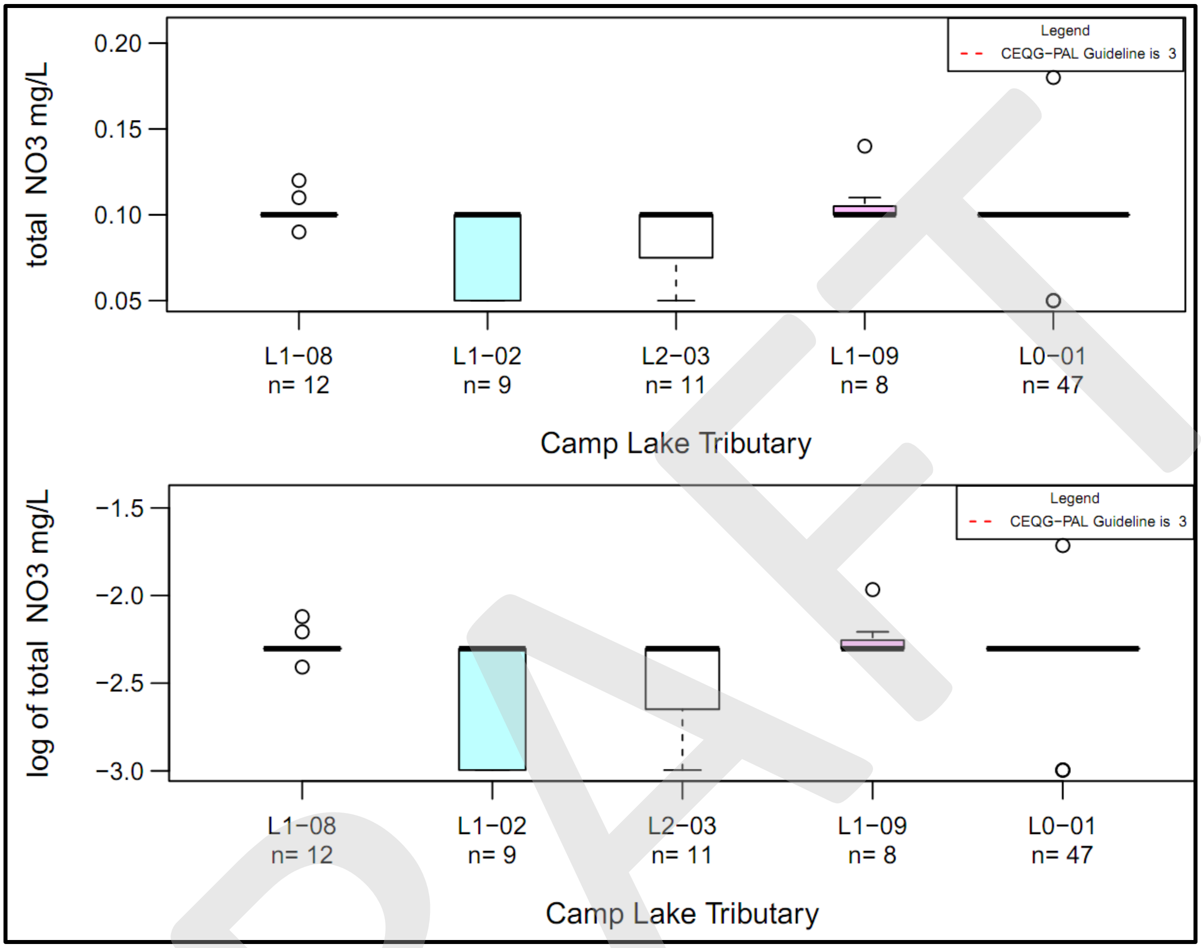
NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure C.26 Camp Lake Tributary – Variability of Chloride in Water

Nitrate (Figure C.27)

Eighty-seven (87) nitrate samples were collected from the Camp Lake Tributary sampling area. At each geographically distinct sampling station, between 11 to 47 samples were collected. The vast majority of samples collected for nitrate are at MDLs (Figure C.27). Two distinct MDLs are noted: at 0.05 mg/L, and 0.1 mg/L. Due to detection limit interference, distinct geographic trends are difficult to discern. Seasonal trends are not observed due to detection limit interference.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

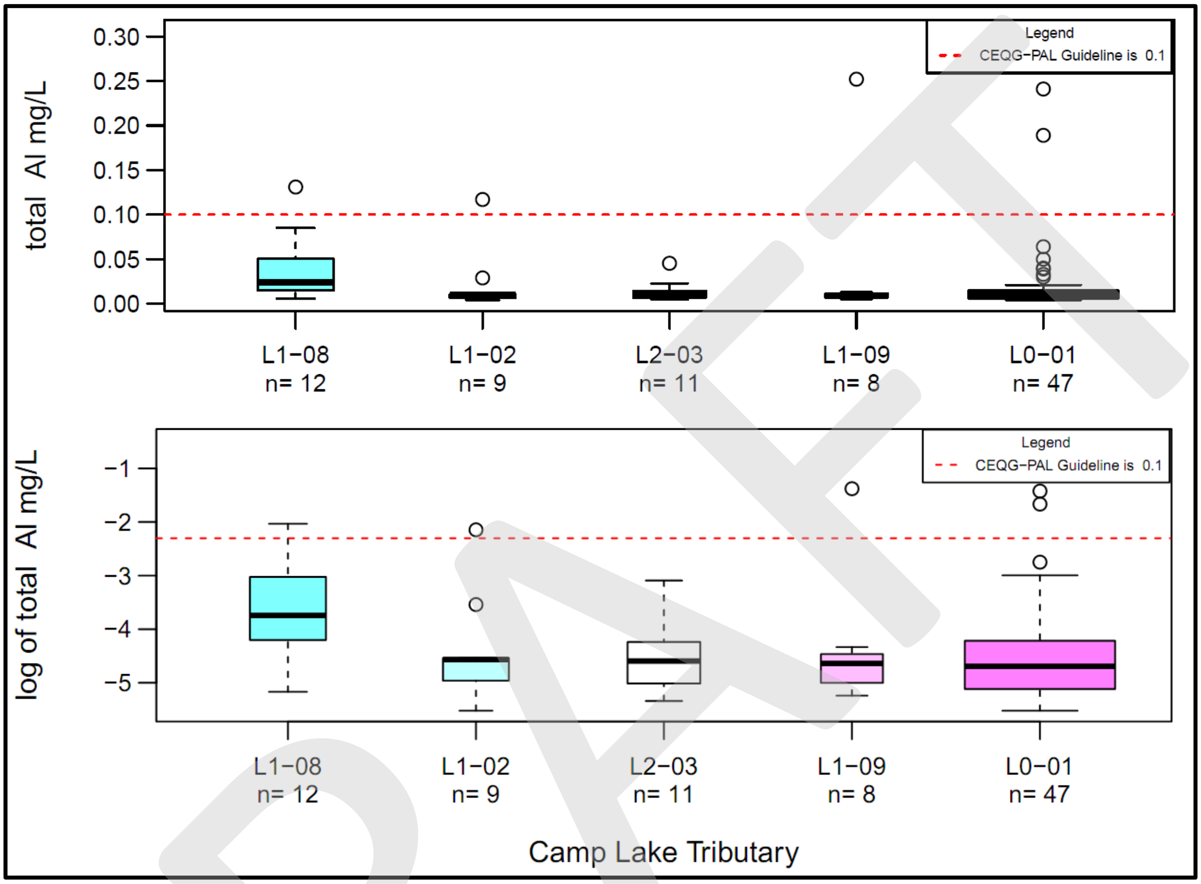
Figure C.27 Camp Lake Tributary – Nitrate Concentrations in Water

The following sections summarize the results for the metal parameters of interest: aluminum, arsenic, cadmium, copper, iron, and nickel.

Total Aluminum (Figures C.28 and C.29)

Eighty-seven (87) samples of total aluminum concentration were collected in the Camp Lake Tributary with 8 to 47 samples collected at each geographically distinct sampling station. Baseline aluminum concentrations occur consistently above MDL, but generally below the CWQG-PAL guideline (0.1 mg/L), except during the spring and summer (Figure C.28). During summer sampling, one outlying maximum aluminum concentrations occurs just above the CWQG-PAL limit and below the Interim SSWQO (0.94 mg/L). Aluminum concentrations at L1-08, the furthest upstream station, are slightly elevated when compared to other sampling stations.

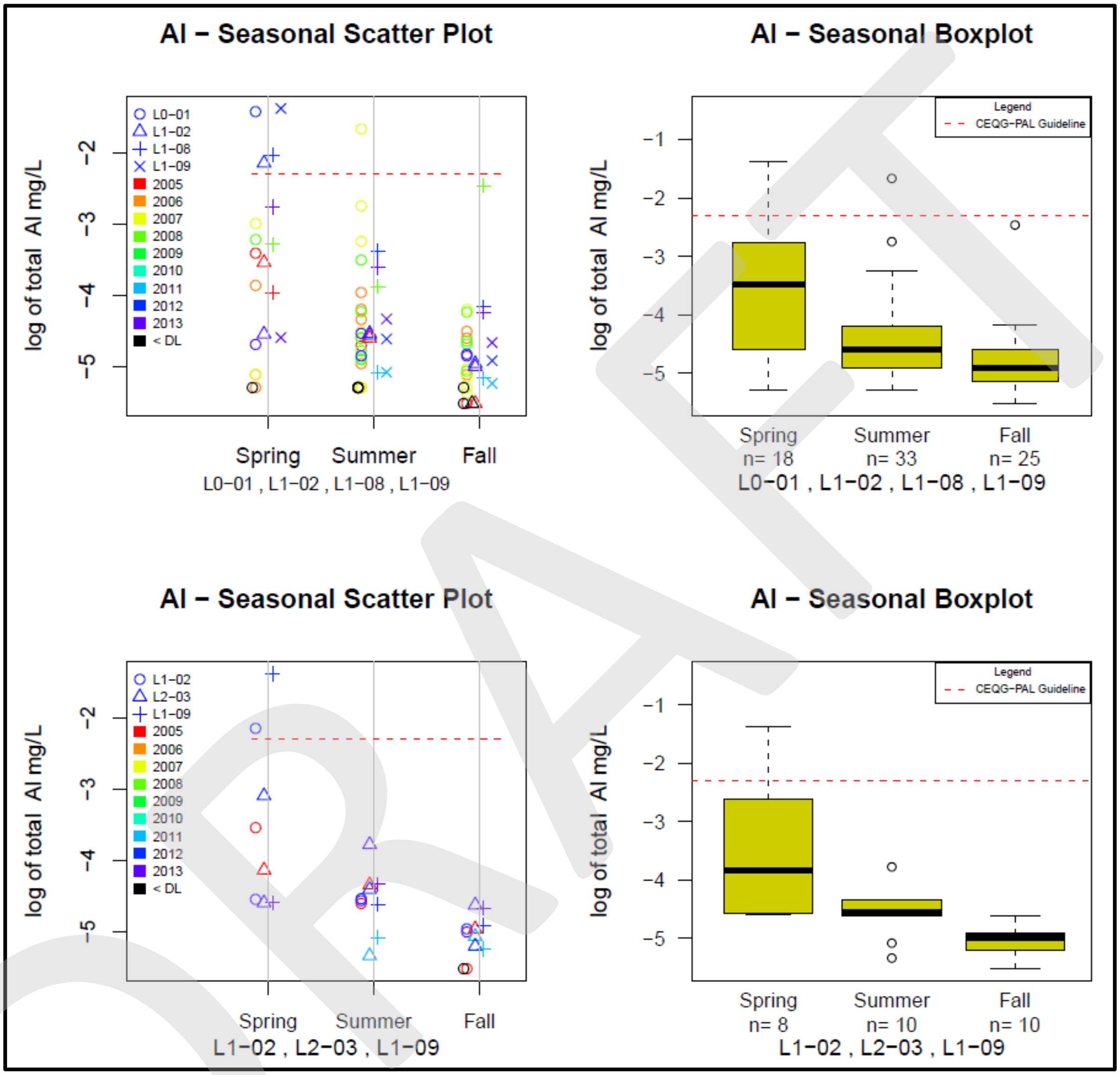
Data from 2012 and 2013 tends to be slightly elevated when compared to other years of sampling (Figure C.29). As mentioned above, seasonal boxplots for the Camp Lake Tributary area show a conserved trend of highest concentrations occurring in the spring, with slightly lower summer concentrations and slightly lower concentrations again in the fall.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure C.28 Camp Lake Tributary – Total Aluminum Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.29 Camp Lake Tributary – Aluminum Data Aggregation

Total Arsenic

Eighty-seven (87) total arsenic samples were collected in the Camp Lake Tributary area with 8 to 61 samples collected at each geographically distinct sampling station (47 samples were collected at L0-01 and between 8 to12 samples were collected at the remaining stations). Baseline arsenic concentrations occur consistently at MDL and do not change over time. Therefore, graphical analysis is not warranted.

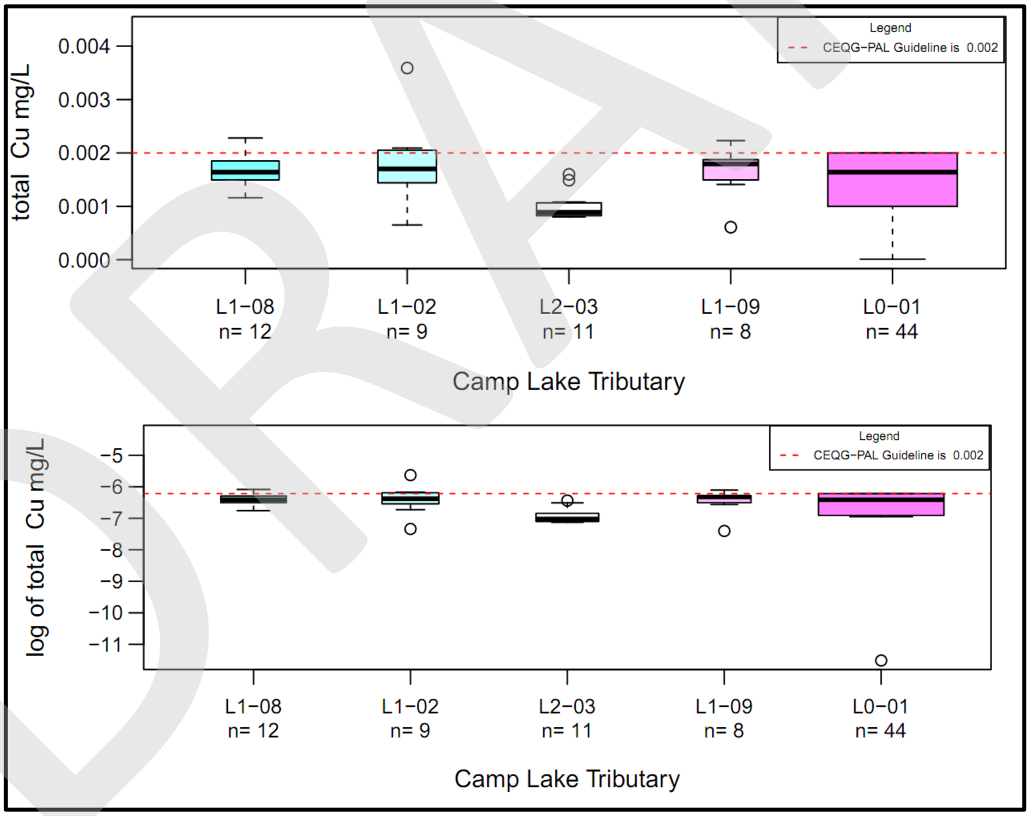
Total Cadmium

Eighty-seven (87) total cadmium samples were collected in the Camp Lake Tributary area with 8 to 47 samples collected at each geographically distinct sampling station (47 samples were collected at L0-01; 8 to 12 samples were collected at the remaining stations). Baseline cadmium concentrations occur consistently at MDL and do not warrant graphical analysis.

Total Copper (Figures C.30 and C.31)

Eight-four (84) copper samples were collected in the Camp Lake Tributary area with 8 to 44 samples collected at each geographically distinct sampling station. Baseline copper concentrations occur consistently above MDL, and close to or above the CWQG-PAL guideline (Figure C.30). Maximum and 75th percentile concentrations occur at or above the CWQG limit at L0-01, L1-02, L1-08, and L1-09. Total median copper concentrations remain at a consistent value for all stations, except L2-03, where copper concentrations are lower.

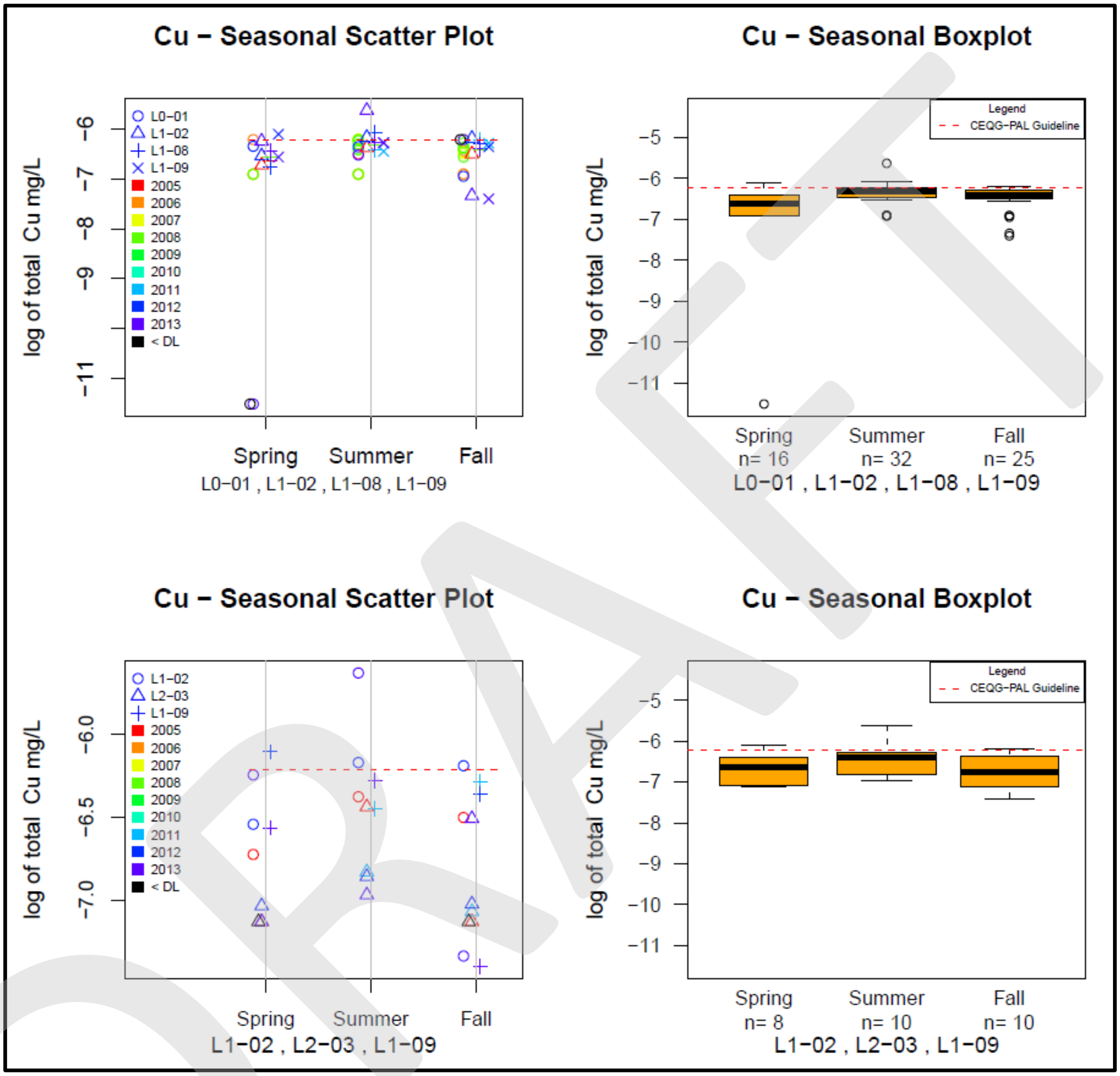
Large magnitude seasonal trends are not observed, but slightly elevated summer concentrations are observed (Figure C.31). No consistent temporal trends are noted over the eight-year sampling history.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.30 Camp Lake Tributary – Total Copper Concentrations in Water



NOTES:

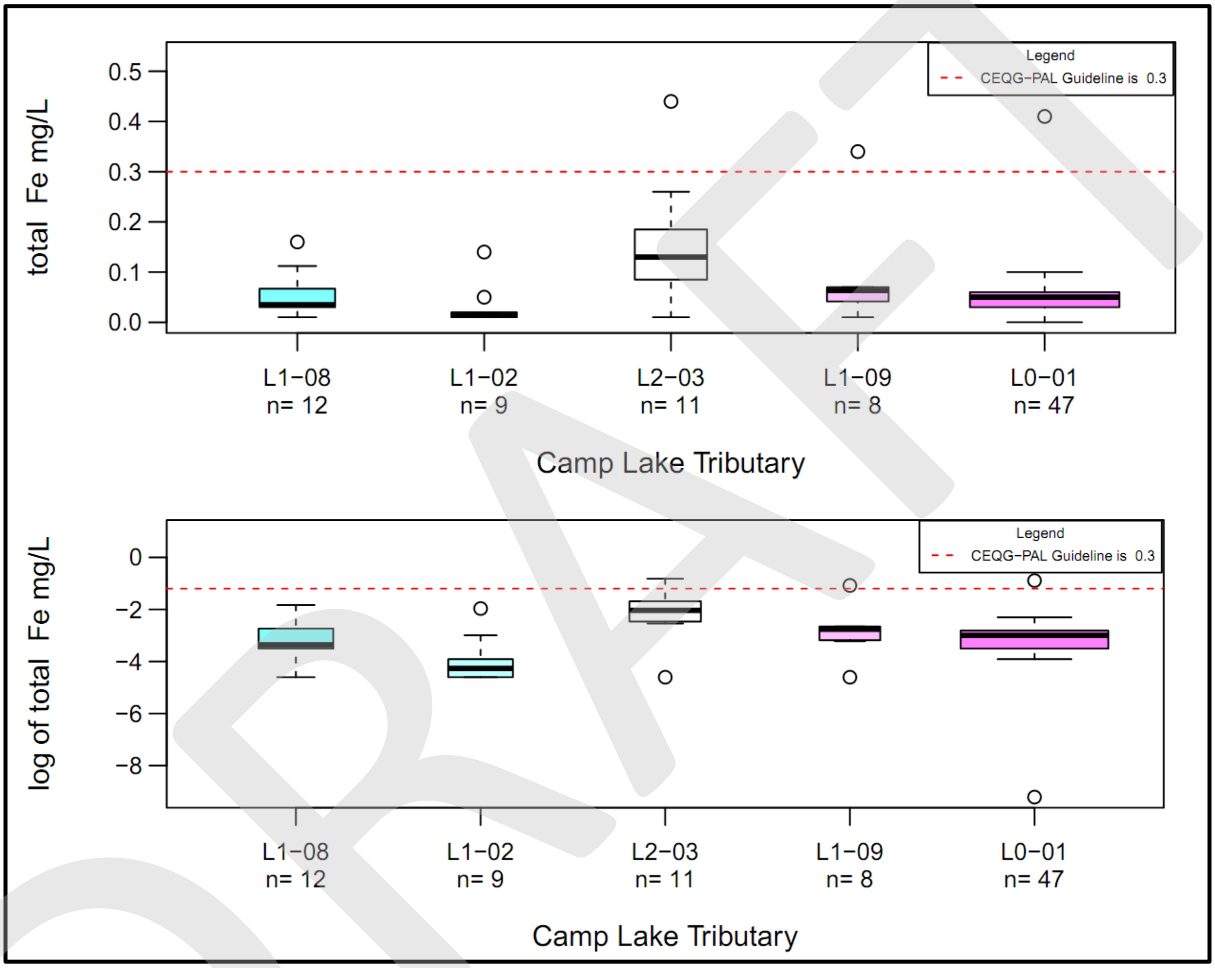
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.31 Camp Lake Tributary – Copper Data Aggregation

Total Iron (Figures C.32 and C.33)

Eighty-seven (87) total iron samples were collected in the Camp Lake Tributary area with 8 to 47 samples collected at each geographically distinct sampling station. Baseline iron concentrations occur consistently above MDL, with just 25% of all data collected in the Camp Lake Tributary occuring below MDL (Figure C.32). Total and seasonal median iron values occur consistently below the CWQG-PAL guideline; however, outlying concentrations occur at or above the CWQG limit at several stations (L2-03, L1-09 and L0-01). Iron concentrations at L2-03 are slightly elevated compared to other stations.

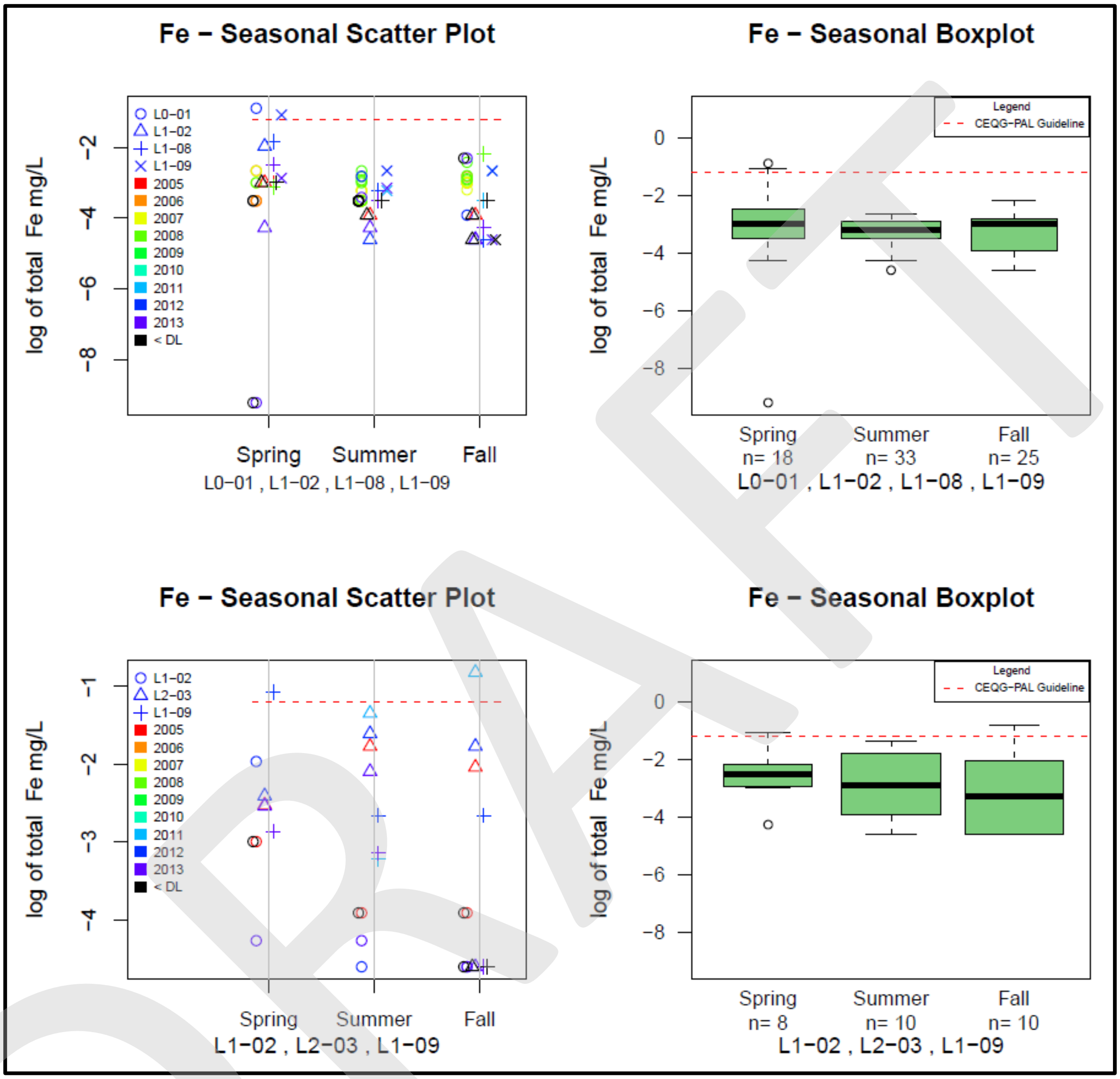
Seasonal box plots show fairly consistent median iron concentration, regardless of season (Figure C.33). In addition, no consistent temporal trends are noted over the eight-year sampling history.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure C.32 Camp Lake Tributary – Total Iron Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

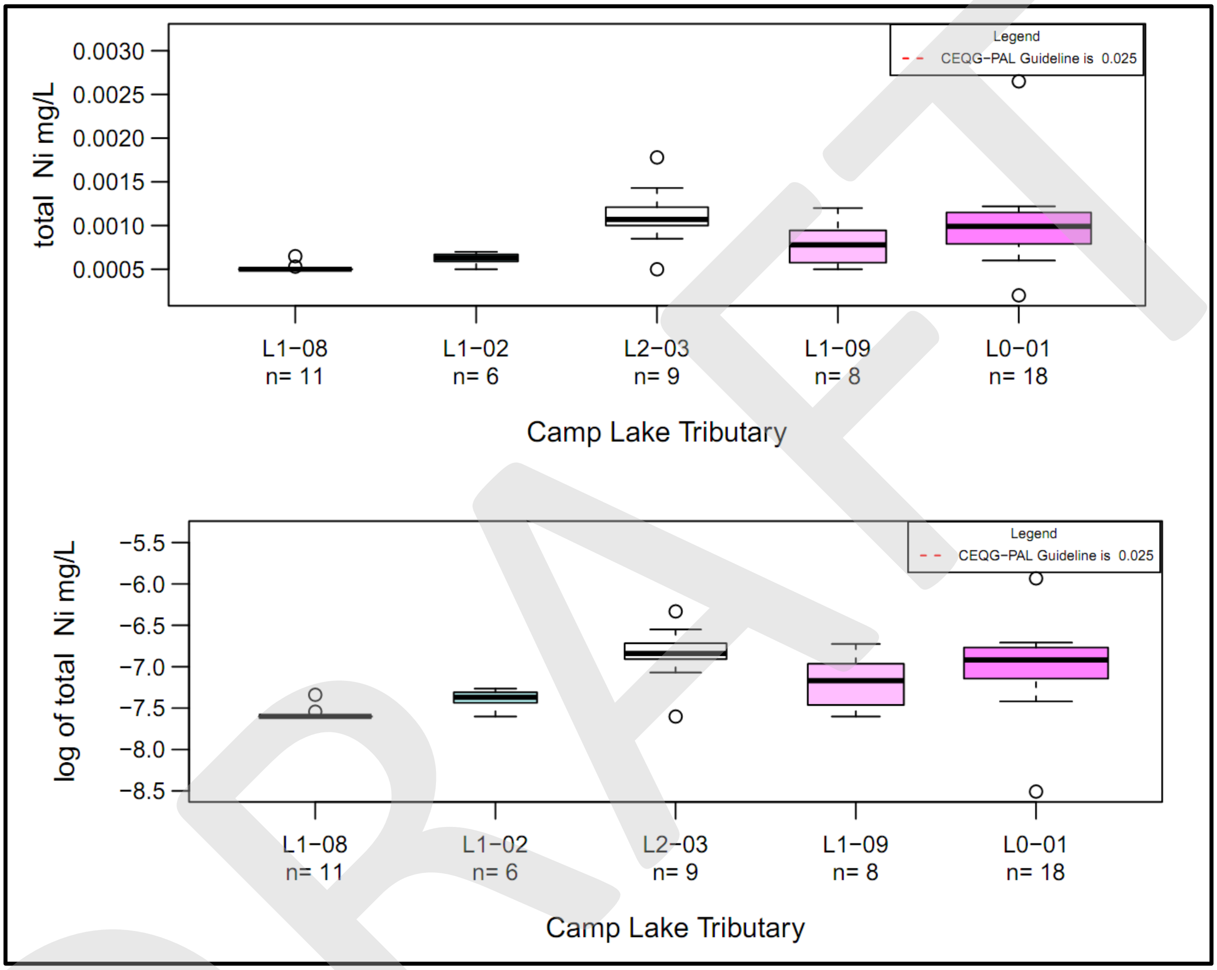
Figure C.33 Camp Lake Tributary – Variability of Total Iron in Water

Total Nickel (Figures C.34 and C.35)

Fifty-two (52) total nickel samples were collected in the Camp Lake Tributary area with 6 to 18 samples collected at each geographically distinct sampling station. Baseline nickel concentrations are consistently low, but occur above MDL (Figure C.34).

All measured concentrations of nickel occur well below the CWQG-PAL guideline, which is a hardness dependent guideline (calculated to be 0.025 mg/L with 50 mg/L $CaCO_3$). Similar to iron, nickel concentrations at L2-03 are slightly elevated compared to other stations, with concentrations at L0-01 occuring just behind those at L2-03.

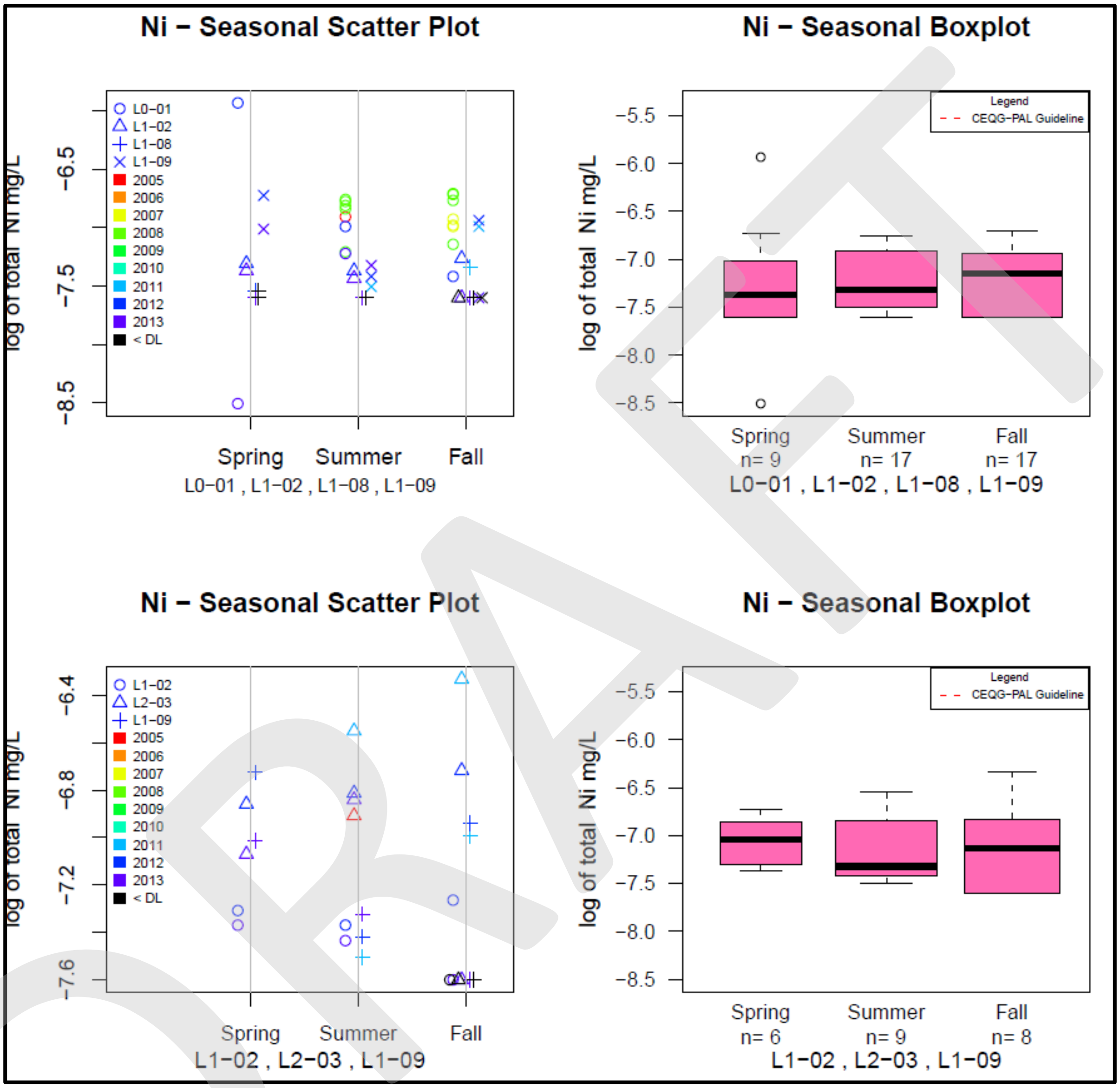
Seasonal box plots show consistent median iron concentration, regardless of season (Figure C.35). In addition, no consistent temporal trends are noted over the eight-year sampling history.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.34 Camp Lake Tributary – Total Nickel Concentrations in Water



NOTES:

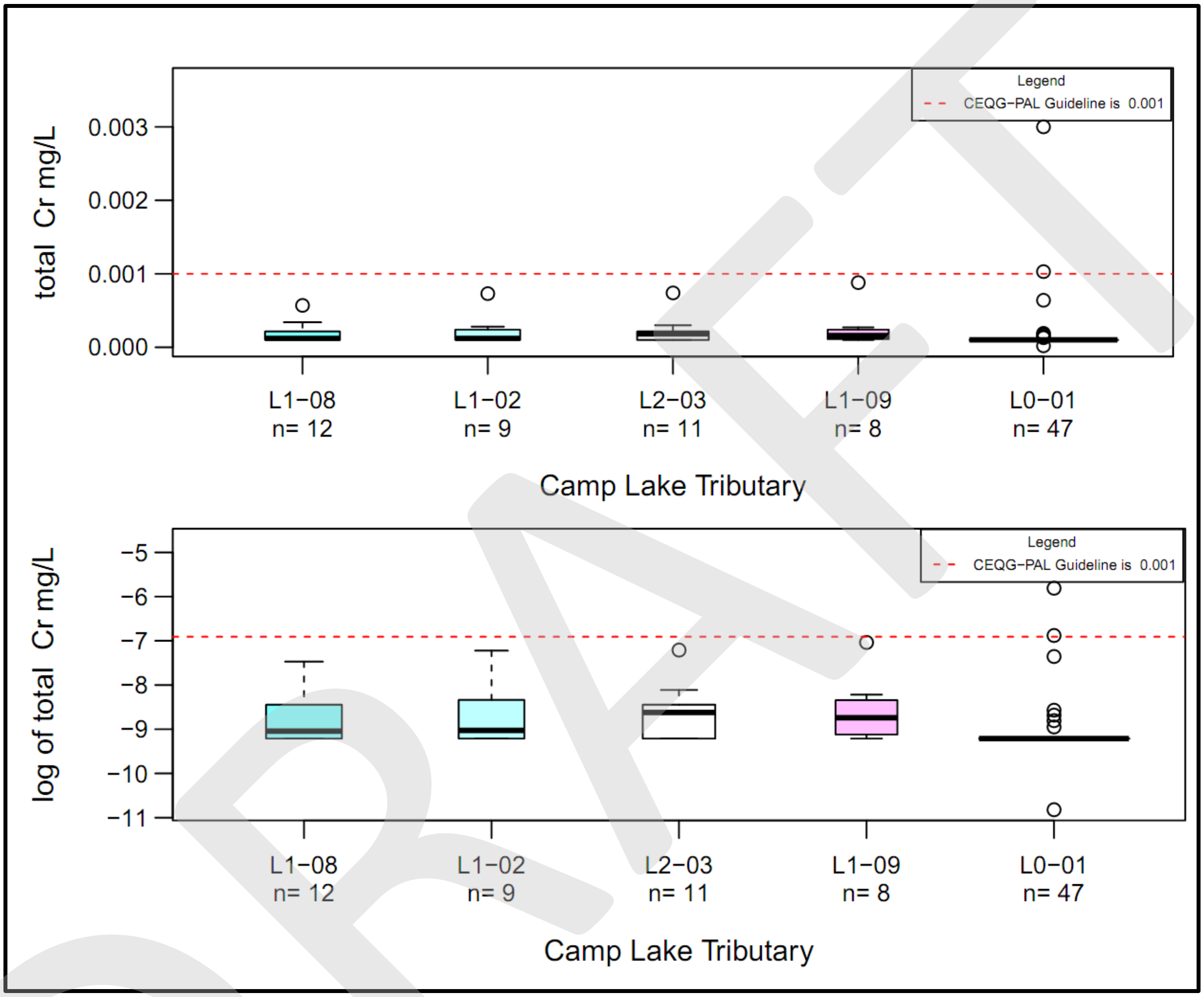
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.35 Camp Lake Tributary – Nickel Data Aggregation

Total Chromium (Figures C.36 and C.37)

Eighty-seven (87) total chromium samples were collected in the Camp Lake Tributary area with six to forty-seven samples collected at each geographically distinct sampling station. Baseline chromium concentrations are consistently elevated and occur close to the CWQG-PAL guideline (Figure C.36).

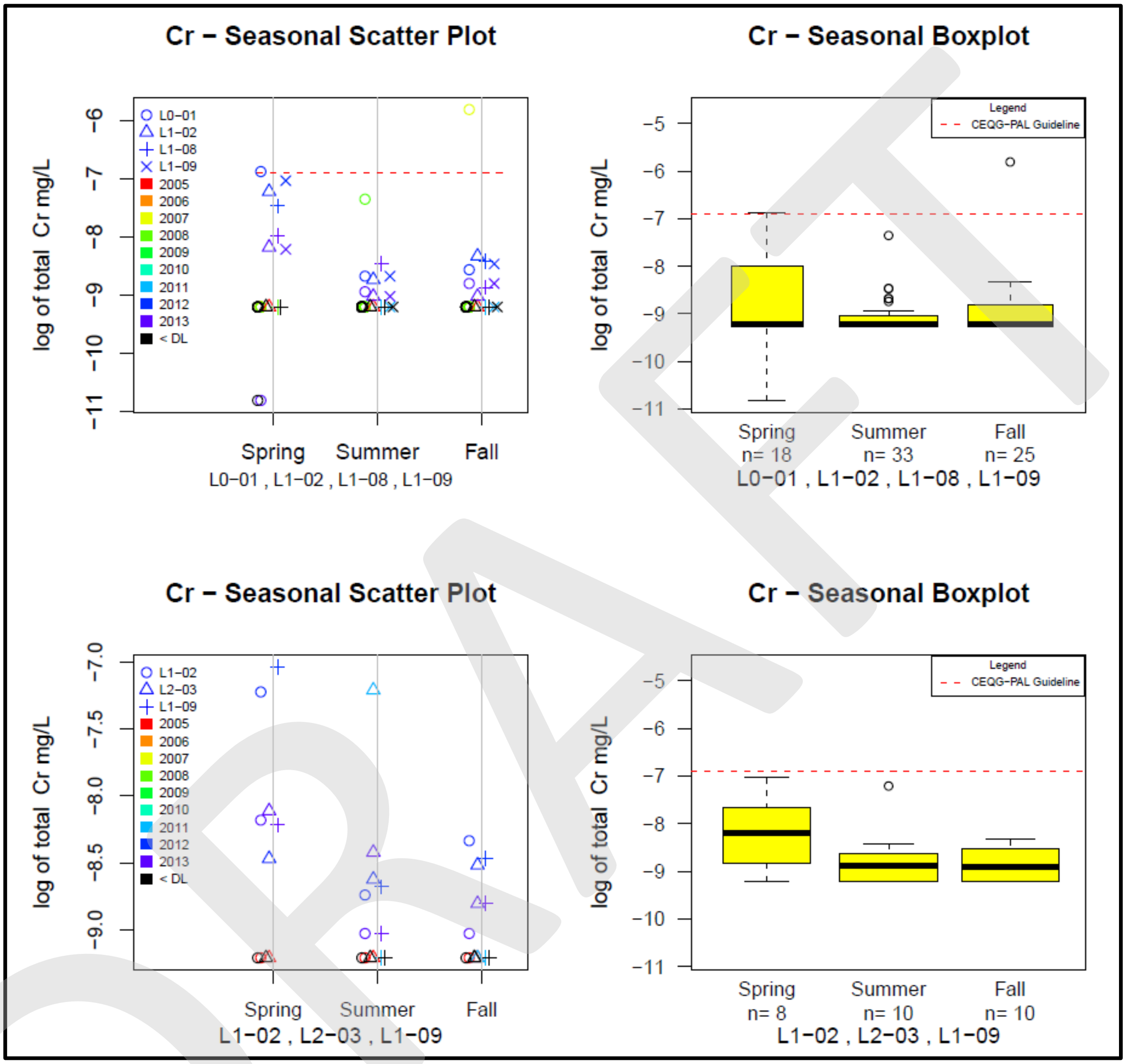
Seasonal box plots show consistent median chromium concentrations, regardless of season (Figure C.37). Data from 2012 and 2013 show slightly elevated values compared to previous years, but insufficient amount of data is avialable to prove this is the case.



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.36 Camp Lake Tributary – Total Chromium Concentrations in Water



NOTES:

1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure C.37 Camp Lake Tributary – Chromium Data Aggregation

Summary of trends observed during review of Camp Lake Tributary baseline data:

- Station L0-01 has the greatest sample size, with sample size ranging from 30 to 61, depending on the parameter sampled.
- Aluminum and chromium data from 2012 and 2013 was observed to be slightly elevated when compared to other data.
- The L2-03 station recorded slightly higher concentrations of chloride, iron and nickel.

- Seasonal trends occurred for some parameters, and were specific to the parameter: baseline chloride concentrations were highest in the fall, lowest in the spring; aluminum concentration were highest in the spring, lowest in fall; nickel, chromium and iron had consistent median values, regardless of season and copper concentrations were highest in the summer, lowest in the spring.
- Nitrate, arsenic and cadmium were consistently measured to occur below MDLs and seasonal trends were not observed, due to detection limit interference.

C.3.3 River Summary

Since 2005, a variety of watercourses have been sampled as part of the baseline monitoring program. For the purposes of the CREMP, a subset of the total stations was selected that were deemed applicable for future monitoring. As a result, only two river/tributary systems were examined: Mary River and the Camp Lake Tributary. In general, similar station-wide and seasonal trends were noted for each parameter within rivers/tributary systems on the property. No distinct inter-annual trends were noted. Comparison of the general chemistry of the two systems indicates the general composition is quite similar: water is characterised as circum-neutral/slightly alkaline pH and high alkalinity/low sensitivity to acidic inputs. Hardness ranges from “soft” to “moderately soft” and is almost entirely carbonate hardness.

Chemical concentration trends were analysed with the knowledge that the intense spring runoff period resulting from winter snowpack melting characterizes the artic hydrologic cycle (Stewart and Lamoureux, 2011). Our data indicates highest trace metal concentrations occur during summer (and occasionally fall), and that spring concentrations are generally lowest. This indicates that the snowpack is acting as a fresh, diluting seasonal input.

Station-wide, nitrate, arsenic and cadmium general occur at detection limit. Chloride and nickel generally occur above MDL, but below guideline values. Chloride concentration increases through the seasons from the lowest recorded concentration in the spring to the highest recorded concentrations in the fall. In Mary River, the highest nickel concentrations occur in the summer; whereas, no seasonal trends are noted for nickel within the Camp Lake Tributary. Copper concentrations are consistently close to guideline value throughout the station, with highest concentrations occurring in the summer and fall.

Aluminum and iron show slightly different trends between stations within Mary River and the Camp Lake Tributary. Within Mary River, median total aluminium concentrations occur above CWQG-PAL guideline, but below the SSWQO and are highest during the summer. Within the Camp Lake Tributary, median total aluminum concentrations are generally low and below the CWQG guideline and are highest during the spring. Total iron concentrations within Mary River are consistently close to the guideline, with maximum values exceeding guideline and highest concentrations occurring in the summer. Within the Camp Lake Tributary, iron concentrations are consistently below guidelines, with maximum values occurring during the spring.

It is observed that the MDLs are higher for Cr (III) and Cr (VI) compared to total chromium. As such, 38% of samples in Mary River analyzed for total chromium were above MDL. Only 5% of Cr (III) and 2% of Cr (VI) samples were above MDLs. This supports the assumption that most chromium is in suspended particulate.

C.4 POWER ANALYSIS

Parameter and station-specific power analyses were completed in order to determine the power of the proposed sampling program to detect statistical changes. As per the AEMP Assessment Approach and Response Framework (Figure 2.12 in the main report), management action will be triggered if the mean concentrations of any parameter at selected stations reach benchmark values. Benchmarks have been developed as reference concentrations for comparison in the response framework (Intrinsik, 2014). Sufficient statistical power is required to ensure that management action is triggered correctly, and this has necessitated the completion of a power analysis. Inputs to the power analyses include all baseline data sampled to date and the benchmark values. The methodology used in the following sections follows closely the methodology used on lake water quality data in Appendix B.

The *a priori* power analysis determines, based on a given sample size, variability and effect size[2], the number of samples required to obtain a certain power at a certain alpha value or Type I error rate. The analysis utilized a two-sided alpha value of 0.10 (with an alpha of 0.05 on each side). The power analyses were run based on two effect sizes: 1) the difference between the station baseline mean and benchmark and 2) halfway between the station baseline mean and benchmark.

The following parameters were selected for power analysis as they have a large number of detected values, have elevated concentrations during baseline conditions and are expected to be the most affected parameters during mine operation:

- Aluminum
- Arsenic
- Cadmium
- Copper
- Iron

Two different types of power analysis were run, depending on the proportion of data above MDL. Several modifications to each approach were taken, depending on availability of data at a specific site.

1) The power to detect a change in means was assessed for parameters with sufficient data above MDL (<15% of non-detected data). A before-after-control-impact (BACI) design was used to assess the power to detect differences in log mean concentration values (using the methods of Stroup, 1999)[3]. A BACI design is rigorous in the sense that it shows a change in the difference between impact (exposure) and control (reference) stations from before to after the commencement of a potential environmental impact. This method accounts for background natural variation, such as seasonal trends, that may occur during the same period as the potential environmental impact. In order to utilize this design, sufficient baseline data is required at both control and impact sites.

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[2] Effect size is the magnitude of an effect. In *a priori* power analysis, the effect size quantifies the magnitude difference between two groups that the test will be able to determine.

[3] Comparison of medians or log means are both supported methods to compare data sets. Median comparisons are more robust when distributions are non-normally distributed. Median or mean comparisons are equally robust when distributions are normally distributed. Log distribution of water quality data collected created a data set that was normally distributed. As a result, mean comparison was determined appropriate.

For the purposes of analysis, for parameters with <15% non-detected data, only detected data was analyzed. This method was selected due to a variety of detection limits present in the historic data. In some cases, imputation of detection limits occurred, as discussed in Section 2.2. Although all imputation assumptions were conservative; analysis of the detected data removes the possibility that data analysis was affected by imputation or elevated detection limits. To verify the use of the detected data to inform mean values for the power analysis, the mean values estimated with detected data are compared to the mean values estimated via Regression on Order (ROS) method. The Regression on Order (ROS) statistics method is recommended by the BC Ministry of Environment as a method to calculate statistics in data sets including non-detects and especially those affected by left-censored data (Huston and Juarez-Colunga, 2009). Both of these values are provided for each key parameter examined for the sake of comparison. In general, the mean estimate based on detected data is larger than the ROS estimate. This is conservative for the power analysis as a higher baseline mean corresponds to a smaller change to be detected post mining.

The following modifications to the complete BACI approach were taken, as dictated by the data available:

a. Before-after (BA) design was used when control data was not available. Under this design, power analysis was carried out using a two sample t-test to compare means. This approach is less rigorous when compared to the BACI design and does not control for natural temporal changes.

b. Control-impact (CI) design was assumed when very little baseline data was available. Under this design, power analysis for testing means was carried out using a paired t-test. This approach is less rigorous when compared to the BACI design does not control for natural geographic differences between the control and impact sites.

2) The power to detect a change in the proportion of values above MDL was assessed for parameters with a large proportion of values below MDL (>15% of non-detected data). For some parameters the baseline dataset is represented predominantly by values below MDL. This occurred for arsenic and cadmium at all stations. For these parameters, the exact magnitude of the parameters under baseline conditions is unknown. Although a full BACI analysis will be carried out for data analysis purposes, simplified designs were assumed for the power analysis. Two approaches were utilized for the test of proportions:

a. BA designs were assessed using a test for two independent proportions (Agresti, 1990).

b. McNemar’s test (Agresti, 1990) was used to assess the power to detect a difference between the paired proportions at impact and control stations. As for continuous data, pairing allows exploitation of the fact that the variance of the difference between paired data is smaller than the variance of the difference between independent samples (Agresti, 1990). Under a full BACI design, the baseline and post-mining paired proportions can be compared to assess whether a change is mine related.

McNemar test for the equivalence of paired proportions (each impact sample paired with a correlated control sample collected at a comparable time) is carried out using the off-diagonal elements (p_{01} and p_{10}) of a 2x2 contingency table. It is helpful to reference Table C.3 for discussions related to the analysis of proportions. This is a novel approach that enables the use of data highly affected by censored data, where a meaningful comparison of means is not possible and the utility of left-censored methods is limited. To our knowledge, this approach has not been used in other projects, but is supported within scientific literature as a valid method to deal with left-censored data (Agresti, 1990).

Table C.3 Proportion Labels for 2x2 Contingency Table

Impact	Control		
	<MDL	>MDL	Total
<MDL	p_{00}	p_{01}	p_{0+}
>MDL	p_{10}	p_{11}	p_{1+}
Total	p_{+0}	p_{+1}	p_{++}

Stations were strategically selected to ensure sampling, and subsequent statistical testing would provide information regarding the source of the contaminants, if any, that arise during the course of mine development. Carrying out the power analysis for each station separately ensures sufficient power to detect change at each location. This is important as pooling data from near-field and far-field stations could potentially wash out effects at near field stations. By choosing stations located at various distances from a potential contaminant source, the spatial extent of potential impacts can be identified and the impact source(s) potentially isolated. These stations are specific to the water body.

C.4.1 Camp Lake Tributary

C.4.1.1 Methods

No pre-mining reference stations were available and the analysis was run assuming no control data, using a before-after (BA) design. Three key monitoring stations within the Camp Lake tributary were assessed. These stations also correspond to the Camp Lake tributary near-field and far-field exposure areas examined as part of the EEM.

- L0-01
- L1-09
- L1-02

Very few data points exist for L1-09 and L1-02, and the most number of samples at Camp Lake tributary were collected for L0-01. By assessing these key points, that also contain the smallest sample sizes, the study design is designed conservatively.

Metrics for sample size, median, mean and standard deviation will be used as a method to compare power between stations for a variety of lakes. In general, sample sets that have a lower sample size, higher variability and a small difference between station baseline mean and benchmark have low power.

C.4.1.2 Results

Since the power analysis was completed on a station-specific and parameter-specific basis, the results were interpreted by identifying the stations and parameters that are most constraining. Table B.5 highlights the stations and parameters that are expected to constrain power. Note that this power analysis is conservative because the effect size used is equal to halfway between the station baseline mean and the benchmark. It is not unexpected that aluminum is a constraining factor across a number of stations since aluminum is the most enriched metal during baseline conditions. Analysis of Table C.4 shows that stations identified as constraining factors for aluminum concentrations are those stations where the distribution of aluminum data occurs close to the benchmark. Discussion of each parameter follows.

Table C.4 Camp Lake Tributary Power Analysis – Constraining Stations and Parameters

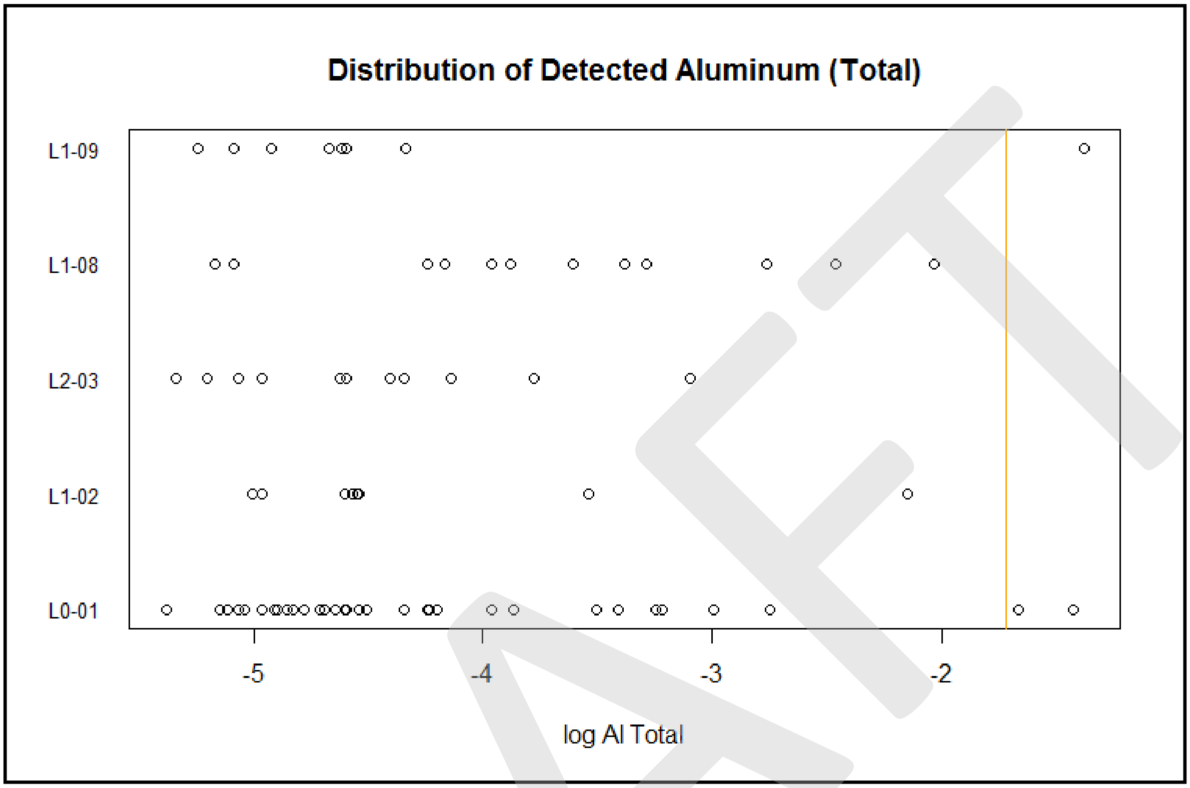
Parameter	Station	Waterbody	Power (given sample size of 10, alpha of 0.1)	Power (given sample size of 50)
Copper	L1-09	Camp Lake Tributary	58%	78%
	L1-02	Camp Lake Tributary	40%	58%
Iron	L1-09	Camp Lake Tributary	60%	80%
	L1-02	Camp Lake Tributary	65%	82%
Aluminum	L1-09	Camp Lake Tributary	70%	90%

NOTES:
1. POWER IS CALCULATED BASED ON AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION BASELINE MEAN AND BENCHMARK.

Aluminum

Total aluminum values are elevated throughout the mine site area but concentrations are significantly reduced in the Camp Lake Tributary when compared to the Mary River. Within the Camp Lake Tributary, measured baseline aluminum concentrations have several values that exceed the benchmark at L0-01 and L1-09 (Figure C.38). All measured concentrations at L1-08, L2-03 and L1-02 occur below the benchmark value. The benchmark for aluminum within the Camp Lake Tributary is 0.18 mg/L.

Five (5) samples are expected to be sufficient given an alpha value of 0.1 at all sites with the exception of L1-08 and L1-09, which are anticipated to require 5-10 and 20 samples, respectively.



NOTES:

1. THE CAMP LAKE TRIBUTARY BENCHMARK FOR ALUMINUM IS 0.18 mg/L (LOG VALUE = -1.7), DISPLAYED AS YELLOW LINE.

Figure C.38 Detected Total Aluminum Values in Camp Lake Relative to Benchmark

Table C.5 Results of Aluminum Power Analysis – Camp Lake Tributary Stations

Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
L0-01	47	39	0.010	0.047	-4.3	0.91	-4.6	0.18	-1.7	2.6	5
L1-02	9	8	0.011	0.038	-4.2	1.0	-4.5	0.18	-1.7	2.5	5
L2-03	11	11	0.010	0.012	-4.5	0.67	-4.5	0.18	-1.7	2.8	~5[2]
L1-08	12	12	0.024	0.037	-3.7	0.96	-4.7	0.18	-1.7	1.9	~5-10[2]
L1-09	8	8	0.010	0.086	-4.4	1.2	-4.4	0.18	-1.7	2.6	20

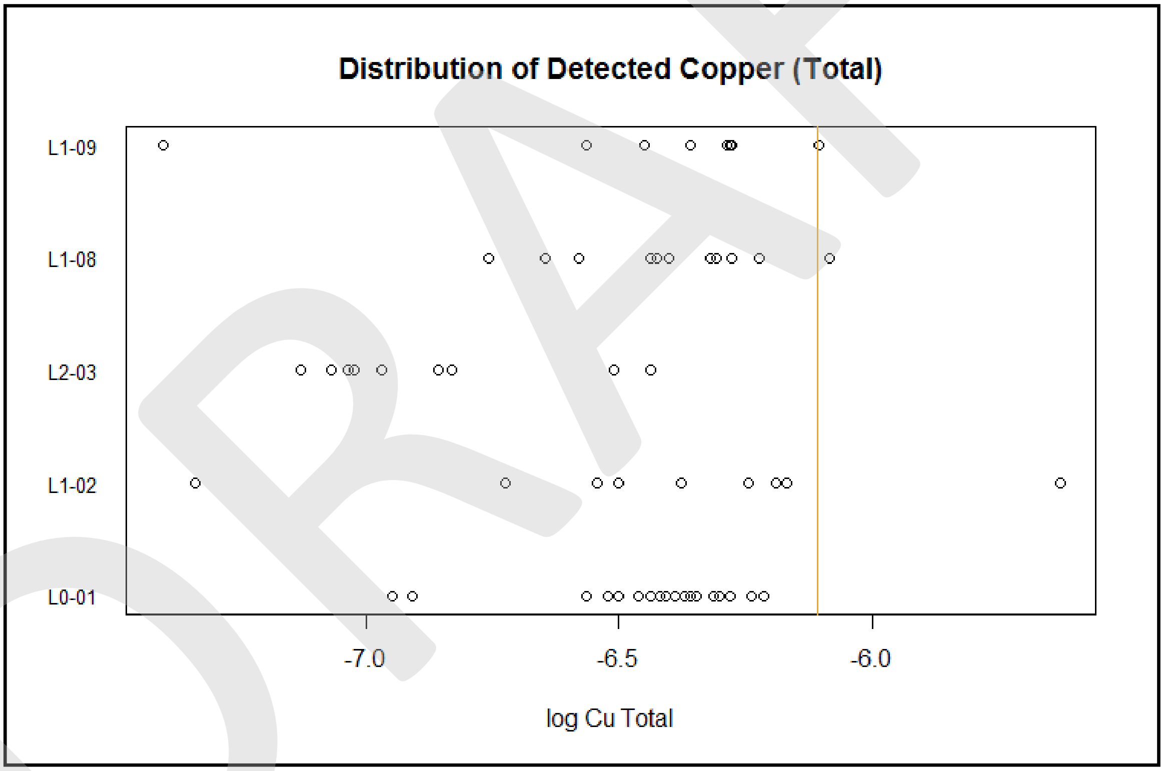
NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR STATIONS.
3. ALL STATISTICS EXCEPT THE ROS LOG MEAN ARE CALCLUATED BASED ON DETECTED DATA. ROS LOG MEAN DATA IS CALCULATED BASED ON BOTH DETECTED AND NONDETECTED DATA.

Copper

Total copper values are observed to be elevated site-wide and are particularly elevated within Mary River and Camp Lake tributary. Median copper values for stations within the Camp Lake tributary range from 0.00094 mg/L to 0.0016 mg/L. The CWQG-PAL guideline for copper is 0.002 mg/L and the benchmark value is 0.0022 mg/L (log value of -6.1). Figure C.39 shows that even though L0-01, L1-02 and L1-9 have median copper concentrations that vary slightly, the distribution of values are quite different.

L1-02 and L1-09 stations are problematic in obtaining adequate sample size to test for pre-mining and post-mining differences in copper. Even with the collection of fifty samples at these stations, the power obtained is still less than adequate (78% for L1-02 and 58% for L1-09) (Table C.6). The power analysis is constrained by the small baseline sample size, which is expected to increase after 2014 sampling.



NOTES:

1. THE CAMP LAKE TRIBUTARY BENCHMARK FOR COPPER IS 0.0022 mg/L (-6.1), DISPLAYED AS YELLOW LINE.

Figure C.39 Detected Total Copper Values in Camp Lake Tributary Relative to Benchmark

Table C.6 Results of Copper Power Analysis – Camp Lake Tributary Stations

Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Bench mark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
L0-01	44	42	0.0016	0.00041	-6.5	0.29	-6.5	0.0022	-6.1	0.40	20
L1-02	9	9	0.0017	0.0008	-6.4	0.47	-6.4	0.0022	-6.1	0.30	50
L2-03	11	9	0.00094	0.00029	-6.9	0.25	-7.0	0.0022	-6.1	0.76	NA
L1-08	12	12	0.0016	0.00031	-6.4	0.19	-6.4	0.0022	-6.1	0.30	NA
L1-09	8	8	0.0018	0.00048	-6.5	0.40	-6.5	0.0022	-6.1	0.36	50

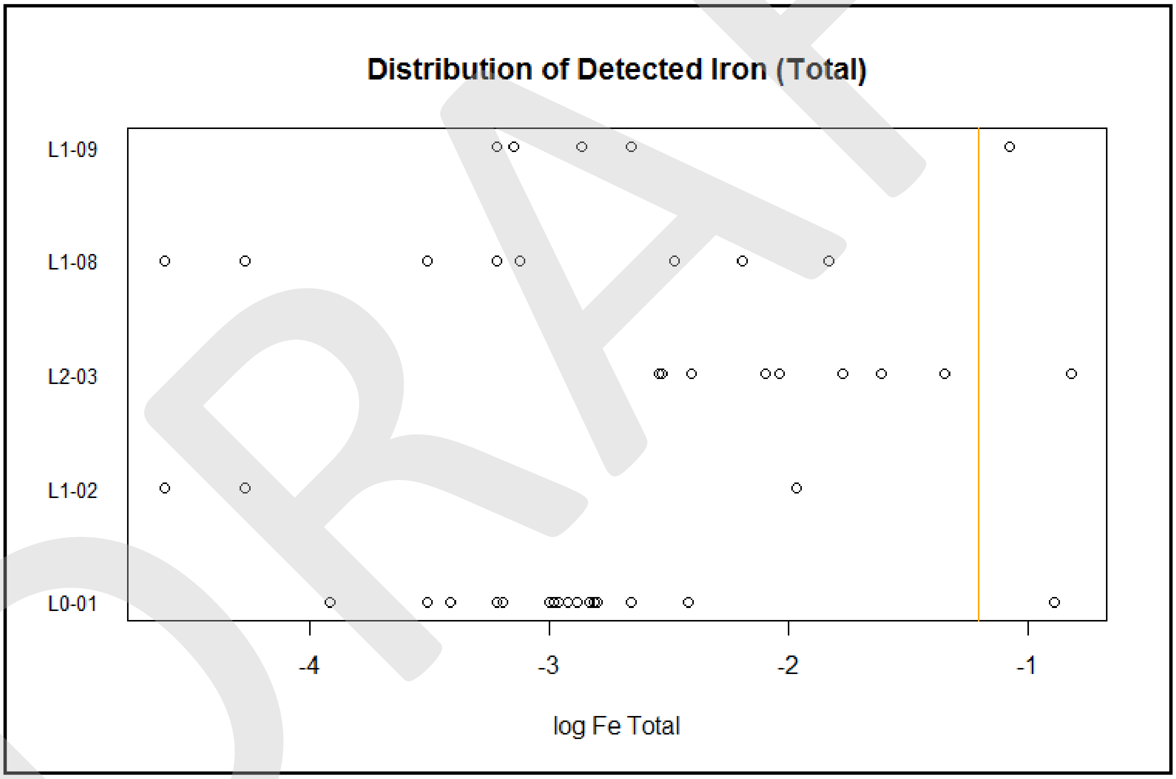
NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. NA STATIONS WERE NOT ASSESSED AND CANNOT BE ESTIMATED BASED ON ASSESSED STATIONS.
3. ALL STATISTICS EXCEPT THE ROS LOG MEAN ARE CALCLUATED BASED ON DETECTED DATA. ROS LOG MEAN DATA IS CALCULATED BASED ON BOTH DETECTED AND NONDETECTED DATA.

Iron

Similar to aluminum and copper, iron concentrations are moderately elevated within the Camp Lake Tributary (Figure C.40). Median iron concentrations within the Camp Lake tributary range from 0.042 mg/L to 0.11 mg/L and the number of detectable samples ranges from 8 through 47.

As expected, the L0-01 station requires the least amount of samples post-mining to detect a statistical change (Table C.7). This is as a result of a high sample size for pre-mining data (36) and a low median iron concentration. Twenty post-mining samples are predicted to be required at L1-02, due mostly to the low sample size of pre-mining data. L1-09 proves to be a problematic station to determine significant differences for iron. This station has a low sample size and very high standard deviation. At L1-09, up to 50 samples are required to achieve 80% power. It is expected that the number of samples required at these stations will decrease after the completion of 2014 sampling; however, additional samples at L1-09 in particular key location is recommended to increase power.



NOTES:

1. THE BENCHMARK FOR IRON IN THE CAMP LAKE TRIBUTARY IS 0.3 mg/L (LOG VALUE = -1.2), DISPLAYED AS YELLOW LINE.

Figure C.40 Detected Total Iron Values in Camp Lake Tributary Relative to Benchmark

Table C.7 Results of Iron Power Analysis – Camp Lake Tributary Stations

Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Bench mark Value (mg/L)	Log Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
L0-01	47	36	0.052	0.061	-2.9	0.46	-3.1	0.30	-1.2	1.7	5
L1-02	9	5	0.014	0.057	-3.9	1.1	-4.4	0.30	-1.2	2.7	20
L2-03	11	10	0.150	0.110	-1.9	0.55	-2.0	0.30	-1.2	0.7	NA
L1-08	12	8	0.042	0.053	-3.2	0.97	NA	0.30	-1.2	1.9	NA
L1-09	8	7	0.070	0.107	-2.6	0.7	-2.8	0.30	-1.2	1.4	50

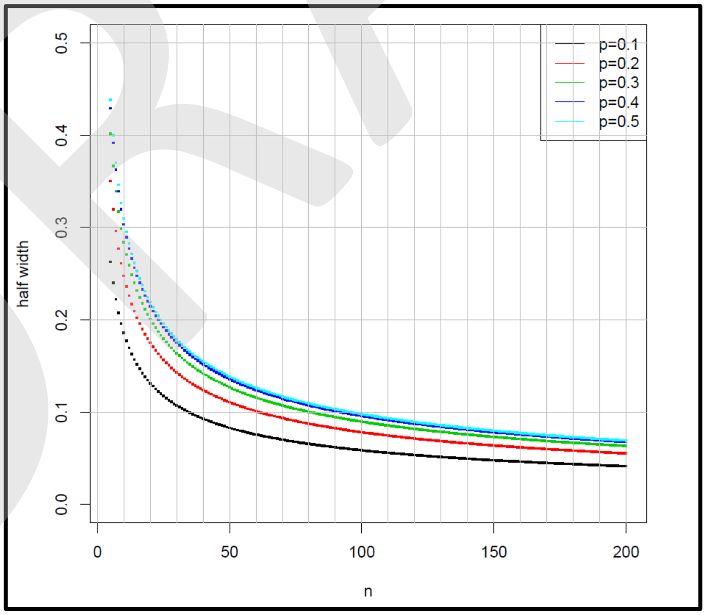
NOTES:

1. REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. NA STATIONS WERE NOT ASSESSED AND CANNOT BE ESTIMATED BASED ON EXISTING STATIONS.
3. ALL STATISTICS EXCEPT THE ROS LOG MEAN ARE CALCLUATED BASED ON DETECTED DATA. ROS LOG MEAN DATA IS CALCULATED BASED ON BOTH DETECTED AND NONDETECTED DATA.

Arsenic and Cadmium

More than 90% of samples at each station in the Camp Lake Tributary have arsenic and cadmium concentrations that are below detection limits. As a result, assessment of the proportion of values above MDL was used for these parameters. A normal approximation to the binomial distribution was used to obtain the estimates of the width of confidence intervals for various proportions and sample sizes (based on a normal approximation) shown in Figure C.41. A statistically significant difference between proportions is equivalent to non-overlapping confidence intervals (CI) for the baseline and post-mining proportions. Figure C.41 can be used to determine the accuracy of the proportion estimates (CI) for various proportions and samples sizes. For arsenic and cadmium, the proportion of values below detection limits is greater than 90% (10% above); therefore, the p=0.1 line (black) is selected. For example, L0-01 has a baseline sample size of 47. Thus, a 95% CI on a proportion would be 0.1+/- 0.085 or (1.5%, 18.5%). The post-mining confidence interval for 50% above MDL with 20 samples would be 0.5 +/- 0.22 or (28%, 72%) and would be sufficient to detect such a change. The normal approximation does not hold for small sample sizes and extreme proportions but an exact confidence interval can be calculated. A sample size of 10 would produce a 95% baseline CI of (2%, 40%). Thus, only a large change to approximately 65% (CI = (44%, 86%)) above MDL would differ for a sample 20.

The power to detect a difference between independent samples can also be calculated. To detect a change from 10% to 50% approximately 20 samples are required at baseline and post-mining. With only 10 baseline samples and 10 post-mining samples, 80% power can be obtained for a larger change to 68% above MDL.



NOTES:

1. P EQUALS PROPORTION OF SAMPLES BELOW DETECTION LIMIT.

Figure C.41 Half 95% Confidence Interval Width for Proportions – L0-01

C.4.2 Mary River

C.4.2.1 Methods

Similar to the methods used for the Camp Lake Tributary power analysis, parameter and station-specific power analyses were completed in order to determine the power of the proposed sampling program to detect statistical changes. In contrast to the method used for the Camp Lake Tributary power analysis, pre-mining reference and impact stations exist; therefore, a complete Before-After-Control-Impact (BACI) analysis is utilized.

The stations along the Mary River used in the power analysis were:

- E0-10
- E0-03
- E0-21 and E0-20 (pooled), and
- C0-10.

The best reference station for each impact station was considered to be the G0-09 value collected on the same day. Comparing data on the same day was considered optimal as it would minimize the effects of time. Since data from the same day was not always available, the data was infilled using the following alternatives, listed in order of priority and data proximity (0:29 with 0 indicating the best quality):

- 0-4: G0-09 same day, within 1 day, within 2 days, within 3 days, within 4 days
- 5-9: G0-03 same day, within 1 day, within 2 days, within 3 days, within 4 days
- 10-14: G0-01 same day, within 1 day, within 2 days, within 3 days, within 4 days
- 15-19: G0-09 within 5 days, within 6 days, within 7 days
- 20-24: G0-03 within 5 days, within 6 days, within 7 days, and
- 25-29: G0-01 within 5 days, within 6 days, within 7 days.

For future sampling, it is recommended that the timing of sampling for impact and control sites occur as closely as possible.

C.4.2.2 Results

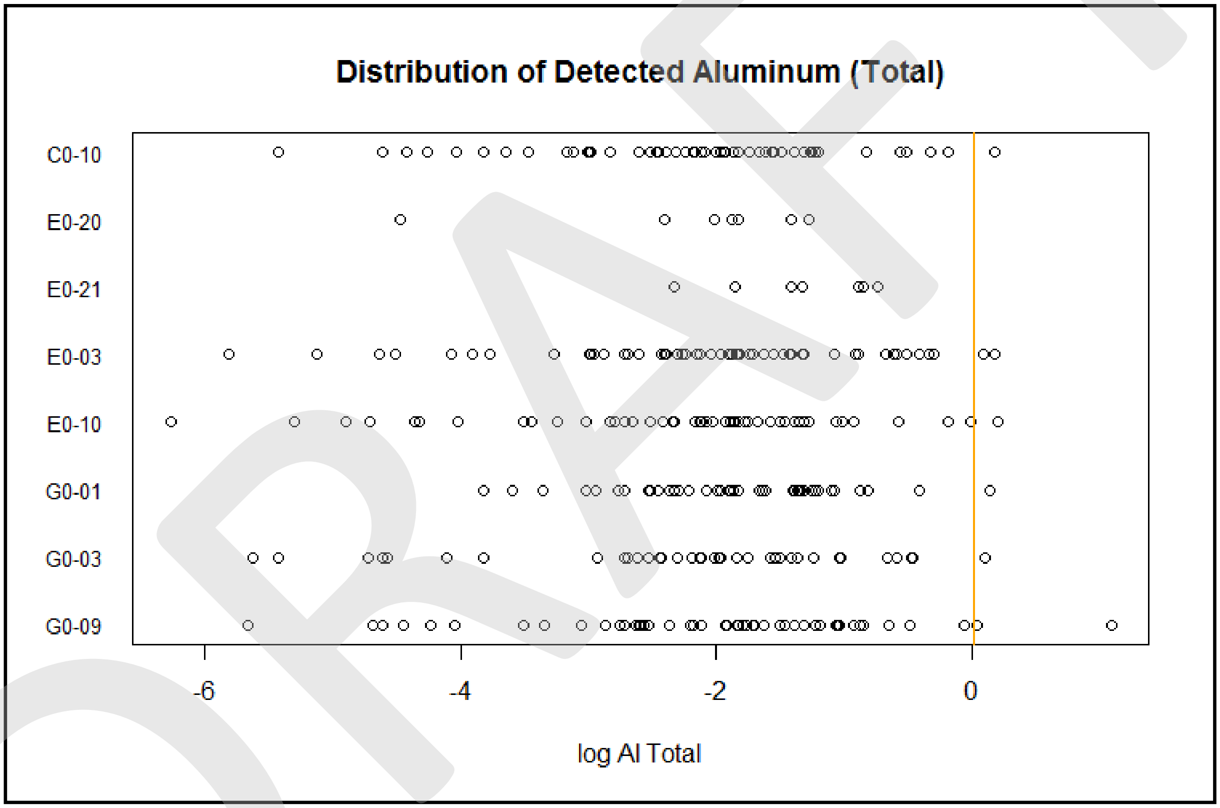
Since the power analysis was completed on a station-specific and parameter-specific basis, the results were interpreted by parameter and station. Unlike the Camp Lake Tributary, no particularly constraining stations or parameters were identified. Power analysis determined between five to ten samples are sufficient to provide 80% power at key stations within the Mary River. Discussion of each parameter individually follows.

Aluminum

Aluminum concentrations are elevated site-wide and are particularly elevated within Mary River. Median aluminum concentrations obtained from all stations in Mary River exceed the CWQG-PAL guideline (0.10 mg/L). The benchmark derived for aluminum is based on the 97.5th percentile of baseline concentrations, and is 1.01 mg/L, which is approximately one order of magnitude greater than the CWQG-PAL guideline. Median aluminum concentrations from the examined stations within Mary River range from 0.13 mg/L to 0.35 mg/L, and standard deviations range from 0.093 mg/L to

0.23 mg/L (Table C.8). Based on the existing baseline and reference data (from stations G0-09, G0-03 and G0-01), all key stations in the Mary River require between eight to ten samples to have adequate power to show significant differences in pre-mining and post-mining data. No “constraining” stations were identified, unlike the Camp Lake tributary (Section C3.1) or lakes assessment (Appendix B).

Figure C.42 shows that there is a strong correlation between aluminum concentrations at impact and control stations. For these stations, the standard deviation of the difference between the impact and control data is smaller than the standard deviation of either sample. The BACI design takes advantage of this correlation and is one of the reasons that relatively low sample sizes can achieve high power.



NOTES:

1. THE BENCHMARK FOR ALURMINUM IN MARY RIVER IS 1.01 mg/L (LOG VALUE = 0.01), DISPLAYED IN RED.

Figure C.42 Detected Total Aluminum Values in Mary River with Respect to Benchmark

Table C.8 Results of Aluminum Power Analysis – Mary River

Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
G0-09	52	52	0.15	0.45	-2.1	-0.80	-2.1	1.01	0.01	2.1	NA
G0-03	36	36	0.13	0.23	-2.3	-1.46	-2.3	1.01	0.01	2.2	NA
G0-01	45	45	0.16	0.19	-1.9	-1.65	-1.9	1.01	0.01	1.9	NA
E0-10	48	48	0.14	0.25	-2.3	-1.40	-2.3	1.01	0.01	2.2	10
E0-03	59	59	0.14	0.25	-2.1	-1.37	-2.1	1.01	0.01	2.1	8
E0-21	7	7	0.27	0.14	-1.3	-1.93	-1.3	1.01	0.01	1.3	10
E0-20	7	7	0.15	0.09	-2.2	-2.41	-2.2	1.01	0.01	2.2	
C0-10	53	53	0.12	0.22	-2.2	-1.49	-2.2	1.01	0.01	2.2	8

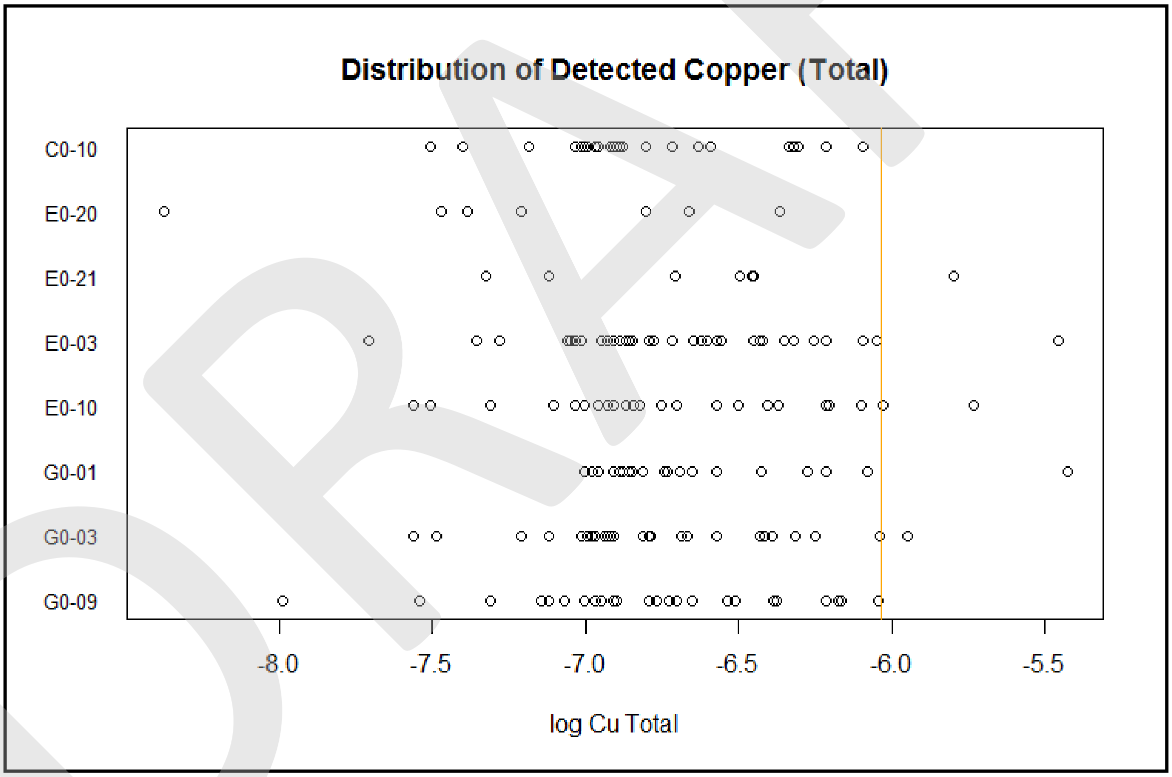
NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR STATIONS.
3. NA STATIONS WERE NOT ASSESSED AND CAN NOT BE ESTIMATED BASED ON EXISTING STATIONS.
4. ALL STATISTICS EXCEPT THE ROS LOG MEAN ARE CALCLUATED BASED ON DETECTED DATA. ROS LOG MEAN DATA IS CALCULATED BASED ON BOTH DETECTED AND NONDETECTED DATA.

Copper

Similar to aluminum, copper is elevated throughout the site. The CWQG-PAL guideline is 0.002 mg/L and the benchmark derived for Mary River is 0.0024 mg/L, which is only slightly above the CWQG-PAL guideline. Median copper values at key stations within Mary river range from 0.00074 mg/L to 0.0015 mg/L (Table C.9). The standard deviation of the baseline copper concentrations at stations along the Mary River are quite low and range from 0.0004 mg/L to 0.00071 mg/L.

Although certain stations have median concentrations that are relatively close to the benchmark (Figure C.43), most stations have median concentrations 50% less than the benchmark and have low standard deviations. As a result, between eight to ten samples are required at the key stations in the Mary River, to achieve 80% power to detect statistical change from baseline concentrations to half of the benchmark value. E0-03 and C0-10 required the least samples (5 and 8, respectively) and E0-20 and E0-21 required the most samples.



NOTES:

1. THE BENCHMARK FOR ALUMINUM IN MARY RIVER IS 0.0024 mg/L (LOG VALUE = -6.0), DISPLAYED IN RED.

Figure C.43 Detected Total Copper Values in Mary River with Respect to Benchmark

Table C.9 Results of Copper Power Analysis – Mary River

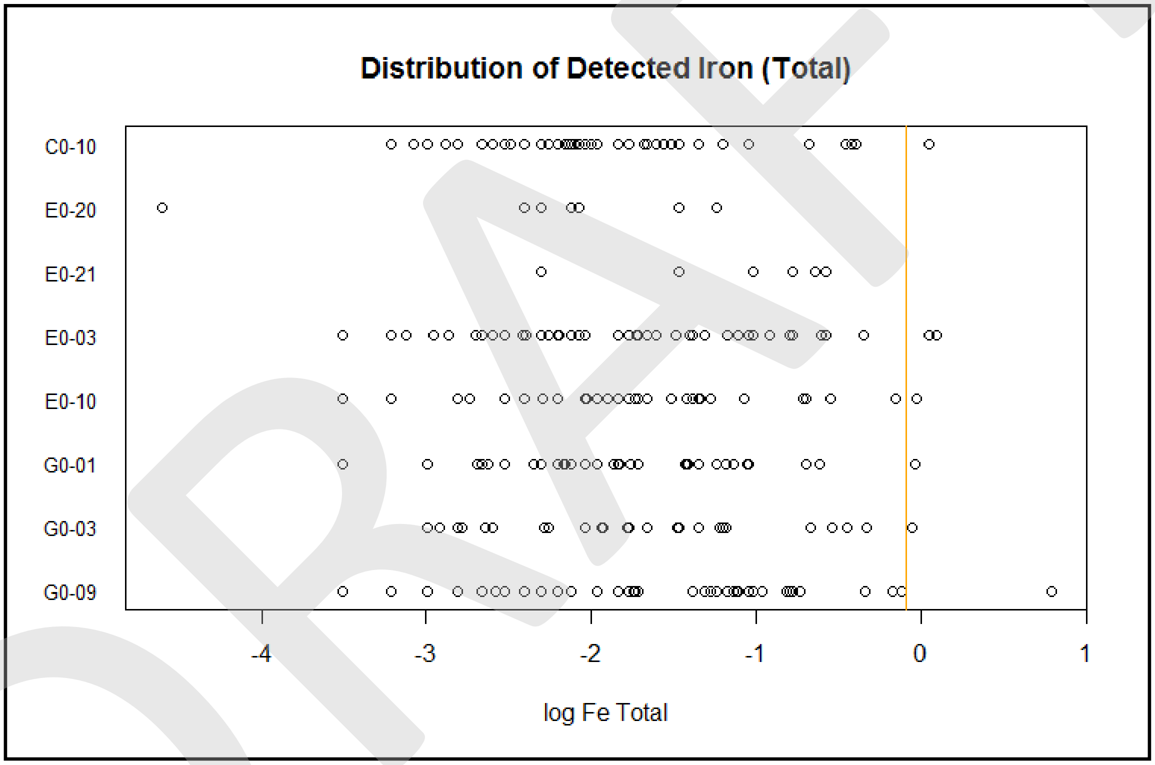
Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
G0-09	36	36	0.0011	0.00051	-6.7	0.42	-6.7	0.0024	-6.0	0.71	NA
G0-03	30	29	0.0010	0.00050	-6.8	0.38	-6.8	0.0024	-6.0	0.76	NA
G0-01	29	27	0.0010	0.00071	-6.7	0.36	-6.8	0.0024	-6.0	0.68	NA
E0-10	28	28	0.0011	0.00065	-6.7	0.47	-6.7	0.0024	-6.0	0.71	10
E0-03	42	41	0.0011	0.00065	-6.7	0.40	-6.7	0.0024	-6.0	0.69	5
E0-21	7	7	0.0015	0.00078	-6.6	0.50	-6.6	0.0024	-6.0	0.59	10
E0-20	7	7	0.00074	0.00050	-7.2	0.66	-7.2	0.0024	-6.0	1.15	
C0-10	35	33	0.0010	0.00040	-6.8	0.32	-6.8	0.0024	-6.0	0.79	8

NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR STATIONS.
3. NA STATIONS WERE NOT ASSESSED AND CAN NOT BE ESTIMATED BASED ON EXISTING STATIONS.
4. ALL STATISTICS EXCEPT THE ROS LOG MEAN ARE CALCLUATED BASED ON DETECTED DATA. ROS LOG MEAN DATA IS CALCULATED BASED ON BOTH DETECTED AND NONDETECTED DATA.

Iron

Iron concentrations are relatively elevated throughout the mine site area, and are particularly elevated within Mary River. Median iron levels at baseline range from 0.12 mg/L through 0.17 mg/L. The CWQG-PAL guideline for iron is 0.30 mg/L and the benchmark value (derived from the 97.5th percentile of baseline data) is 0.92 mg/L (log value of -0.088 mg/L). The power analysis was completed based on the statistical test determining a difference halfway between baseline mean and the 0.916 mg/L benchmark. Due to the high effect size, and the distribution of baseline values (Figure C.44), all key stations within Mary River only require between five to ten samples to obtain 80% power to detect the effect size required (Table C.10).



NOTES:

1. THE BENCHMARK FOR IRON IN MARY RIVER IS 0.92 mg/L (LOG VALUE = -0.880), DISPLAYED AS YELLOW LINE.

Figure C.44 Detected Total Iron Values in Mary River with Respect to Benchmark

Table C.10 Results of Iron Power Analysis – Mary River

Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Benchmark Value (mg/L)	Difference between log mean and log benchmark (mg/L)	N Required
G0-09	52	46	0.17	0.35	-1.8	0.97	-2.0	0.92	-0.088	1.7	NA
G0-03	36	27	0.17	0.23	-1.7	0.85	-2.2	0.92	-0.088	1.7	NA
G0-01	45	42	0.16	0.17	-1.9	0.70	-2.0	0.92	-0.088	1.8	~5
E0-10	48	41	0.14	0.20	-1.9	0.80	-2.2	0.92	-0.088	1.8	5
E0-03	59	52	0.17	0.23	-1.8	0.87	-2.1	0.92	-0.088	1.7	5
E0-21	7	6	0.41	0.18	-1.1	0.66	-1.3	0.92	-0.088	1.0	10
E0-20	7	7	0.12	0.093	-2.3	1.10	-2.3	0.92	-0.088	2.2	
C0-10	58	49	0.13	0.20	-2.0	0.76	-2.1	0.92	-0.088	1.9	5

NOTES:

1. N REQUIRED IS BASED ON A POWER EQUAL TO 80%, AN ALPHA VALUE EQUAL TO 0.1 AND AN EFFECT SIZE EQUAL TO HALFWAY BETWEEN THE STATION MEAN AND THE BENCHMARK. THIS ANALYSIS ASSUMES EQUAL STANDARD DEVIATION BEFORE AND AFTER MINE INFLUENCE.
2. VALUES ESTIMATED BASED ON SIMILAR STATIONS.
3. NA STATIONS WERE NOT ASSESSED AND CAN NOT BE ESTIMATED BASED ON EXISTING STATIONS.
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Arsenic

Baseline concentrations of arsenic are very low site-wide. At each station in the Mary River, between 86% to 96% of arsenic samples at each station measured below detection limits. Median detected values for arsenic ranged from 0.00010 mg/L to 0.00017 mg/L. The benchmark for arsenic equals the CWQG-PAL guideline (0.005 mg/L). Table C.11 and Table C.12 list the proportions of samples above and below MDL at stations within the Mary River. Since baseline data was available for control sites in the Mary River, the power analysis was based on McNemar test for the difference between paired proportions. Based on a two-sided alpha value of 0.1 (0.05 on each side), for a power equal to 80%, to detect a difference in paired proportions indicated by: 10% of observations below MDL at impact and above MDL at control; 40% above MDL at impact and below MDL at control.

Table C.11 Number of Arsenic Samples Above and Below MDL at Mary River Stations

	E0-10		**C0-10**		**E0-03**	
	Control < MDL	**Control > MDL**	**Control < MDL**	**Control > MDL**	**Control < MDL**	**Control > MDL**
Impact < MDL	43	3	47	3	52	4
Impact > MDL	1	1	2	1	2	1

Table C.12 Proportion of Arsenic Samples Above and Below MDL at Mary River Stations

	E0-10		**C0-10**		**E0-03**	
	Control < MDL	**Control > MDL**	**Control < MDL**	**Control > MDL**	**Control < MDL**	**Control > MDL**
Impact < MDL	0.90	0.06	0.89	0.06	0.88	0.07
Impact > MDL	0.02	0.02	0.04	0.02	0.03	0.02

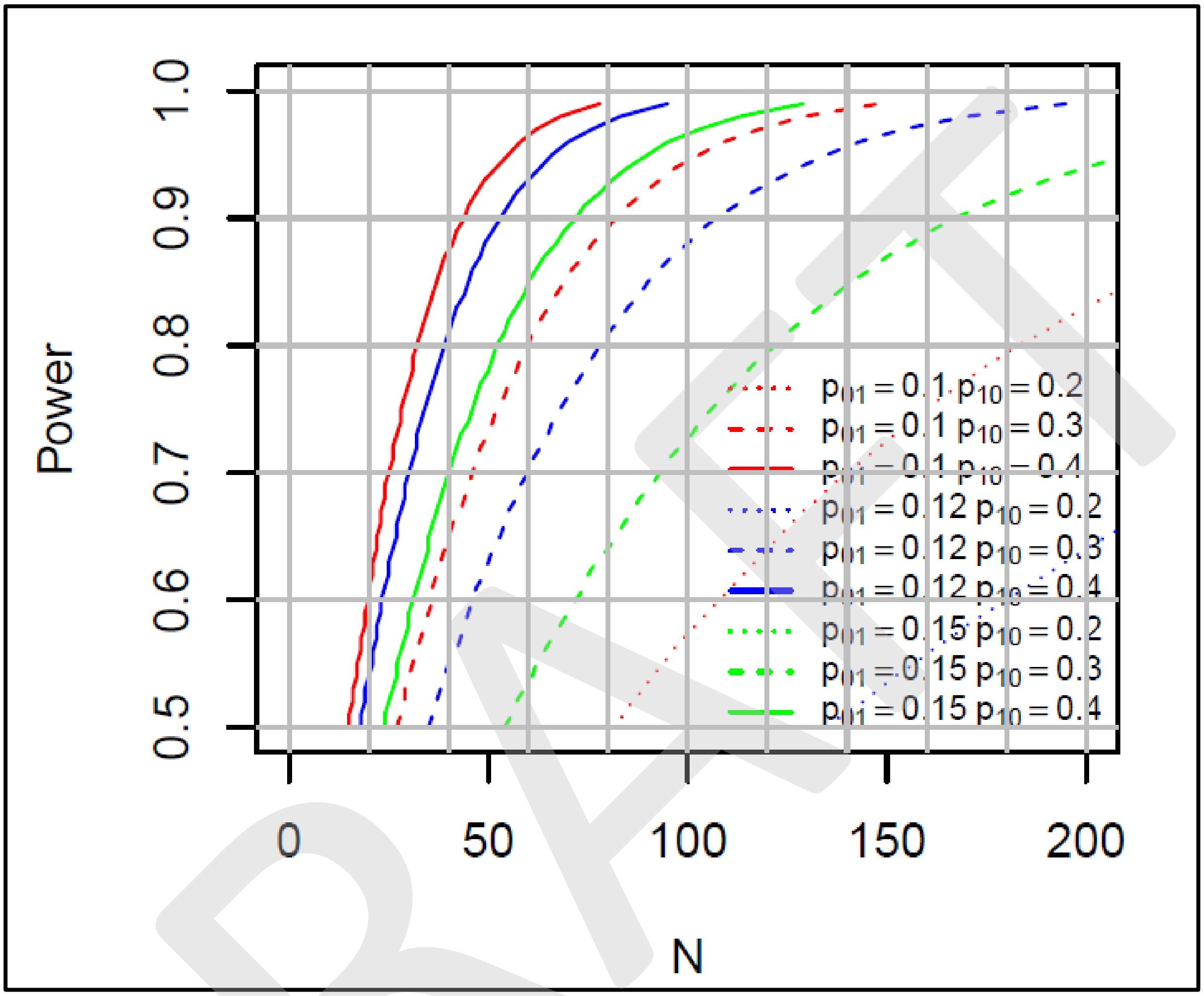

Figure C.45 Arsenic Sample Size Requirements for Equality of Proportions

Cadmium

Baseline concentrations of arsenic are very low site-wide. Between 86% to 100% of cadmium samples at each station in Mary River were below detection limits. Median detected values for cadmium ranged from 0.00001 mg/L to 0.0001 mg/L. The benchmark cadmium equals 0.0001 mg/L. Table C.13 and Table C.14 list the proportions of samples above and below MDL at stations within the Mary River. Based on the McNemar test (using an alpha value of 0.1, for a power equal to 80%), in order to detect a difference in paired proportions with pre-mining data composed of 10% of observations below MDL at impact site and above MDL at control site, requires 50% above MDL at impact and 50% below MDL at control site.

Table C.13 Number of Cadmium Samples Above and Below MDL at Mary River Stations

	E0-10		C0-10		E0-03	
	Control < MDL	**Control > MDL**	**Control < MDL**	**Control > MDL**	**Control < MDL**	**Control > MDL**
Impact < MDL	45	10	47	2	51	2
Impact > MDL	1	1	4	0	6	0

Table C.14 Proportion of Cadmium Samples Above and Below MDL at Mary River Stations

	E0-10		C0-10		E0-03	
	Control < MDL	**Control > MDL**	**Control < MDL**	**Control > MDL**	**Control < MDL**	**Control > MDL**
Impact < MDL	0.94	0.02	0.89	0.04	0.86	0.03
Impact > MDL	0.02	0.02	0.08	0.00	0.10	0.03

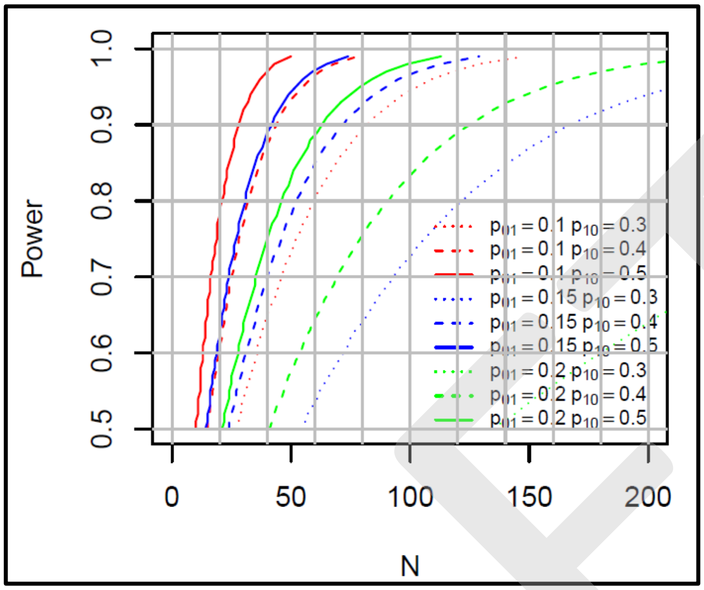

Figure C.46 Cadmium Sample Size Requirements for Equality of Proportions

C.4.3 Recommendations

Power analyses were run on key stations on both the Camp Lake Tributary and the Mary River for key parameters of concern, providing useful information to inform the study design and future power analyses on monitoring data. This analysis identified two major factors that evidently constrain the power analysis for the Camp Lake Tributary samples. First, elevated and variable copper concentrations create difficulties obtaining sufficient power at all stations. Second, the L1-09 and L1-02 station consistently have difficulty obtaining sufficient power with a sample size equal to ten. The Camp Lake Tributary analysis does show that between 5 to 20 samples will be adequate to have good power to detect changes in all parameters at L0-01 (far field EEM station). It is expected that additional sampling during 2014, concurrent to mine construction, but prior to discharge of mine effluents and dispersion of ore dust, will increase the available power.

The power analysis for Mary River identified fewer constraints for Mary River. Power analysis for copper, iron and aluminum concentrations measured during the baseline data collection within Mary River indicate that sufficient sample size can be obtained with between 5 to 10 samples. Parameters with a significant number of concentrations below detection limit might require more samples, although it is expected that additional baseline sampling in 2014 will moderate this requirement.

As a result of these analyses, the following are recommended to augment the study design:

1. Increase the amount of baseline data (this will occur during the one extra season of baseline data collection in 2014, concurrent to mine construction but prior to the discharge of mine effluents and the dispersion of ore dust);
2. Collect additional samples at L1-09 to improve baseline power;
3. Add an additional station in vicinity to L1-09 to provide enough statistical power to detect changes to near-field stations;

4. Recognize that our ability to detect changes to copper and iron are reduced at the Camp Lake Tributary.
5. Add reference station for Camp Lake samples on an adjacent tributary.
6. Four samples (one set of seasonal samples) is likely adequate for most parameters to determine significance. For parameters that require eight to ten post-mining samples, combining the analysis of data from stations with similar effluent additions is recommended.

C.5 REFERENCES

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ATTACHMENT D
DETAILED REVIEW OF BASELINE SEDIMENT QUALITY

(Pages D-1 to D-37)

ATTACHMENT D

DETAILED REVIEW OF BASELINE SEDIMENT QUALITY

(Pages D-1 to D-37)

ISO 9001 - FS 64925
ISO 14001 - EMS 550121
OHSAS 18001 - OHS 550122

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DETAILED REVIEW OF BASELINE SEDIMENT QUALITY
NB102-181/33-1D

Rev	Description	Date
1	Issued in Final	May 30, 2014

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CONSULTING

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D – SEDIMENT QUALITY REVIEW

D.1 OVERVIEW

A detailed review of sediment quality within the mine site area was undertaken to facilitate the development of the Core Receiving Environment Monitoring Program (CREMP) for water and sediment quality. As stated in Section 1.2 of the main report, the objectives of the baseline review were as follows:

- Identify data quality issues
- Understand natural enrichment of the mine site area waters and sediment
- Understand the inter-annual variability of sediment quality
- Determine whether or not mineral exploration and bulk sampling activities conducted since 2004 have affected water or sediment quality in the mine site area
- Determine the potential to pool data from multiple sample stations to increase the statistical power of the baseline sediment quality dataset
- Develop a study design for monitoring sediment quality in mine site lakes and streams
- Determine if changes to the existing sediment quality monitoring program are required to meet monitoring objectives

The focus of this review of sediment quality is the mine site area lakes: Camp Lake, Sheardown Lake NW, Sheardown Lake SE and Mary Lake. As discussed in this review, characteristics of streams are such that metals accumulation is variable, and therefore measuring statistically-defensible change in stream sediment is challenging.

The relationship of metals accumulation with total organic carbon (TOC) and fines content in sediment is a focus of this review. Stressors of potential concern (SOPCs) in sediment are the focus of the review. SOPCs include these metals elevated in the iron ore to be produced at site, as well as those metals found to be naturally elevated in the mine site area (see Section 3.4 of the main report).

A review of sediment quality was completed by sediment SOPC, followed by a detailed review by lake and stream. Concentration data measured for the parameters of interest have been log transformed and presented on scatter plots to understand the spatial variability of metals concentrations in sediment. A detailed review of the relationship between metals accumulation and TOC and % sand is completed to identify cut-off values as a means to normalize the influence of each on metals accumulation.

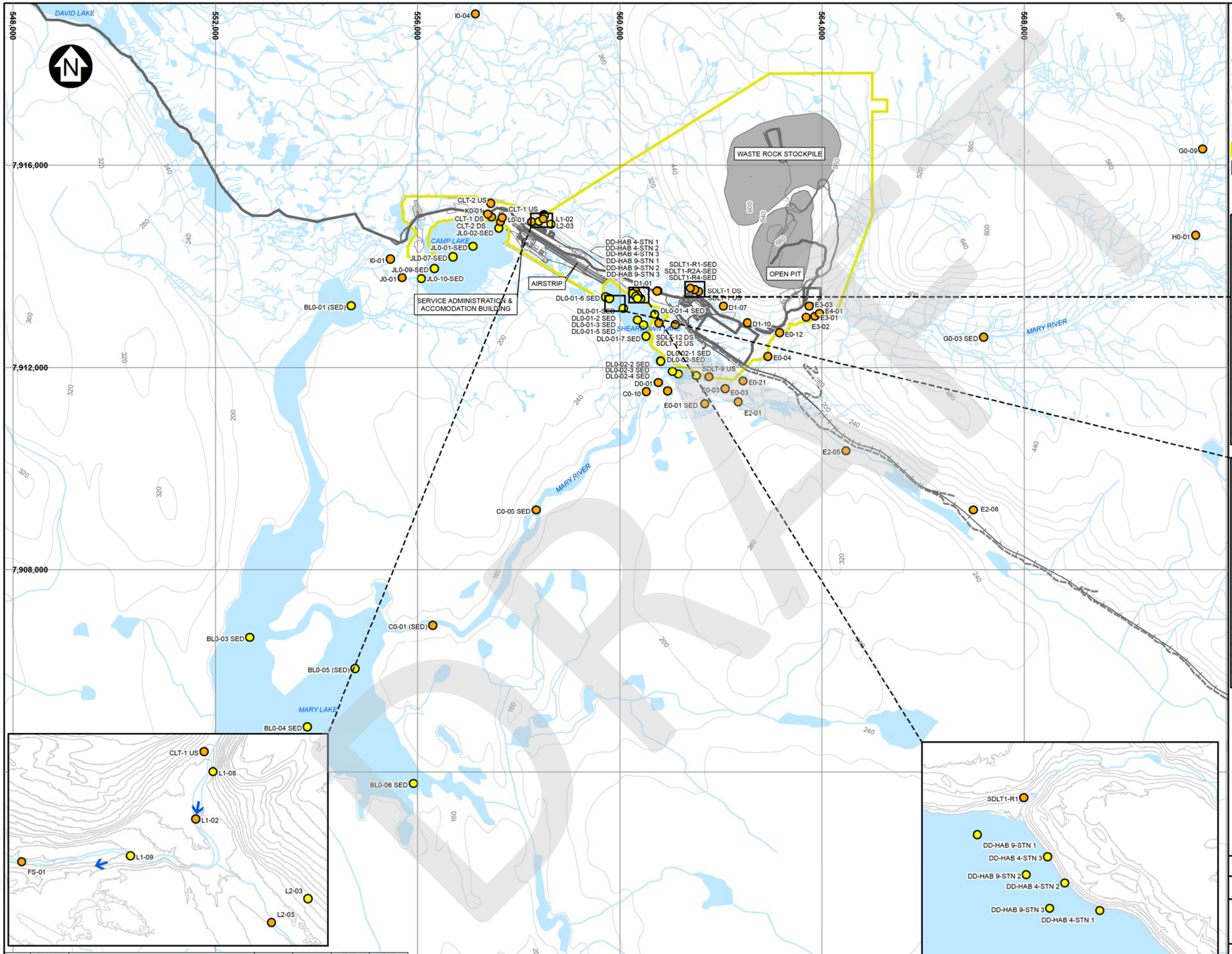
To assist in the development of study designs, parameter and station-specific a priori power analyses were completed in order to determine the power of the proposed sampling program to detect statistical changes. As per the Assessment Approach and Response Framework in the CREMP (see Figure 2.12 in the main report), management action is triggered if the mean concentrations of any parameter at selected stations reach benchmark values. Interim area-wide benchmark values were developed for sediment SOPCs that consider aquatic toxicology, natural enrichment in the Project area, or low concentrations below MDLs (Intrinsik, 2014; see Section 3.6.3 of the main report). Interim area-wide benchmarks were applied in the power analysis of the baseline presented in this detailed review. The resultant study design for the monitoring of Project-related effects to sediment quality is presented in Section 3.6 of the main report.

D.2 REVIEW OF SEDIMENT QUALITY BY PARAMETER

Sediments comprise important habitat within the aquatic ecosystems and may also act as long-term reservoirs for particulate forms of a variety of contaminants. This appendix reviews the metal concentrations recorded within sediment samples taken throughout the Mary River Project's mine site area during baseline conditions. This assessment focuses on the parameters of interest, defined as those with federal sediment quality guidelines (Canadian Environmental Quality Guidelines; CEQG) and/or provincial sediment quality guidelines (Ontario Sediment Quality Guidelines; OSQG) as discussed in Section 3.1 of the report. Sediment quality guidelines provide general scientific reference points for evaluating the potential to observe adverse biological effects in aquatic ecosystems. The parameters of interest identified for the Project include: arsenic, cadmium, chromium, copper, iron, manganese, nickel, lead and zinc.

Metal concentrations currently detected in the lakes and streams are related to the natural enrichment of the area; therefore, an exceedance of the generic sediment quality guidelines is not necessarily indicative of toxicity. There are a variety of physical factors that reduce the bioavailability of metals in the environment (e.g., speciation, availability of dissolved organic carbon, pH, alkalinity, hardness) and a variety of biological processes that modify or reduce toxicity naturally within biota (e.g., acclimation, adaptation). The observations and trends of the baseline data regarding concentrations of specific parameters of concern that have CSQG limits and/or PSQG limits are discussed below.

Historic sediment sampling locations are shown on Figure D.1. Concentrations are also shown graphically in relation to log TOC and percent sand on Figures D.2 through D.10 to understand the relationship between the concentration of a given metal and sediment TOC and fines content. The area of the plotted circle in these plots is proportional to the concentration of the given metal, and the color of the circle is indicative of the lake.



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REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
1	30MAY'14	ISSUED WITH REPORT	RAC	SWK	RAC	RAM
0	27MAR'14	ISSUED WITH REPORT	DKK	AS	RAC	RAM

LEGEND:

●	LAKE SAMPLE LOCATION
●	STREAM SAMPLE LOCATION
—	EXISTING TOTE ROAD
—+—	PROPOSED RAILWAY ALIGNMENT
- - -	PROPOSED CONSTRUCTION ACCESS ROAD
—	PROPOSED SITE INFRASTRUCTURE
—	RIVER/STREAM/DRAINAGE
🟦	WATER
▭	POTENTIAL DEVELOPMENT AREA (PDA)
▨	PROPOSED MINE INFRASTRUCTURE

NOTES:

1. BASE MAP: © HER MAJESTY THE QUEEN IN RIGHTS OF CANADA, DEPARTMENT OF NATURAL RESOURCES (2004). ALL RIGHTS RESERVED.
2. COORDINATE GRID IS UTM NAD83 ZONE17.
3. CONTOUR ARE IN METRES. CONTOUR INTERVAL VARIES.
4. NOT ALL LOCATIONS WERE SAMPLED EVERY YEAR.
5. INFRASTRUCTURE INFORMATION PROVIDED BY HATCH ON JANUARY 31, 2014.

SCALE 1 0.5 0 1 2 3 4 km

BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

HISTORIC SEDIMENT QUALITY STATIONS MINE SITE AREA

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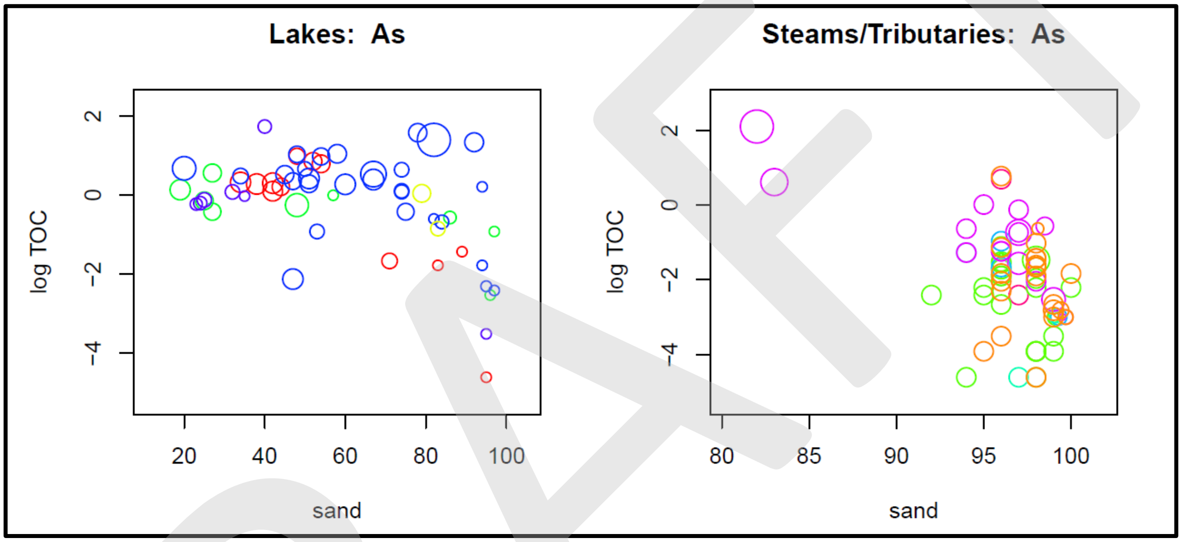
P/A NO.	REF NO.
NB102-181/33	1

FIGURE D.1 REV 1

Arsenic (Figure D.2)

- Lake sediment results show concentrations above the MDL in all areas, with exceedances of guidelines in Sheardown Lake NW. These concentrations exceed the CEQG-TEL guideline and PSQG-LEL guideline but neither exceed the CEQG-PEL or PSQG-SEL guideline.
- Most stream/tributary samples have low arsenic concentrations below MDL and high proportions of sand. Two Sheardown Lake tributary samples report slightly higher arsenic concentrations and a lower proportion of sands.
- No exceedances of sediment quality guidelines were detected in stream sediment samples.



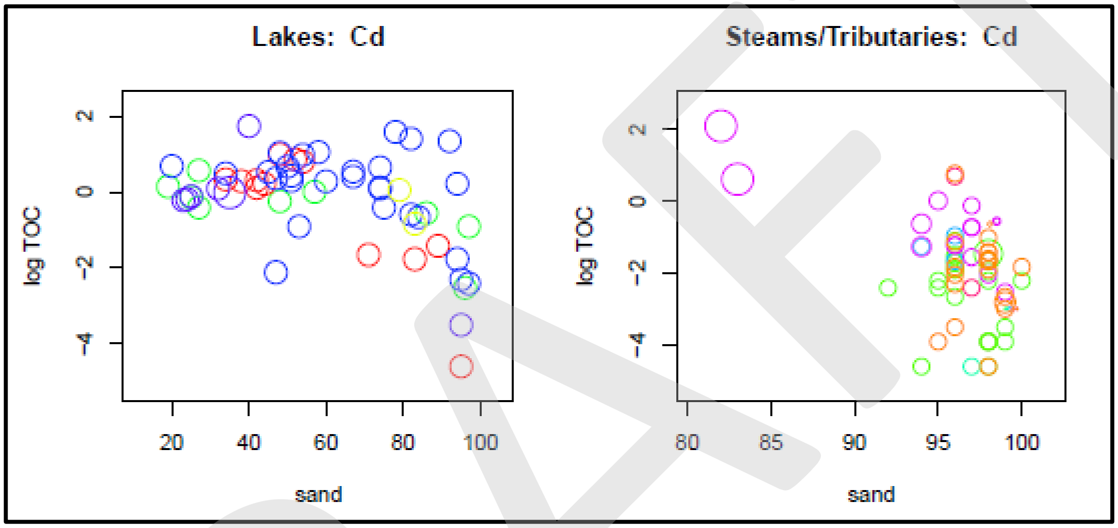
NOTES:

1. RED COLOR REPRESENTS CAMP LAKE; BLUE COLOR INDICATES SHEARDOWN LAKE; GREEN COLOR REPRESENTS MARY LAKE AND YELLOW COLOR REPRESENTS DAVID LAKE.
2. THE X-AXIS REPRESENTS THE % SAND PORTION AND Y-AXIS REPRESENTS THE LOG OF THE TOC (%).
3. THE AREA OF THE DOT REPRESENTS THE CONCENTRATION OF THE METAL.
4. VALUES RECORDED AT OR BELOW DETECTION LIMIT ARE PLOTTED AT THEIR DETECTION LIMIT.

Figure D.2 Arsenic in Sediment as a Function of Log TOC and Percent Sand

Cadmium (Figure D.3)

- All lake concentrations were near to or below the MDL.
- All stream area concentrations were below the MDL with the exception of a Sheardown Lake tributary (the two large circles in the top left) and one instance in a Camp Lake tributary.
- The large proportion of non-detect results for cadmium are evident by the circles being the same diameter for most of the samples (note the scale difference for percent sand between lakes and streams).



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3. THE AREA OF THE DOT REPRESENTS THE CONCENTRATION OF THE METAL.
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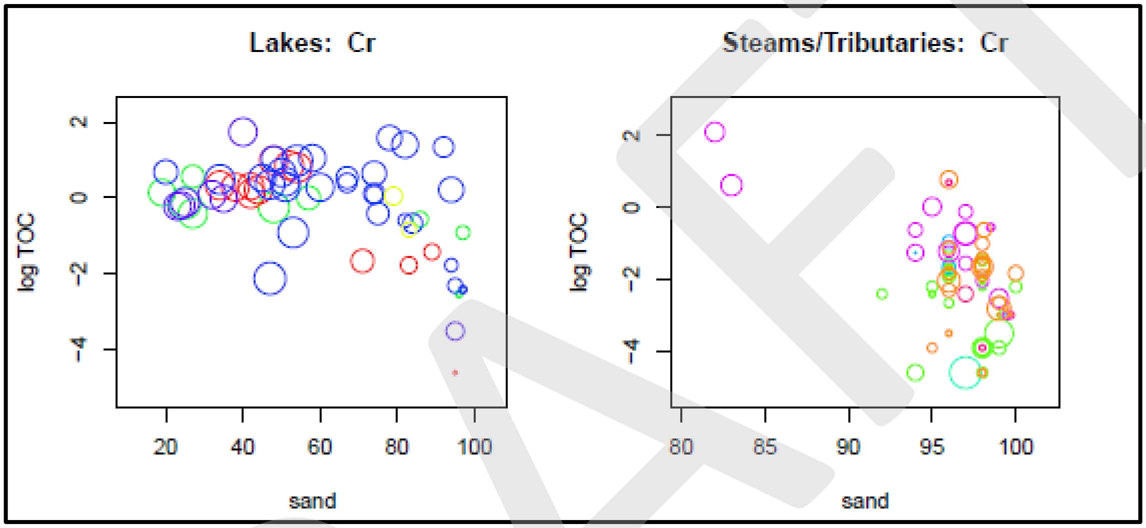
Figure D.3 Cadmium in Sediment as a Function of Log TOC and Percent Sand

Chromium (Figure D.4)

- Each of the lake areas reported concentrations above sediment quality guidelines except the near shore dust monitoring stations in Sheardown Lake. The near-shore dust monitoring stations were not in a depositional environment according to low TOC and a low proportion of fines.
- All mine site streams and tributaries show concentrations above sediment quality guidelines except the Tom River and Phillips Creek.



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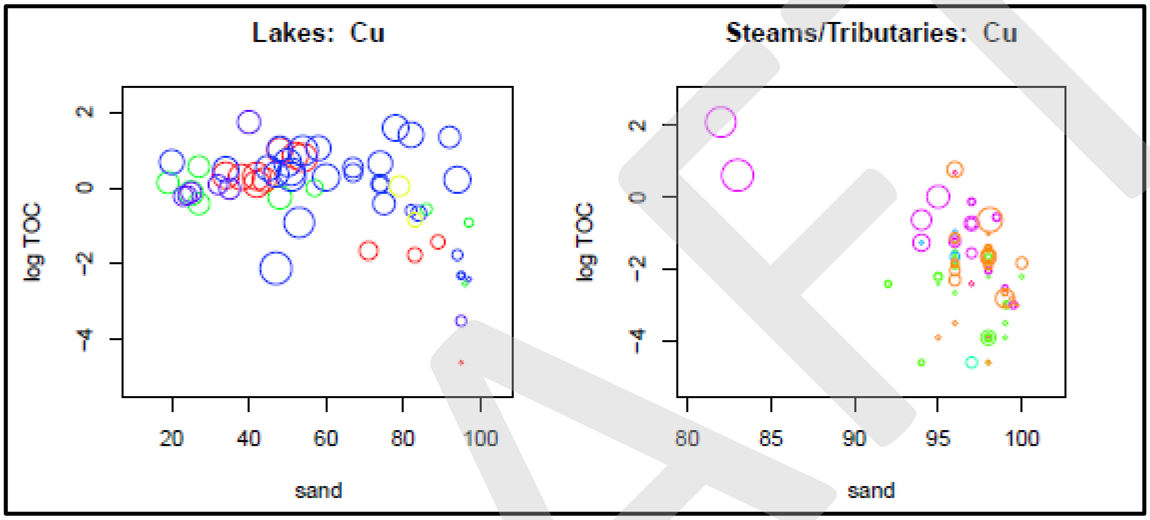
4. VALUES RECORDED AT OR BELOW DETECTION LIMIT ARE PLOTTED AT THEIR DETECTION LIMIT.

Figure D.4 Chromium in Sediment as a Function of Log TOC and Percent Sand

Copper (Figure D.5)

- All lake area results show concentrations above guidelines except the near shore dust monitoring stations in Sheardown Lake (as mentioned above, not located in a depositional environment according to low TOC and a low proportion of fines).
- All stream sample concentrations were below the sediment quality guidelines with the exception of a Sheardown Lake tributary and the Camp Lake tributaries.



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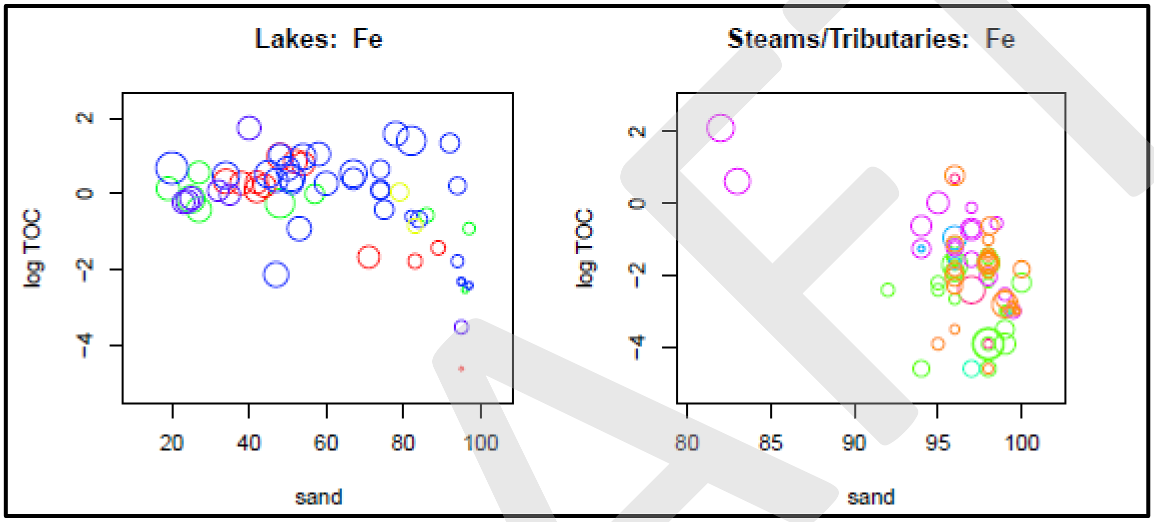
2. THE X-AXIS REPRESENTS THE % SAND PORTION OF THE SAME AND Y-AXIS REPRESENTS THE LOG OF THE TOC (%).
3. THE AREA OF THE DOT REPRESENTS THE CONCENTRATION OF THE METAL.
4. VALUES RECORDED AT OR BELOW DETECTION LIMIT ARE PLOTTED AT THEIR DETECTION LIMIT.

Figure D.5 Copper in Sediment as a Function of Log TOC and Percent Sand

Iron (Figure D.6)

- All lake area results show concentrations above guidelines except the near shore dust monitoring stations in Sheardown Lake, and in David Lake located outside of the mine site area.
- Stream sample concentrations exceeded guidelines for at least one sample in most areas.
- Stream samples from the deposit drainage streams, Phillips Creek area and downstream of Mary Lake had concentrations below the guidelines.



NOTES:

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3. THE AREA OF THE DOT REPRESENTS THE CONCENTRATION OF THE METAL.
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Figure D.6 Iron in Sediment as a Function of Log TOC and Percent Sand

Manganese (Figure D.7)

- All lake areas results show concentrations above guidelines for at least one sample, except the near shore dust monitoring stations in Sheardown Lake.
- Stream sample concentrations were below the sediment quality guidelines for all but one sample (Sheardown Lake tributary).

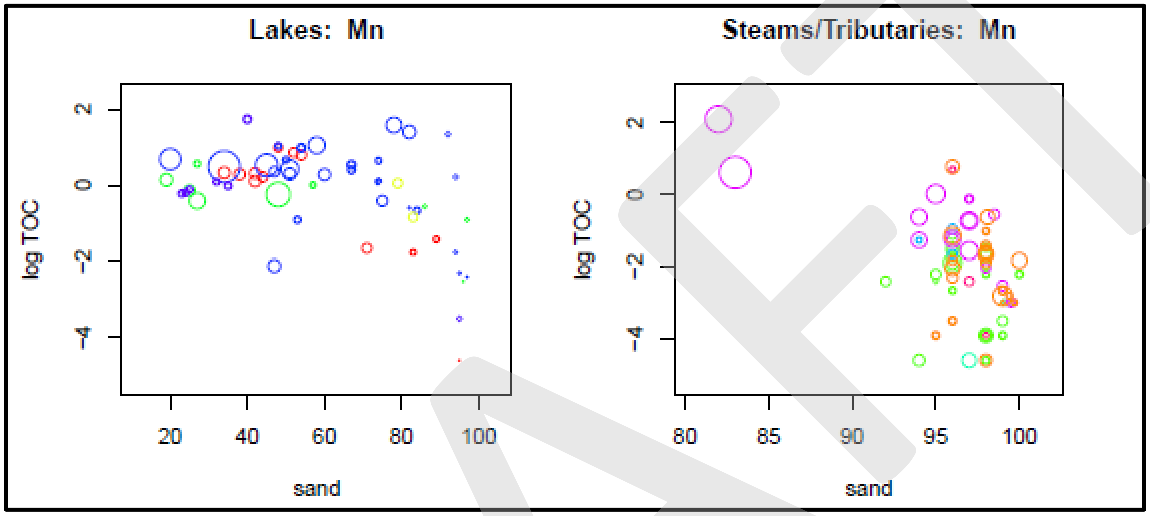

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Figure D.7 Manganese in Sediment as a Function of Log TOC and Percent Sand

Mercury (no figure)

- All stream and lake concentrations were below the MDL.

Nickel (Figure D.8)

- Nickel concentrations exceeded the guidelines in each of the mine site lakes.
- Stream sample concentrations exceeded the guidelines for at least one sample in most areas.
- Stream samples from upstream of the deposit, the Tom River area and the Phillips Creek area had concentrations below the guidelines.

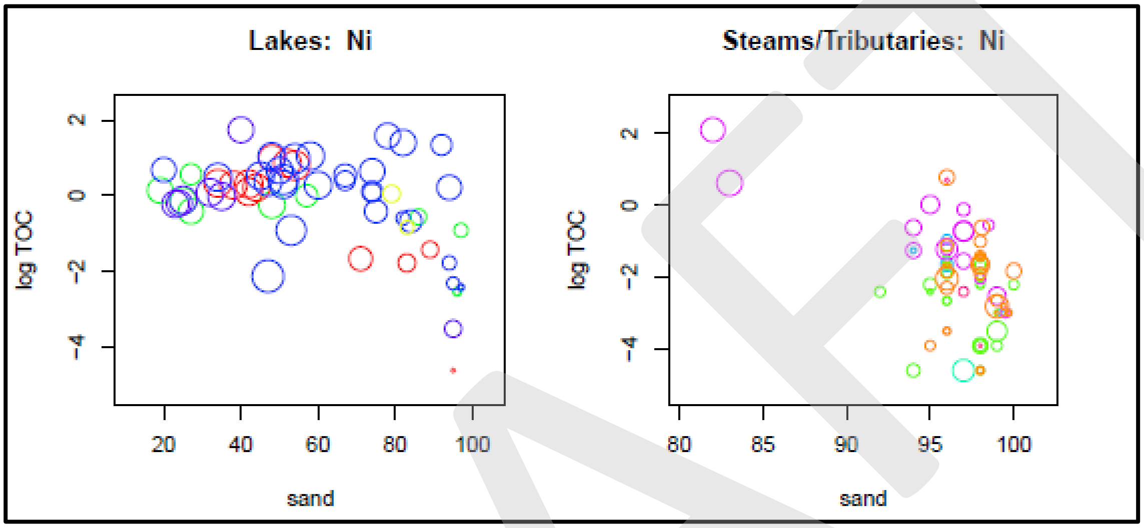

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Figure D.8 Nickel in Sediment as a Function of Log TOC and Percent Sand

Lead (Figure D.9)

- All lake sample concentrations were below the sediment quality guidelines.
- Most stream areas had low concentrations with only one sediment quality guideline exceeded (Sheardown Lake tributary).

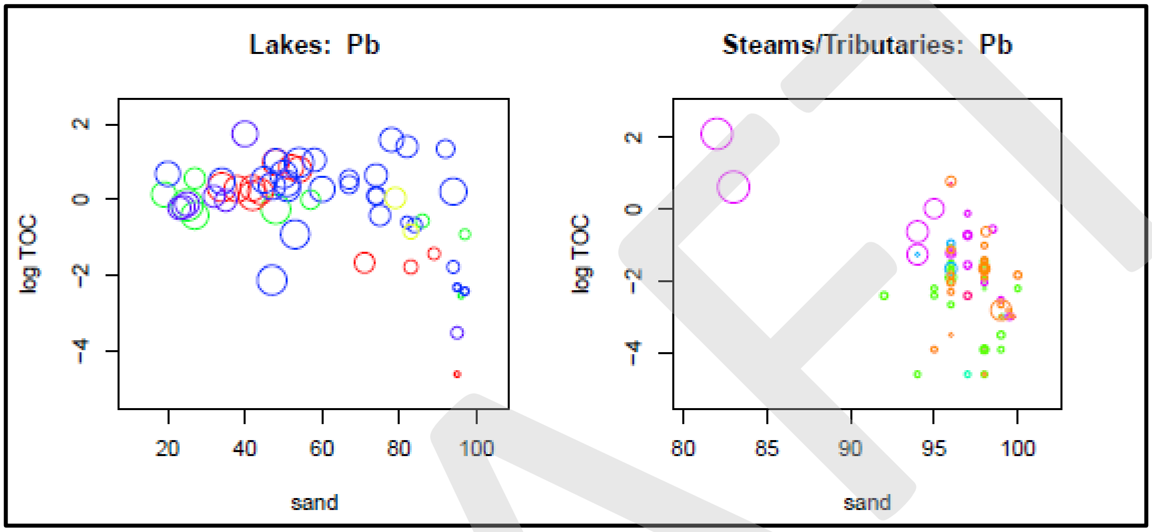

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Figure D.9 Lead in Sediment as a Function of Log TOC and Percent Sand

Zinc (Figure D.10)

- All lake samples tested for zinc were below guidelines.
- Stream sample concentrations were below the sediment quality guidelines for all but one sample (Sheardown Lake tributary).

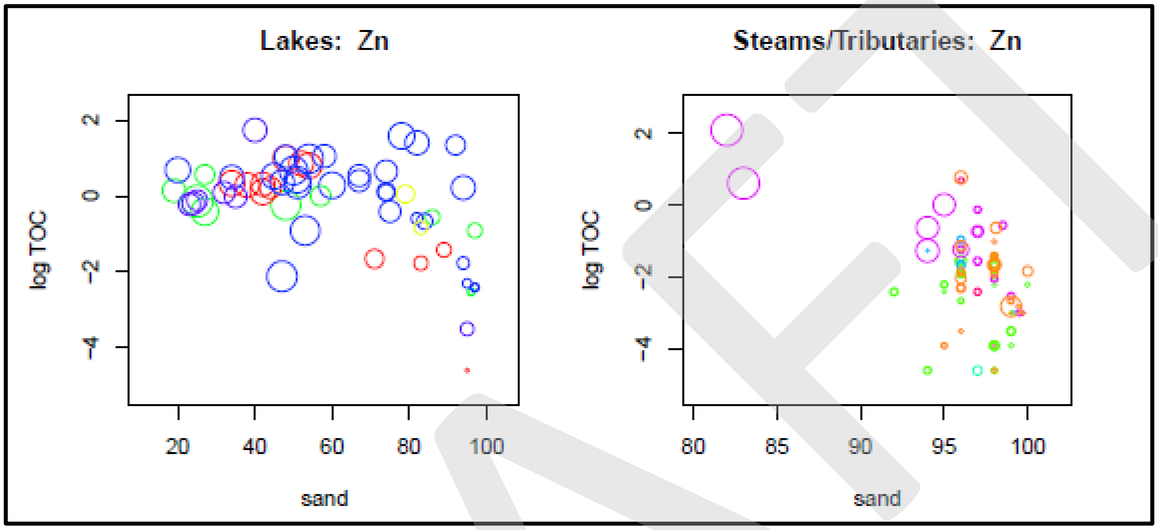

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Figure D.10 Zinc in Sediment as a Function of Log TOC and Percent Sand

Analytical results for the parameters of interest summarized above identify sediment quality guideline concentration exceedances in some areas. These areas have been discussed in the following section and are grouped by stream environments and lake environments.

D.3 SEDIMENT IN STREAM ENVIRONMENTS

Upstream of the Deposits

The three stations positioned upstream of the Project deposits are shown in Figure D.1: G0-09, H0-01 and G0-03. Surface runoff and natural loading contributes to the baseline parameter concentrations in the sediment of Mary River. There were five samples obtained at these stations between 2005 and 2013. Coarse grained sediment (e.g., sand) were the highest proportion of the particle size distribution analysis in this area (≥ 97%).

- **Station G0-09** - The sample results from 2006 show chromium and iron concentrations marginally above the PSQG-LEL criteria. The remaining sample results from this station and surrounding area stations did not show concentrations exceeding sediment quality guidelines.
- **Station H0-01** - One of the two sample results from this station have elevated levels of chromium and iron above their respective PSQG-LEL.
- **Station G0-03** - There is only one result for this station. Sample results from 2007 show elevated chromium and nickel concentrations above their respective CSQG-ISQG and/or PSQG-LEL criteria. These concentrations were the highest detected in this area.

Downstream of the Deposits

These 14 stations are positioned in the Mary River downstream of the waterfall with the exception of Station G0-03 positioned approximately 2.5 km upstream of the waterfall (Figure D.1). The Mary River receives runoff from the deposits that contribute to baseline concentrations found in the stream sediments. There were 25 samples obtained from these stations between 2005 and 2013. Coarse grained sediments (e.g., sand) were the highest proportion of the particle size distribution analysis in this area (≥ 97%). In general, concentrations of chromium, iron and nickel were found in elevated concentrations within this area as discussed below.

- **E-series Stations** - The sample results from the E-series of stations (E0-01, E0-03, E0-04 and E4-01) sampled between 2007 and 2012 show elevated chromium, iron and nickel concentrations. These concentrations were near to or marginally above their respective CSQG-ISQG and/or PSQG-LEL criteria.
- **Station C0-10** - The sample results from 2007 show elevated chromium and iron concentrations above their respective CSQG-ISQG and/or PSQG-LEL criteria. This station is positioned on the Mary River, downstream of the confluence between the Mary River and the Sheardown Lake discharge channel.
- **Station C0-05** - The sample results from 2007 show elevated chromium concentrations close to the PSQG-LEL criteria and below the CSQG-ISQG criteria. This station is positioned on the Mary River, approximately half way between the Sheardown Lake confluence and the outlet to Mary Lake.
- **Station C0-01** - The sample results from 2007 show elevated concentrations of chromium, iron and nickel above their respective CSQG-ISQG and/or PSQG-LEL criteria. This station is positioned less than 2 km from the outlet of the Mary River into Mary Lake. The remaining sample results from this station 2005, 2012 and 2013 did not show concentrations exceeding sediment quality guidelines.

Background Tributary to Mary River

The E2 stream receives surface drainage from the surrounding landscape east of the deposits flows into the Mary River upstream of the confluence with the Sheardown Lake outlet channel (Figure D.1). This area was sampled at three stations to establish baseline sediment conditions outside of the immediate Mary River catchment area. There were four samples obtained between 2005 and 2012, with three of the four samples taken in 2012. Coarse grained sediments (e.g., sand) were the highest proportion of the particle size distribution analysis in this area (≥ 94%). In general, concentrations of iron and nickel were found in elevated concentrations within this area as discussed below.

- **E2-series Stations** - The sample results from station E2-01 (2012) show elevated iron concentrations near to, but above the PSQG-LEL. Similarly, station E2-08 (2012) show elevated nickel concentrations slightly above the PSQG-LEL.

Downstream of Mary Lake

This station is positioned approximately 6 km downstream of the Mary Lake outlet, upstream of Angajurjualuk Lake. This station was sampled twice during the baseline program (2005 and 2007). Coarse grained sediments (e.g., sand) were the highest proportion of the particle size distribution analysis at this station (≥ 97%).

- **Station A0-01** - The sample results from 2007 show elevated chromium and nickel concentrations. Chromium concentrations were above the PSQG-SEL which was the highest reported chromium concentration in the baseline study. Nickel concentrations were above the PSQG-LEL criteria.

Sheardown Lake Tributaries

The Sheardown Lake tributary stations have various labels depending on the field program under which the samples were collected (Figure D.1). Sheardown Lake tributary 1 (SDLT1), historically identified as tributary D1 receives surface water and erosional material from the south slope of the deposit. Streams that receive drainage from the landscape, south of the deposit access road include SDL-Trib 9 and SDL-Trib 12. There were 18 samples obtained from these stations between 2005 and 2013. Coarse grained sediments (e.g., sand) were the highest proportion of the particle size distribution analysis at this station (≥ 82%).

- **Station D1-01** - The sample results from 2012 show elevated chromium and nickel concentrations above the respective CSQG-ISQG and/or PSQG-LEL criteria.
- **Station D1-07** - The sample results from 2011 show elevated cadmium and chromium concentrations above the respective CSQG-ISQG and/or PSQG-LEL criteria. Copper and nickel were measured above their respective PSQG-SEL criteria.
- **Station D1-10** - The sample results from 2011 show elevated total organic carbon (TOC), chromium and copper concentrations above the respective CSQG-ISQG and/or PSQG-LEL criteria. Nickel was above the PSQG-SEL criteria.

- **Station D1-05 (SDLT1-R4 US)** - The sample results show elevated cadmium, chromium, copper, iron, manganese, nickel, lead and zinc concentrations. The 2012 and 2013 sample results had the highest number of sediment quality criteria exceedances, including the only CSQG-ISQG and PSQG-LEL exceedances of lead and zinc of the baseline study. The 2012 sample had the highest TOC concentration of the baseline study, which was above the PSQG-LEL criteria.
- **Station D1-01 (SDLT1-R2A and SDL-Trib 1 DS)** - The sample results show elevated chromium, copper and nickel concentrations. The 2012 chromium results were above the CSQG-ISQG and PSQG-LEL criteria. The 2008 copper results were equal to the PSQG-LEL criteria and below the CSQG-ISQG criteria. The 2008 and 2012 nickel results were above the PSQG-LEL criteria.
- **Station SDLT1-R1** - The sample results from 2008 show elevated chromium and nickel concentrations above the CSQG-ISQG and/or PSQG-LEL criteria.
- **Station SDL-Trib 9 US** - All sample results show elevated chromium and nickel concentrations above the CSQG-ISQG and/or PSQG-LEL criteria.
- **Station SDL-Trib 12 (US and DS)** - The sample results from 2007 show elevated chromium and nickel concentrations above the CSQG-ISQG and PSQG-LEL criteria.

Sample locations D1-10 and D1-05 in the Sheardown Lake tributary 1 are depositional environments that show similar metals accumulation to that of the mine site lakes. These sample locations represent good long-term sampling locations.

Camp Lake Tributaries

The 12 Camp Lake tributary stations have various labels depending on the field program under which the samples were collected (Figure D.1). Camp Lake tributary 1 (CLT-1), historically identified as tributary L1 receives surface water and erosional material from the deposit through the collection of surface water runoff and discharge through the West Pond. The L2 tributary is positioned parallel with the airstrip flowing into the L1 tributary upstream of the tote road. Downstream of the Tote Road, this stream is known as the L0 tributary where station CLT-1 DS is located. Camp Lake tributary 2 or K0 tributary receives runoff from the western portion of the deposit. The J0 station is located in the connecting channel between Camp Lake and the north branch of Mary Lake showing sediment conditions downstream of Camp Lake. A discussion of the sediment quality guideline exceedances has been presented below. There were 22 samples obtained from these stations between 2005 and 2013. Coarse grained sediments (e.g., sand) were the highest proportion of the particle size distribution analysis at this station (≥ 82%).

- **Station CLT-1 US (L1 series)** - The results from 2005, 2007, 2012 and 2013 show elevated concentrations of cadmium, chromium, copper and nickel above the CSQG-ISQG and/or PSQG-LEL criteria. In addition, concentrations of iron were detected above the PSQG-LEL in 2007.
- **Station L2-03** - The results from 2011 to 2013 show all parameter concentrations of interest were below the CSQG-ISQG and/or PSQG-LEL criteria.
- **Station CLT-1 DS (L0 series)** - The results from 2007 show an elevated chromium concentration above the CSQG-ISQG and PSQG-LEL criteria, but below the upstream sample concentration. All other parameter concentrations were below criteria.

- **Station CLT-2 (K0)** - The results from 2013 show an elevated nickel concentration near to, but above the PSQG-LEL. The results from 2005 and 2012 do not show any concentrations above criteria.
- **Station J0-01** - The results from 2012 and 2013 show nickel concentrations near to, but above the PSQG-LEL. The results from 2005 do not show elevated nickel concentrations above criteria.

D.4 SEDIMENT IN LAKE ENVIRONMENTS

Camp Lake

The sample stations are positioned in a northeast to southwest transect across Camp Lake between the CLT-1 inflow stream and the J0-01 outlet stream (Figure D.1). These stations were selected for initial baseline assessments and ongoing monitoring programs. Fine grained sediment (e.g., silt and sand) were the highest percent particle size in the mid lake region, whereas sand was the highest component fraction in most of the other sample areas.

- **Station JL0-01** - This station is located mid-lake and is one of the proposed long-term monitoring stations. Four samples were obtained from this location, two were taken in 2007 and one was taken during the 2012 and 2013 sampling campaigns. The results from all sampling events show elevated TOC, chromium, copper, iron, manganese and Ni concentrations above their respective CSQG-ISQG and/or PSQG-LEL criteria. The samples from this location had the highest manganese concentrations within Camp Lake.
- **Station JL0-02** - This station is positioned offshore from the CLT-1 outlet stream in the northeast corner of Camp Lake. Three samples were obtained from this location, one taken during each of the 2007, 2012 and 2013 sampling campaigns. The results of all samples had elevated TOC, chromium, copper, iron, manganese and nickel concentrations above their respective CSQG-ISQG and/or PSQG-LEL criteria. The 2007 iron concentration was above the PSQG-SEL criteria and was the highest concentration within Camp Lake. This station also had the highest TOC concentrations likely attributable to the contribution of organic inputs from the CLT-1 stream.
- **Station JL0-07** - This station is positioned southwest of station JL0-01 in the main lake basin. One sample was obtained from this location (2007). The results show elevated TOC, chromium, copper, iron, manganese and nickel concentrations above their respective CSQG-ISQG and/or PSQG-LEL criteria.
- **Station JL0-09** - This station is positioned near the outlet channel, upstream of station JL0-10. Three samples were obtained from this location, one taken during each of the 2007, 2012 and 2013 sampling campaigns The results from 2007 show elevated TOC, chromium, copper, iron, manganese and nickel concentrations above the respective CSQG-ISQG and/or PSQG-LEL criteria. The 2012 and 2013 results only show an elevated nickel concentration above the PSQG-LEL criteria. The difference in the number of criteria exceedances between 2007 and the 2012 and 2013 samples may be attributed to the high percent sand content in the recent samples (89% and 83% respectively).
- **Station JL0-10** - This station is located immediately upstream of the outlet channel in the southwest corner of Camp Lake. One sample was obtained from this location (2007). There were no elevated concentrations measured of any of the parameters of concern.

Sheardown Lake (NW Basin)

There were many stations established in the near shore and offshore environment to monitor pre-development sedimentation in these regions of the lake (Figure 3.2). Many stations are included in the ongoing monitoring program. This study will be used for post-Project comparison to baseline condition.

- **Station DL0-01-1** - This is a mid-lake sample station in the deepest area of the lake. Four samples were obtained from this location, one taken during each of the 2007, 2011, 2012 and 2013 sampling campaigns. The sample results from these years show elevated TOC, chromium, copper, iron, manganese and nickel concentrations. The chromium, copper and nickel concentrations were elevated above the respective CSQG-ISQG and/or PSQG-LEL criteria. All iron concentrations were above the PSQG-SEL criteria. The manganese results from 2011, 2012 and 2013 were above the PSQG-SEL, whereas the 2007 results were below this sediment quality guideline criterion. The nickel concentrations were all above the PSQG-LEL with the 2013 concentration also above the PSQG-SEL criteria. The particle size distribution results show a relatively equal proportion of fine grained sediment (e.g., silt and clay) and coarse grained sediment (e.g., sand) at this station.
- **Station DD-Hab 4 series** - There are three stations positioned in the shallow near shore area close to the SDLT-1 inflow stream. One sample was obtained from each station (2008), with one of these results showing elevated nickel concentration equal to the PSQG-LEL criteria. All other concentrations were reported below sediment quality guideline criteria. Particle size distribution data was not available for these samples.
- **Station DD-Hab 9 series** - The three stations in this series are positioned at offshore areas near the SDLT-1 inflow stream. Samples were obtained from each station during the 2008, 2012 and 2013 sampling campaigns. These results show elevated TOC, arsenic, chromium, copper, iron, manganese and nickel concentrations. The TOC concentrations from this series of stations were some of the highest in the lake, likely attributed to the contribution of organic inputs from the SDLT-1 stream. The 2008 arsenic concentration at DD-Hab-9-Stn 3 were reported above the CSQG-ISQG and PSQG-LEL criteria, which was the highest arsenic concentration detected in the lake. The majority of the chromium, copper, iron and nickel concentrations were above the CSQG-ISQG and/or PSQG-LEL criteria. The 2008 manganese concentrations at DD-Hab-9-Stn 2 and DD-Hab-9-Stn 3 were above the PSQG-SEL criteria. The 2008 and 2012 results from DD-Hab-9-Stn 3 reported iron concentrations above the PSQG-SEL. In general, concentrations were higher in this deeper area compared to those reported from the shallow stations (DD-Hab 4 series). Particle size distribution data was not available for these samples.
- **Station DL0-01-5 and -6** - These stations are located in the northwest region of the lake, positioned near the treated sewage effluent outfall from the exploration camp. Four samples were obtained from station DL0-01-5, one taken during each of the 2007, 2008, 2011 and 2013 sampling campaigns, whereas only two samples were obtained from station DL0-01-6 (2007 and 2008). The results show some of the highest chromium, iron, manganese and nickel concentrations within the lake, which were above the CSQG-PEL and/or PSQG-SEL criteria. Copper was generally above the CSQG-ISQG and/or PSQG-LEL criteria. The highest TOC concentrations were measured at station DL0-01-5, which exceeded the PSQG-LEL criteria in 2007, 2008 and 2011. The particle size distribution results for

station DL0-01-5 show a relatively equal proportion of fine grained sediment (e.g., silt and clay) and coarse grained sediment (e.g., sand). The particle size distribution results from station DL0-01-6 show that sand was the dominant fraction in both samples (≥ 75%).

- **Station DL0-01-2 and -3** - These stations are located in the southeast region of this basin, positioned near the largest island in the lake. Three samples were obtained from station DL0-01-2, one taken during each of the 2007, 2008 and 2013 sampling campaigns, whereas only two samples were obtained from station DL0-02-3 (2007 and 2008). The results generally show elevated chromium, copper and nickel concentrations above the CSQG-ISQG and/or PSQG-LEL criteria. The 2008 results from station DL0-01-3 show an elevated arsenic concentration near to, but above the CSQG-ISQG and PSQG-LEL criteria. The manganese concentrations were generally above the PSQG-LEL and/or SEL criteria. All sample results show TOC concentrations above the PSQG-LEL criteria. The particle size distribution results for these stations show a range in the proportion of fine grained sediment (e.g., silt and clay) and coarse grained sediment (e.g., sand) between years. This range is likely due to the variability in substrate types near these stations.
- **Station DL0-01-4** - This station is positioned in a bay at the eastern end of the basin and receives inflow from the SDLT-12 stream. Three samples were obtained from this station one taken during each of the 2007, 2008 and 2013 sampling campaigns. The results show chromium, copper and nickel concentrations above the CSQG-ISQG and PSQG-LEL criteria. The results also show some iron and manganese concentrations above the CSQG-PEL and PSQG-SEL criteria. All sample results show TOC concentrations above the PSQG-LEL criteria and the highest concentration within the lake measured during 2008. The particle size distribution results show that sand was the dominant fraction in these samples (≥ 78%).
- **Station DL0-01-7** - This station is positioned near the outlet channel that connects the Sheardown Lake NW and SE basins. Five samples were obtained from this station, one taken during each of the 2007, 2008, 2011, 2012 and 2013 sampling campaigns. The results show elevated chromium, copper, iron, manganese and nickel concentrations generally above the CSQG-ISQG and PSQG-LEL criteria. The results from 2011 show nickel concentrations were the only parameter above the sediment quality guidelines. The results from 2008 reported the only manganese concentration above the PSQG-LEL criteria. All sample results show TOC concentrations above the PSQG-LEL criteria with the exception of 2011. The particle size distribution results show that sand was the dominant fraction in these samples (≥ 67 %).

Sheardown Lake (SE Basin)

There were four stations established in the near shore and offshore environment to monitor pre-development sedimentation in these regions of the lake (Figure 3.2). One of these stations (DL0-02-3) is included in the ongoing monitoring program. Silt was the highest percent particle size fraction in all but one sample (DL0-02-3 in September 2007). The highest concentrations of the parameters of concern were reported from the stations positioned in the deepest region of the southeast basin.

- **Station DL0-02-1** - This station is located in the northwest corner of this basin and is the first area to receive influent from the NW basin. This area may be subject to increased erosional flows from the NW basin channel during spring freshet that would transport material towards the main lake basin. Two samples have been obtained from this location, both taken during the 2007 sampling campaign. The results show elevated chromium, copper, iron, and nickel concentrations above the CSQG-ISQG and PSQG-LEL criteria.

- **Station DL0-02-2** - This station is located near the deepest area of the SE basin. One sample was obtained from this location (2007). The results show elevated chromium, copper, iron, and nickel concentrations above the CSQG-ISQG and PSQG-LEL criteria.
- **Station DL0-02-3** - This station is located mid-lake, nearest to the outlet channel that connects Sheardown Lake to Mary River. Three samples were obtained from this location, one taken during each of the 2007, 2012 and 2013 sampling campaigns. The 2007 results show elevated chromium and nickel concentrations above the CSQG-ISQG and/or PSQG-LEL criteria. The field sample record from 2007 indicates this material was obtained in a water depth of 1.8 m, which is significantly different than the sample depths in 2012 and 2013 (13 m and 14 m respectively). In addition, it is possible it might not have been obtained in the exact same location. The difference between the TOC results from 2007 (0.03%), 2012 (1.09%) and 2013 (0.98%) suggests the 2007 sample results may not be suitable for comparison to the 2012 and 2013 results. The 2012 and 2013 results show elevated chromium, copper, iron, and nickel concentrations above the CSQG-ISQG and/or PSQG-LEL criteria. In addition, the 2013 results also show an elevated manganese concentration above the PSQG-LEL criteria.
- **Station DL0-02-4** - This station is located in the southeast corner of the basin, in an area that receives influent from the SDLT-9 stream. A single sample was obtained from this location in 2007. The SDLT-9 stream is a source of organic material inputs as shown by the highest TOC concentration within the southeast basin. The results show elevated TOC, chromium, copper, iron, nickel, and manganese concentrations above the CSQG-ISQG and/or PSQG-LEL criteria.

Mary Lake

There are two main basins within Mary Lake (North and South). These basins will eventually receive water and sediment inputs from the mine site and upper reaches of the catchments as previously described. One monitoring station (BL0-01) is located in the north basin, whereas the remaining four stations are located in the south basin (Figure 3.3). The north basin receives influent water from Camp Lake which flows through a network of smaller basins and channels before reporting to the south Mary Lake basin. The majority of the Mary Lake south basin water comes from Mary River. Silt was the highest percent particle size fraction from all stations positioned in the south basin, except station BL0-05. Sand was the highest particle size fraction of the samples obtained from station BL0-01 and station BL0-05. These stations are positioned near the outlet of main streams (Camp Lake outlet and Mary River outlet) and also had the highest concentrations of TOC in Mary Lake.

- **Station BL0-01 (North)** - Two samples were obtained from this location, one taken during each of the 2006 and 2007 sampling campaigns. These results show elevated TOC, chromium, copper, iron and nickel concentrations above the respective CSQG-ISQG and/or PSQG-LEL criteria. The 2007 results also show manganese concentration above the PSQG-SEL criteria.
- **Station BL0-03 (South)** - This station is located in the northwest corner of the Mary Lake south basin, downstream of Station BL0-01. One sample was obtained from this location (2007). These results show elevated chromium, copper, iron, manganese and nickel concentrations.

The copper and nickel concentrations were above the CSQG-ISQG and/or PSQG-LEL criteria. The chromium, iron and manganese concentrations were above their respective CSQG-PEL and PSQG-SEL criteria. Station BL0-03 had the highest iron and manganese concentrations measured in Mary Lake.

- **Station BL0-04 (South)** - This station is located downstream of station BL0-03 and is positioned on the western edge of the deepest lake basin. One sample was obtained from this location (2007). These results show elevated chromium, copper, iron, manganese and nickel concentrations. The copper, iron and nickel concentrations were above the CSQG-ISQG and/or PSQG-LEL criteria. The chromium and manganese concentrations were above their respective CSQG-PEL and/or PSQG-SEL criteria.
- **Station BL0-05 (South)** - This station is positioned at the outlet of Mary River. Two samples were obtained from this location, one taken during each of the 2006 and 2007 sampling campaigns. These results show elevated nickel concentrations above the PSQG-LEL criteria. Results from 2012 show elevated copper, iron and nickel concentrations above the PSQG-LEL criteria, with chromium concentrations above the CSQG-ISQG and PSQG-LEL criteria.
- **Station BL0-06 (South)** - This station is located in the southwestern corner Mary Lake, immediately upstream of the main lake outlet channel. One sample was obtained from this location (2007). These results show elevated chromium, copper, iron, manganese and nickel concentrations. Copper, manganese and nickel concentrations were above the CSQG-ISQG and/or PSQG-LEL criteria. The chromium concentration was above the CSQG-PEL, but below the PSQG-SEL. The iron concentration was above the PSQG-SEL criteria.

David Lake

There were two stations sampled in 2012 to assess baseline sediment quality conditions prior to development. Sand was the highest percent particle size fraction at these locations, followed by silt.

- **Station DL-12-02** - This station is positioned at the western end of the lake in the main basin. The manganese and nickel concentrations were elevated above the PSQG-LEL criteria.
- **Station DL-12-03** - This station is located in the southeastern basin of the lake, near the main inflow stream. The inflow stream is a source of organic material inputs as shown by the high TOC concentration compared to the DL-12-02 station (1.05% and 0.43% respectively). The TOC, chromium, copper, manganese and nickel concentrations were elevated above their respective CSQG-ISQG and/or PSQG-LEL criteria.

D.5 INFLUENCE OF TOC AND FINES ON METALS ACCUMULATION

Metals concentrations in sediment are positively correlated with both finer grained particles as well as higher organic carbon content (Horowitz, 1991; EC, 2012). These relationships are observed within the sediment quality baseline dataset. Metals concentrations are consistently higher in depositional environments that generally have a higher proportion of organic carbon and fines in the substrate. Depositional environments were predominantly found within the mine site lakes, with the exception of select stations within the main tributary of Sheardown Lake (tributary 1). Streams at the mine site most often are high gradient, high energy and are not therefore depositional environments consisting of fine grained sediment or high organic carbon content.

For this reason, metals concentrations in lake sediment were consistently higher than sediment in streams. This is observed when reviewing mean concentrations of key metals as presented in Table D.1 (numbers have been rounded). Stream versus lake sediment sample groupings are shaded different colours.

Additionally, metals concentrations in depositional environments (higher TOC and/or fines) tended to be higher in the same metals. In the three mine site lakes, the mean concentrations of chromium, copper, iron, manganese and nickel exceeded applicable guidelines. Throughout the sediment quality dataset it is observed that depositional environments typically contain exceedances of most of these metals.

Metals concentrations in depositional lake samples are relatively consistent between samples, between sample stations within a given lake, as well as between each of the three mine site lakes (Camp, Mary, Sheardown). Sample location D1-05 within Sheardown Lake tributary 1 also exhibited the same substrate characteristics and elevated metals concentrations.

Conversely, metals concentrations in lake sediment and most stream sediment stations which were low in fines and/or TOC contained comparatively lower concentrations of metals and a high degree of variability in metals concentrations between sampling events between nearby sampling stations.

Table D.1 Mean Concentrations of Key Metals in Sediment at the Mine Site

Sample ID		**As µg/g**	**Cd µg/g**	**Cr µg/g**	**Cu µg/g**	**Fe µg/g**	**Mn µg/g**	**Ni µg/g**	**Pb µg/g**	**Zn µg/g**
CCME	ISQG	**5.9**	**0.6**	**37.3**	**35.7**				**35**	**123**
	PEL	**17**	**3.5**	**90**	**197**				**91.3**	**315**
Ontario Sediment Quality Guidelines	LEL	**6**	**0.6**	**26**	**16**	**20,000**	**460**	**16**	**31**	**120**
	SEL	**33**	**10**	**110**	**110**	**40,000**	**1,100**	**75**	**250**	**820**
	n									
Upstream of Deposits	4	0.9	0.4	12.8	1.9	9,446	41	5	1.6	5.9
Downstream of Deposits	22	<1	<0.5	22.9	4.5	11,795	83	13	2.4	8.5
Drainages Off the Deposits	10	<1	<0.5	**28.3**	12.8	9,688	135	**21**	2.9	15.1
Mary River Tributary E2	7	1.0	0.4	18.5	3.8	9,507	64	12	2.5	7.0
Mary River Downstream of Mary Lake	2	0.7	0.3	**74.5**	7.0	6,050	90	**29**	1.5	7.8
Sheardown Lake Tributaries	18	1.4	**0.65**	**45.2**	**27.0**	13,524	235	**39**	12.1	47.6
Camp Lake Tributaries	12	0.9	0.4	**27.0**	12.3	8,501	95	**22**	3.7	13.3
Tom River	4	<1	<0.5	14.5	2.3	6,993	48	7	1.5	5.8
Mary Lake	9	2.5	<0.5	**54.6**	**21.7**	**27,469**	**1,099**	**40**	13.4	51.6
Camp Lake	12	2.7	<0.5	**60.2**	**33.2**	**27,748**	**700**	**52**	14.7	48.8
Sheardown Lake NW	32	3.1	<0.5	**59.6**	**36.8**	**30,687**	**1,149**	**54**	14.6	56.6
Sheardown Lake SE	7	1.5	**0.6**	**68.0**	**23.4**	**27,462**	397	**57**	13.3	46.3

Therefore, further evaluation of the sediment quality database was undertaken to understand the relationship between TOC, the proportion of fines, and metals concentrations.

Figure D.11 shows clay, sand and silt plotted for the entire sediment quality dataset. Circle size represents the proportion of silt. Figure D.12 shows the same information in another way, plotting the proportion of clay/clay+silt by sand. The figures show the 3-way relationship between sand, silt and clay and the negative association between sand and clay.

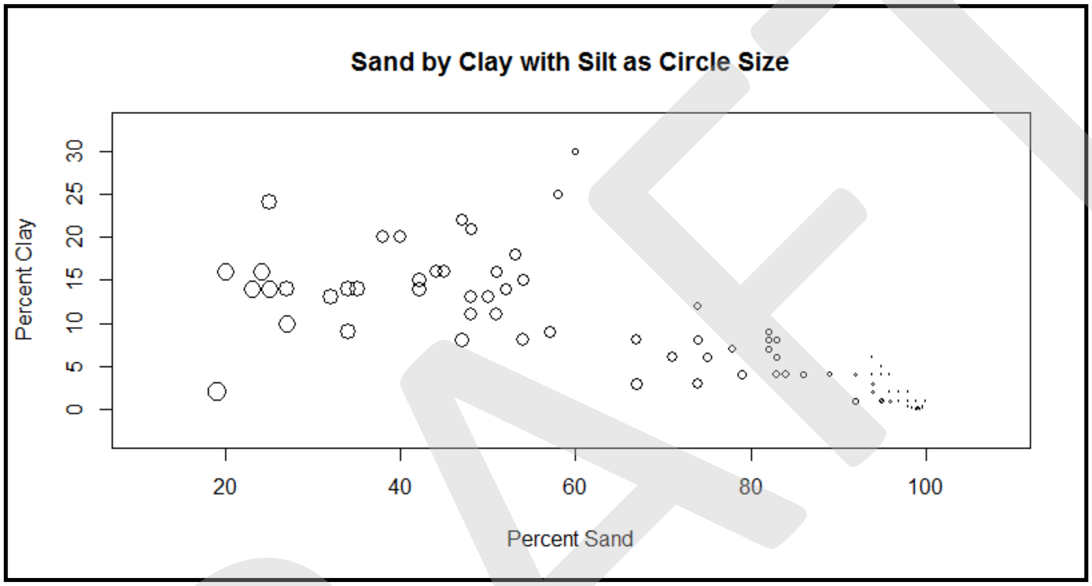

Figure D.11 Clay by Sand with Silt as Circle Size

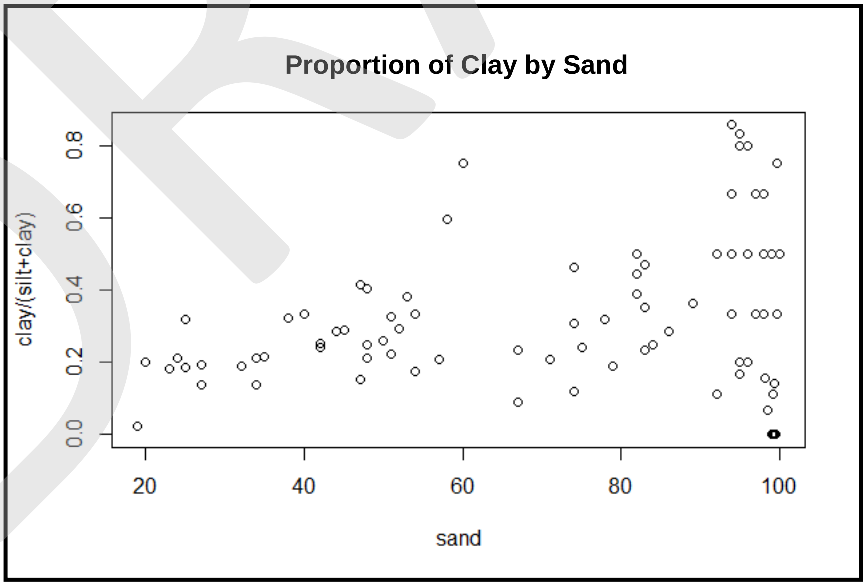

Figure D.12 Dependent Relationship between Sand, Silt and Clay in Sediment

Colored scatter plots (Figure D.13) show the relationship between TOC (or log TOC) and sand for lakes, streams and tributaries. Lakes are plotted using circles, streams and tributaries with triangles.

Colors are used to identify the specific water bodies. Note that the x axis limits for streams and tributaries were adjusted because all the stream data is clumped at high proportions of sand (minimum of 82%). The figure shows that the majority of lake sediment samples contain elevated TOC and higher proportions of fines (a lower proportion of sand), and conversely, the majority of stream samples are low in TOC and low in fines (predominantly sand).

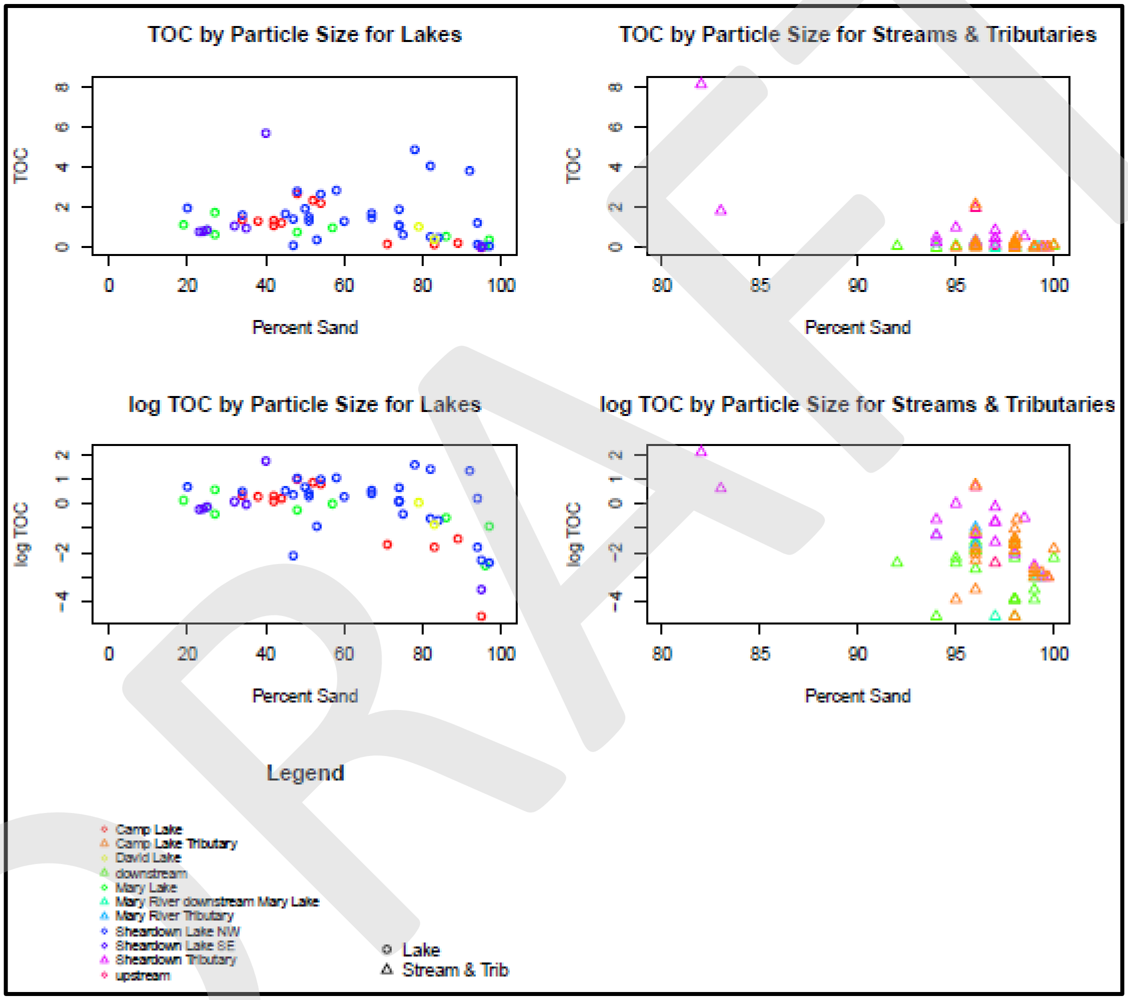

Figure D.13 Sediment TOC versus Particle Size for Lakes and Streams

A further evaluation was undertaken to identify cut offs in TOC and percent sand that could be applied to identify sediment samples in the baseline that can be used for comparison purposes, with the same cut off thresholds for TOC and percent sand applied to sediment samples collected for monitoring. In terms of long-term monitoring, it is recommended that sediment sampling stations in depositional environments be the focus of monitoring and the application of the assessment protocol identified in the AEMP Framework (e.g., detection of a change; establishing if the change is mine related; comparison to AEMP benchmark; undertaking a low or moderate action depending on the result compared to the AEMP benchmark). The high level of variability of metals concentrations within sediment samples characterized by high TOC (low proportion of sand) are likely to mask instead of allow for the detection of Project-related change, as the variability between samples may mask any project-related changes and collection of a sufficient number of samples to obtain statistical power is likely not possible.

D.6 STATISTICAL AND CUT POINT ANALYSIS

Percent sand and TOC are generally related to parameter concentrations. Deposition seems to be limited in sediment samples with high amounts of sand and very little TOC. For the AEMP, the focus of monitoring will be on identified mine-related changes in parameter concentrations. Variability due to TOC and particle size is a nuisance and introduces extraneous noise. In general, it is better to control confounding factors in the study design rather than adjust for them post hoc in the data analysis. Environment Canada (2012) recommends that normalized metal concentrations be used to account for the effects of particle size and organic carbon. This method was considered, but it was found that the best way to minimize the relationship to organic carbon and fines involved creating data cut-offs. Additionally, normalized metals concentrations do not reflect the actual toxicity exposure in the environment.

To identify sensitive depositional environments and minimize variability related to TOC and particle size the data were explored to determine appropriate TOC and particle size cut-offs. Regression analyses were used for 4 key parameters: arsenic, cadmium, iron and nickel.

Several arsenic samples, and many cadmium samples were below MDLs. For this analysis the MDL was used as the estimated concentration for samples below MDLs. Further analysis could be refined by using Tobit regression to account for the left censoring related to MDLs. However, methods to adjust for left censoring may not be appropriate when very large portions of the data are below MDLs as is the case for cadmium.

B-splines were used to obtain flexible, non-linear fits to explore the relationships between percent sand (Figure D.14) and TOC (Figure D.15) and each parameter. The fits using percent sand and TOC are shown in Figure D.16. These plots helped identify cut points in the vicinity of inflection points on the curves. The cut points were used in subsequent linear regression analyses to assess the linear relationship above and below the cut off points (black, green and red lines represent fits using 80%, 85% and 90% cut offs for sand or 0.2%, 0.6% and 1% TOC respectively).

The regression analyses were set up to accommodate separate, but connected, slopes on either side of the cut points. For sand, a cut point of 80% led to relatively gentle regression slopes below 80% and steep negative slopes above 80%. The cut points for TOC were not as clear. However, considering the size of the plotting symbols and the results of bivariate regressions, which include both TOC and percent sand (Figure D.16), defining cut points based on both percent sand and TOC was found to be useful.

A subset of the data was defined which excluded all samples with greater than 90% sand as well as samples with less than 0.6% TOC and greater than 80% sand (indicated in orange in Figure D.17). Alternatively, a cut off could be established such as the sloped black line in Figure D.17. It may be useful to carry out future research with additional data to develop such a rule. Figure D.18 shows the relationships between parameter concentrations and TOC and percent sand were generally negligible for the quantitatively defined subsets. The only exception is cadmium which has a large proportion of data below MDLs.

The selection criterion reduces variability associated with TOC and particle size. For post-mining data, using only samples which meet the criterion is expected to be a conservative approach since samples with more than 80% sand and low TOC tend to have the smallest parameter concentration.

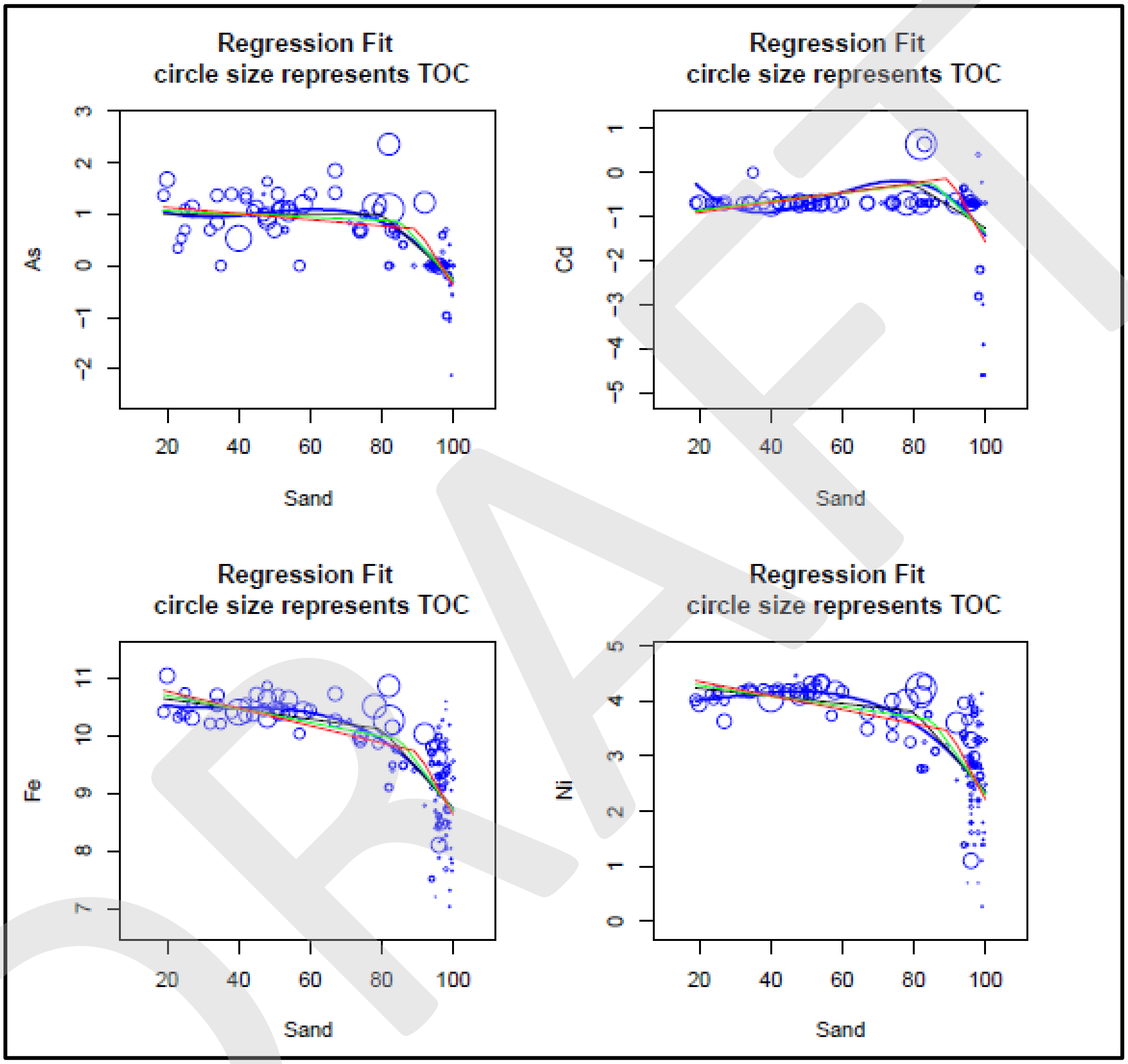

Figure D.14 **Concentrations of As, Cd, Fe and Ni in Sediment Based on Percent Sand**

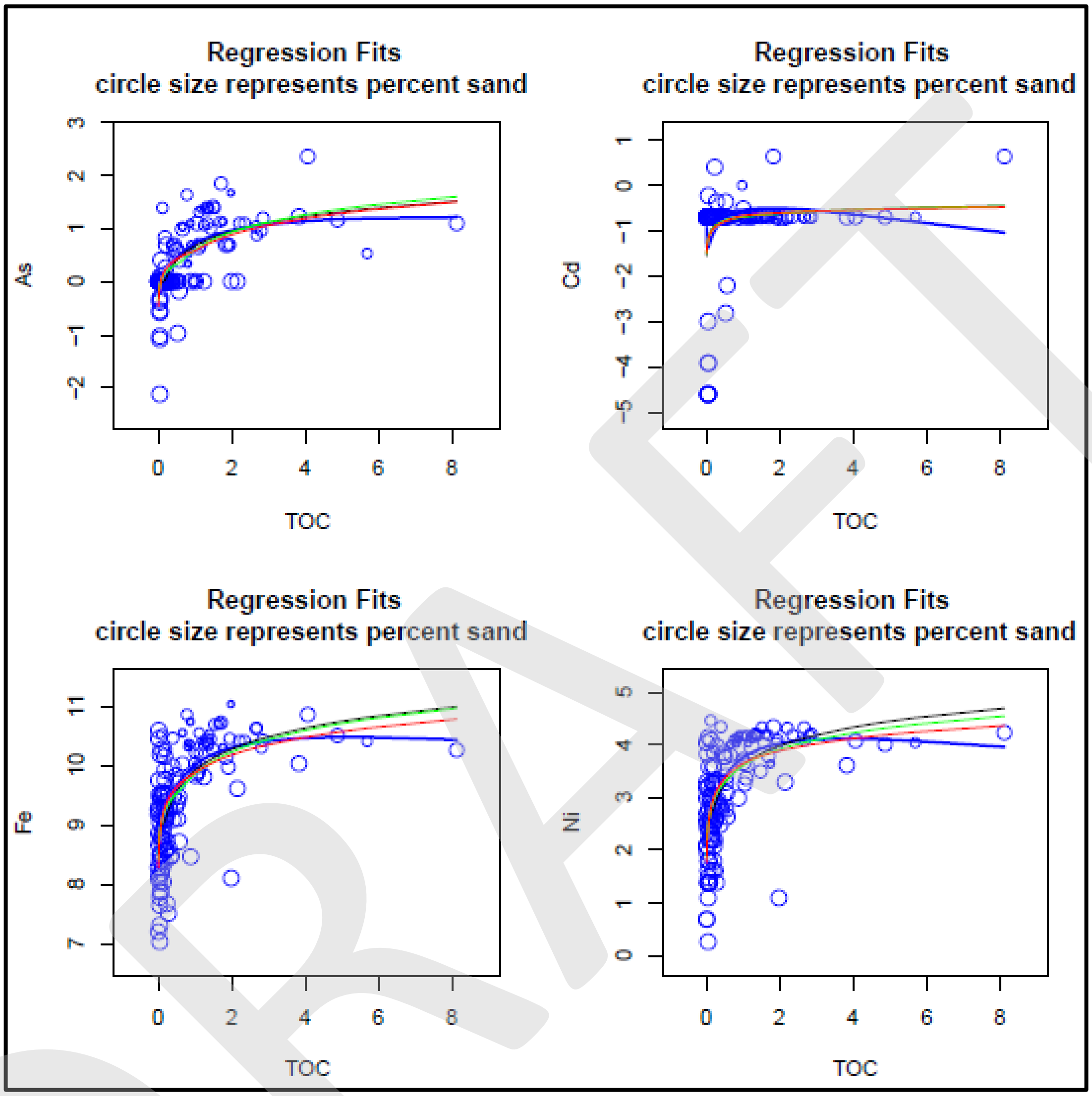

Figure D.15 Concentrations of As, Cd, Fe and Ni in Sediment Based on Percent TOC

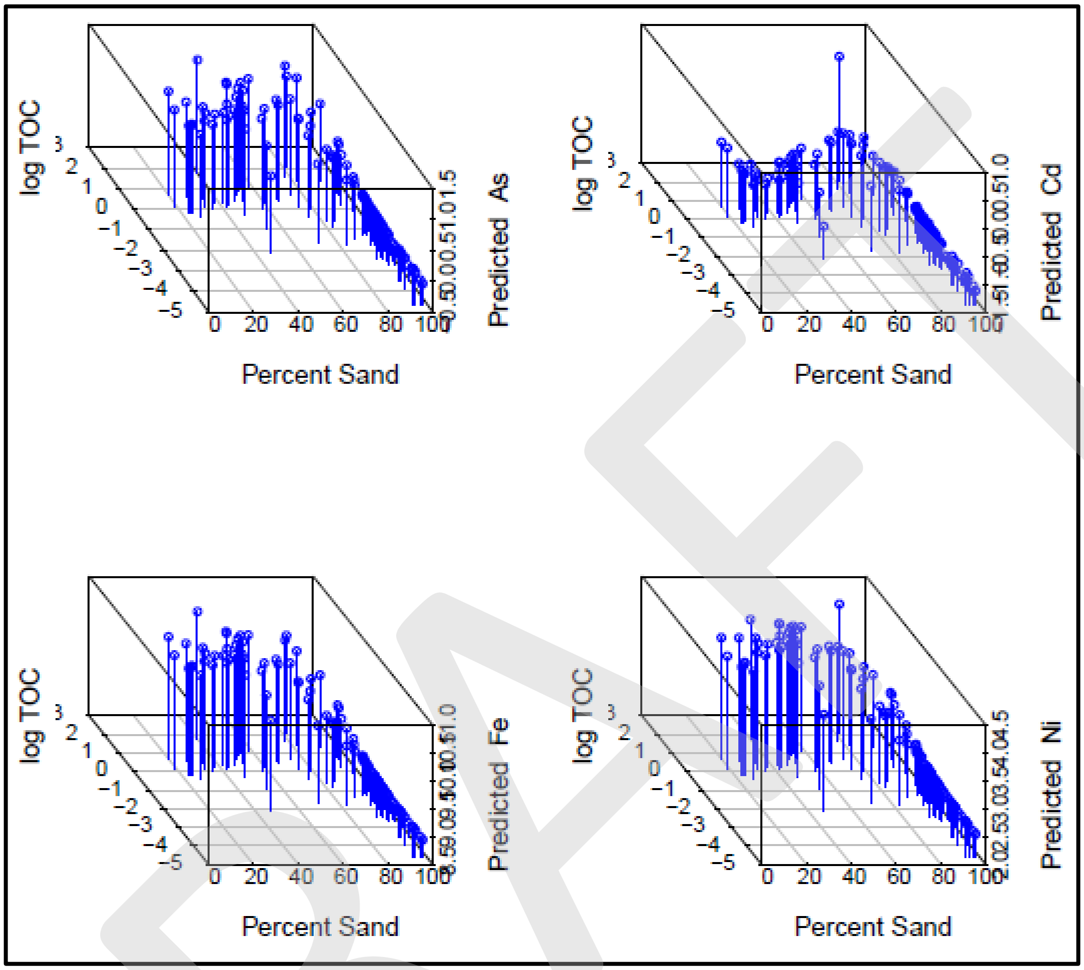

Figure D.16 Concentrations of As, Cd, Fe and Ni in Sediment Based on Log TOC and Percent Sand

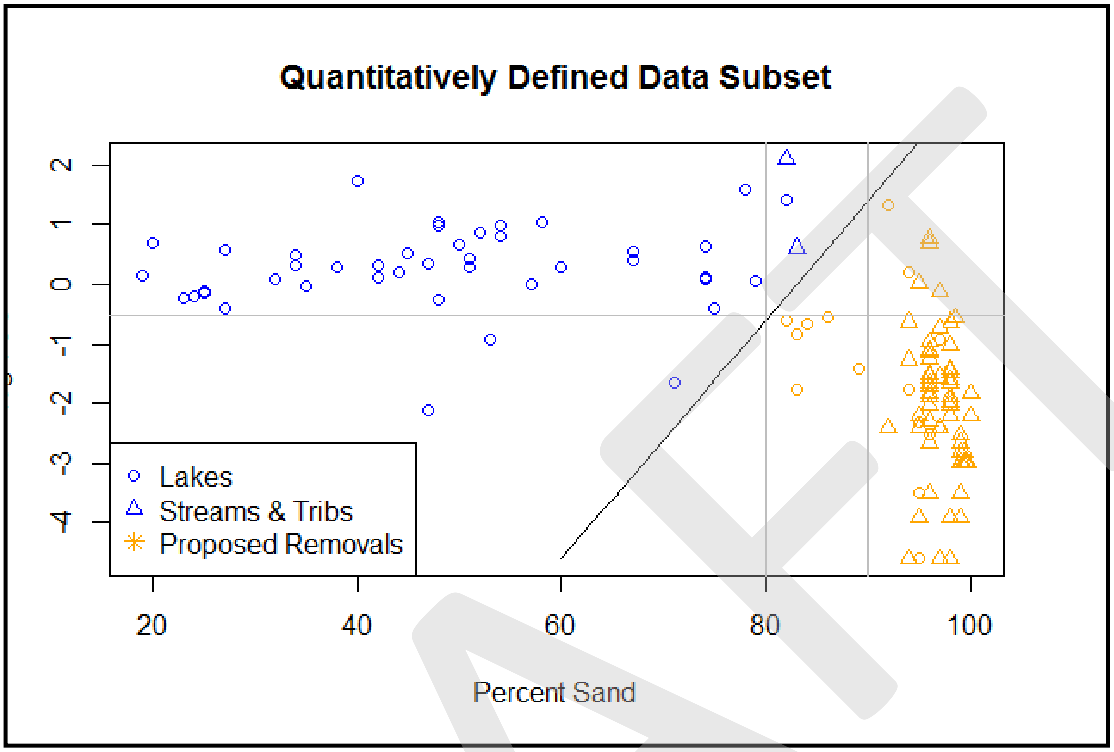

Figure D.17 Results of Cut Point Analysis for Sediment

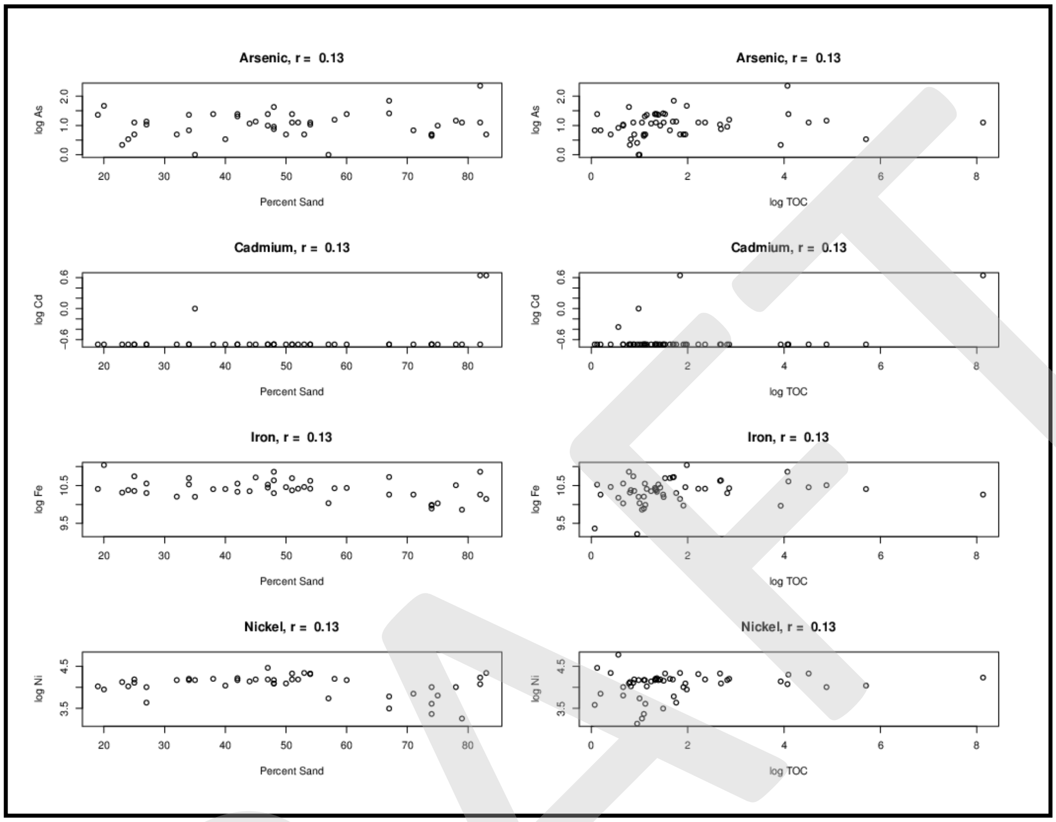

Figure D.18 Correlations between TOC and Percent Sand, and the 4 Key Parameters for the Subset Data, Second Stage Cuts in Blue

D.7 TEMPORAL AND SAMPLING EFFECTS

Sediment sampling from 2005 to 2008 was carried out using of a Petite Ponar dredge sampler to collect a maximum sample collection thickness of 5 cm. This depth is appropriate for monitoring studies where historical contamination is not a priority (Environment Canada, 2012). As a result of a recommendation from Environment Canada that the upper 1 to 2 cm of sediment be collected as part of Project monitoring, collection of a thinner (2 cm) core sediment sample was implemented by Baffinland starting in 2012. A comparison of the lake data from 2006 to 2013 was completed to determine if appreciable differences in sediment concentrations occurred as a result in the change of sampling techniques. Note that 2005 data was not included in the temporal sampling, since lake sampling did not occur in 2005. Review of Figures D.19 and D.20 indicate that significant inter-annual effects do not occur for any of the parameters of interest; however, certain parameters show slightly depressed concentrations in 2006 (chromium, lead, zinc and nickel). Due to the low sample size in 2006, the slightly depressed 2006 concentrations are considered to be influenced by sample size.

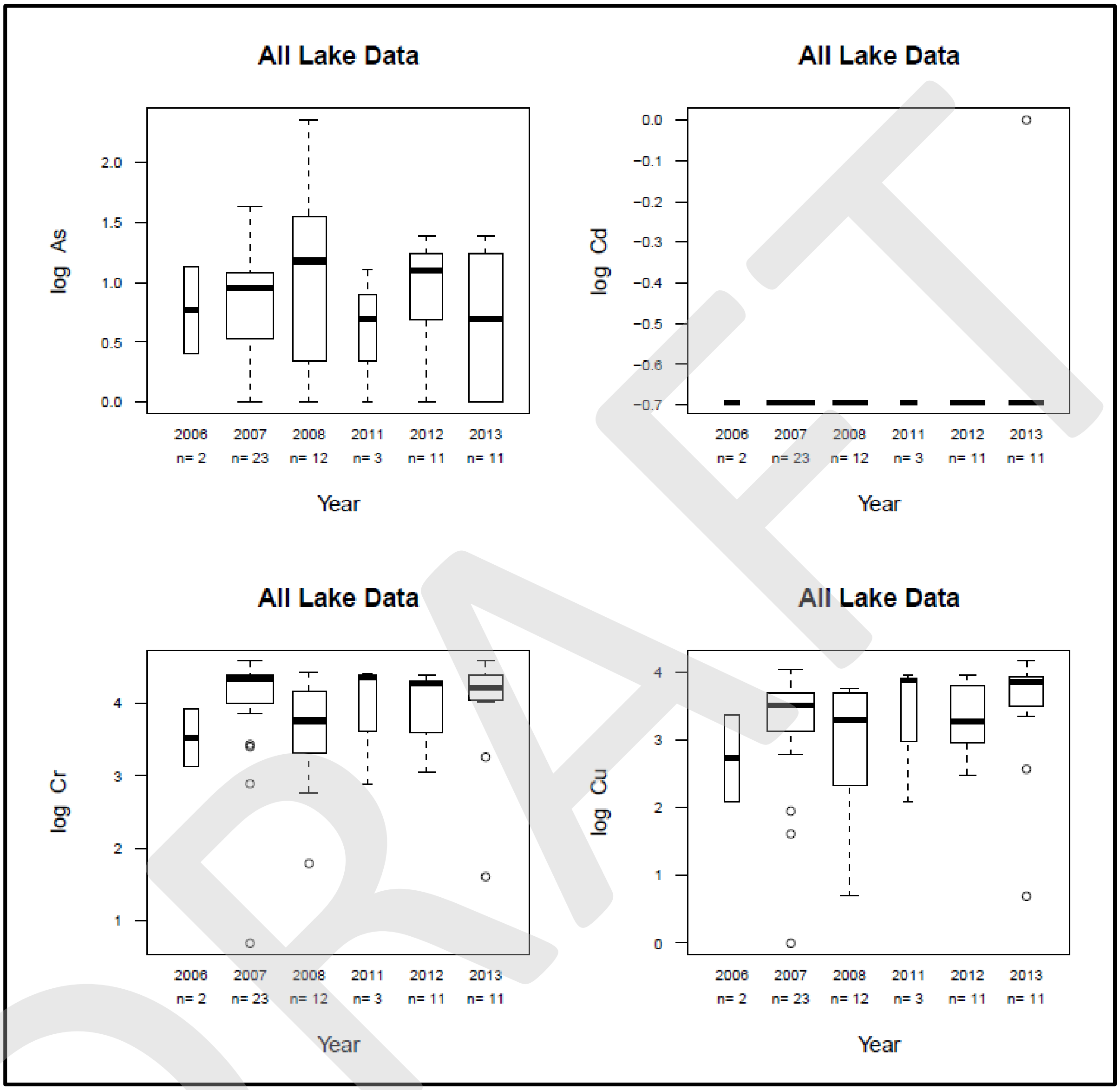

Figure D.19 **Inter-Annual Variability for As, Cd, Cr and Cu in Sediment**

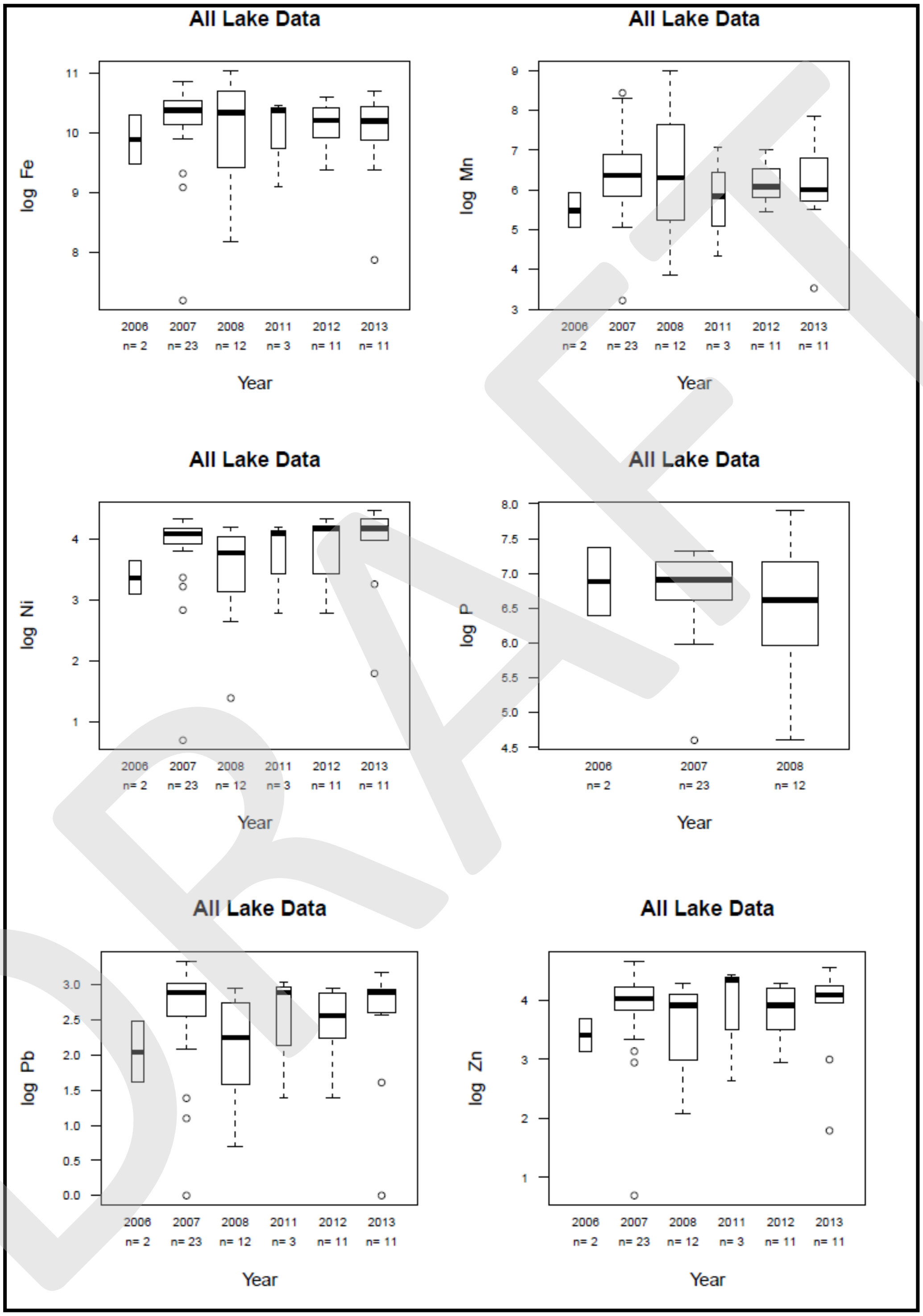

Figure D.20 **Inter-Annual Variability for Fe, Mn, Ni, P, Pb and Zn in Sediment**

D.8 POWER ANALYSIS

The baseline sediment quality monitoring program results from the stream and lake environments surrounding the Project site show naturally elevated concentrations above the lower sediment quality criteria concentrations for parameters of concern such as chromium, copper, iron, manganese and nickel. The iron and manganese concentrations were also typically above the severe effect levels in the lake environments.

After an initial exploratory analysis of the sediment baseline data, it was decided to retain fifty-two (52) samples that fit the criteria for TOC and percent sand. Sufficient power to detect a change from baseline values was desired for each station. Baseline data was not collected at reference stations and therefore, since baseline reference (control) data was not available, a full BACI design was not used for the power analysis. Instead, a before-after (BA) design was used. The power analysis was carried out using a two sample t-test which assumes independence between the before and after samples.

The sample sizes for each year, at each lake are presented in Table D.2. Further sampling carried out in 2014 will supplement this dataset and provide a better basis for refined power analysis. Here, instead of using highly variable estimates of station means from the limited baseline data, a generic analysis was used. Power to detect a change from a baseline mean to 97.5th percentiles for a normally distributed variable was used to get sample size estimates which apply to all sites and metals. This analysis will be refined for specific stations and metals after 2014 samples are collected and benchmarks have been finalized.

Table D.2 Sediment Sample Sizes for the Mary River Project

Area	**2006**	**2007**	**2008**	**2011**	**2012**	**2013**
Camp Lake	0	5	0	0	2	2
Mary Lake	1	4	0	0	1	0
Sheardown Lake NW	0	7	7	2	4	5
Sheardown Lake SE	0	4	0	0	1	1
David Lake	0	0	0	0	1	0

Site-wide preliminary benchmarks were developed by Intrinsik such that the benchmark was set to either the guideline value or the empirical estimate of the 97.5th percentile of the data, whichever was larger. In all cases, the 97.5th percentile was the lowest value. Therefore, the minimum power to detect a change from baseline mean to the benchmark can be obtained by considering this lower bound of the benchmark (97.5th percentile). For parameters where the benchmark is based on the guideline, the effect size is actually larger than considered here and thus the power will also be larger.

Further analysis was carried out to assess the sample size required to have sufficient power to detect smaller changes which act as early warning flags. The early warning value was set as half way between the baseline mean (or median) and the 97.5th percentile ($z = 1.96/2$; approximately the 84th percentile).

Using this approach, power can be calculated simultaneously for all variables and all sites as follows:

- Assume the data (log transformed) is normally distributed based on other analysis of other larger data sets

- Consider the standardized data; a z-score is obtained by subtracting the mean and dividing by the standard deviation
- For standardized normal data, the mean and median are equal with a z-score of 0; the 97.5th percentile has a z-score of 1.96
- The power to detect a before-after change from the baseline mean 0 (= median) to 1.96 (97.5th percentile) can be calculated using a 2 sample t-test
- Choose a one-tailed type I error of 0.05 or 0.01 since only increases in concentration are of interest

This approach allows a generic assessment of power for all parameters. The power for sample sizes of 5, 10, 15, 20 and 25 are shown for the 97.5th percentile and the mid-point value ($z = z_{97:5}=2$) half way between the median ($z_{50} = 0$) and 97.5th percentile ($z_{97:5} = 1:96$). The following tables can be used to assess the sample size requirements for each station provided the 97.5th percentile estimates used for benchmark development is a reasonable estimate for each station. That is, provided the 97.5th percentile of the pooled data (from all stations) is representative of each individual station.

An alpha value of 0.05 was selected to examine the effects of varying the pre-mining and post mining sample size. In order to gain sufficient power, ideally either 15 pre-mining samples are taken and 25 post-mining are taken or 25 pre-mining samples are taken and 15 post-mining samples are taken to have sufficient power to detect early warning flags.

Table D.3 Power Predicted for Various Sample Sizes – Median to 95th Percentile

	N before = 5	N before = 10	N before = 15	N before = 25
N after = 5	0.77	0.89	0.92	0.95
N after = 10	0.97	0.97	0.99	1.00
N after = 15	0.99	0.99	1.00	1.00
N after = 25	1.00	1.00	1.00	1.00

NOTES:

1. ALPHA EQUALS 0.05.
2. THE EFFECT SIZE IS FROM MEDIAN TO THE 95TH PERCENTILE (1.65).

Table D.4 Power Predicted for Various Sample Sizes - Halfway from Median to 95th Percentile

	N before = 5	N before = 10	N before = 15	N before = 25
N after = 5	0.33	0.41	0.46	0.50
N after = 10	0.41	0.55	0.62	0.42
N after = 15	0.46	0.62	0.71	0.80
N after = 25	0.50	0.70	0.80	0.89

NOTES:

1. ALPHA EQUALS 0.05.
2. THE EFFECT SIZE IS HALFWAY FROM MEDIAN TO THE 95TH PERCENTILE (1.65/2).

D.9 RECOMMENDATIONS

The relationship between fine grained sediments and the accumulation of the parameters of concern suggests the sediment monitoring program should focus on the depositional lake environments, since they are the end receiver of stream sediments. Focusing the CREMP to include additional lake sediment monitoring stations and reducing the amount of stream sediment quality monitoring stations would increase the data coverage within the lake basins and strengthen the baseline data set. Stream sediment sampling will be conducted as part of the Environmental Effects Monitoring program required under the MMER in the Mary River and Camp Lake Tributary 1.

In order to achieve the sample sizes required, the following are recommended:

1. An additional year of baseline data collection.
2. Utilization of samples within one lake basin to achieve sufficient pre-mining sample size.
3. Recognition that there will not be sufficient power to complete site-based statistical testing.

D.10 REFERENCES

Environment Canada, 2012. *Metal Mining Technical Guidance for Environmental Effects Monitoring* .National Environmental Effects Monitoring Office.

Horowitz, Arthur J., 1991. *A Primer on Sediment-Trace Element Chemistry, 2nd Edition*. United States Geological Survey, Open File Report 91-76.

Intrinsik Environmental Sciences Inc., 2014. *Development of Water and Sediment Quality Benchmarks for Application in Aquatic Effects Monitoring at the Mary River Project.* Intrinsik Project No. 30-30300.