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APPENDIX B

DETAILED REVIEW OF BASELINE LAKE WATER QUALITY

(Pages B-1 to B-98)

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

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

DETAILED REVIEW OF BASELINE LAKE WATER QUALITY
NB102-181/33-1B

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B – LAKE WATER QUALITY REVIEW

B.1 OVERVIEW

A detailed review of lake water 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
- 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, depth (for lakes) 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 lake water quality is the mine site area lakes: Camp Lake, Sheardown Lake NW, Sheardown Lake SE and Mary Lake.

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 summer, fall and winter 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.

B.2 BASELINE SUMMARY

B.2.1 Camp Lake

A total of 51 lake samples were collected over the baseline sampling period. Most sampling was completed during July and August. Late winter sampling (May) was carried out in 2007, 2008 and 2013. Three stations were monitored (Figures B.1 and B.2):

- JL0-01-S and JL0-01-D - Shallow and deep; centre and deepest part of the lake
- JL0-02-S and JL0-02-D - Near two main tributaries likely to be influenced by the Project
- JL0-09-S and JL0-09-D - Near the outlet of Camp Lake

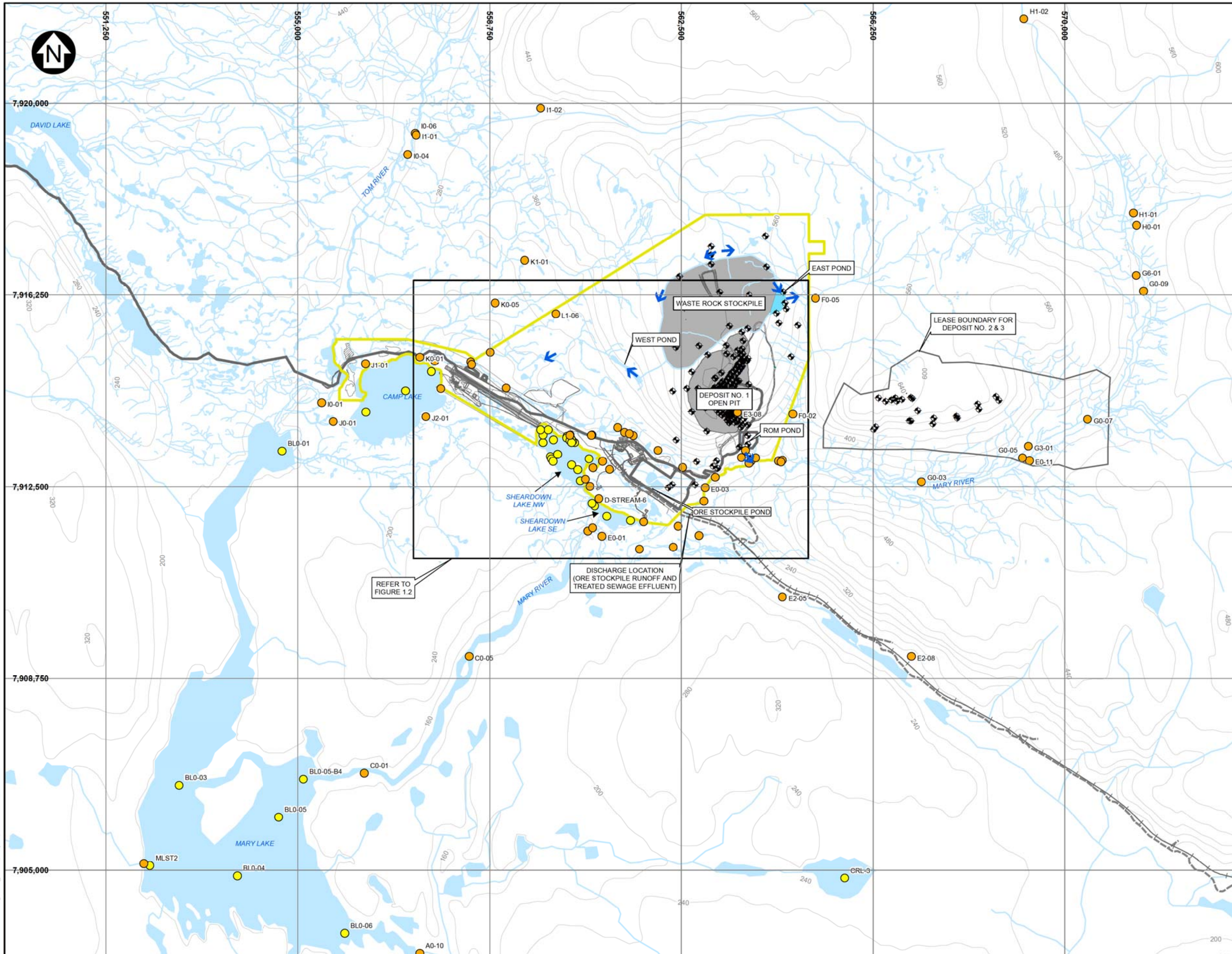
A summary of the data collected during each season are included in Table B.1. A graphical representation of the sampling events is provided in Figure B.3.

Table B.1 Camp Lake Sample Size

Year	Summer	Fall	Winter
2006	2	2	0
2007	6	6	6
2008	6	0	2
2011	4	0	0
2012	0	6	0
2013	5	6	2
Site	**Summer**	**Fall**	**Winter**
JL0-01-S	4	3	1
JL0-01-D	5	4	3
JL0-02-S	3	3	1
JL0-02-D	4	4	1
JL0-09-S	4	3	3
JL0-09-D	3	3	1

NOTES:

1. WINTER SAMPLING OCCURRED DURING APRIL AND MAY; SPRING SAMPLING OCCURRED DURING JUNE; SUMMER SAMPLING OCCURRED FROM JULY TO AUGUST 17; FALL SAMPLING OCCURRED FROM AUGUST 18 THROUGH SEPTEMBER 30.
2. LAKE SAMPLING DID NOT OCCUR DURING SPRING, DUE TO SAFETY CONCERNS OF SAMPLING OVER MELTING ICE.
3. NO SAMPLING OCCURRED DURING 2009 AND 2010.



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

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HISTORIC WATER QUALITY STATIONS MINE SITE AREA

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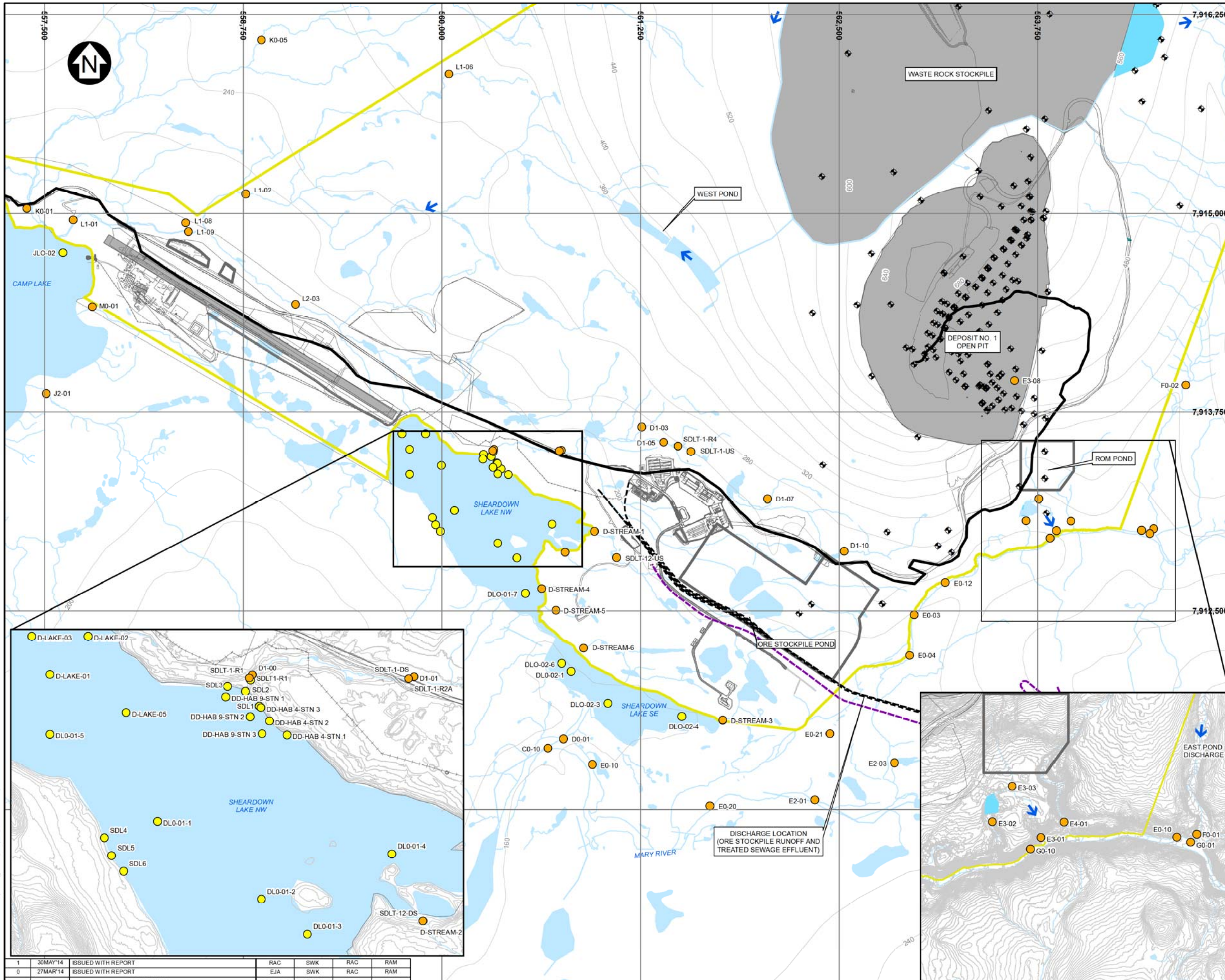
P/A NO. NB102-181/33 | REF NO. 1

FIGURE B.1 | REV 1

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	RAC	SWK	RAC	RAM

SAVED: I:\102\00181\33\A\GIS\Figs\B40_r1.mxd; May 30, 2014 1:11 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 B.2 REV 1

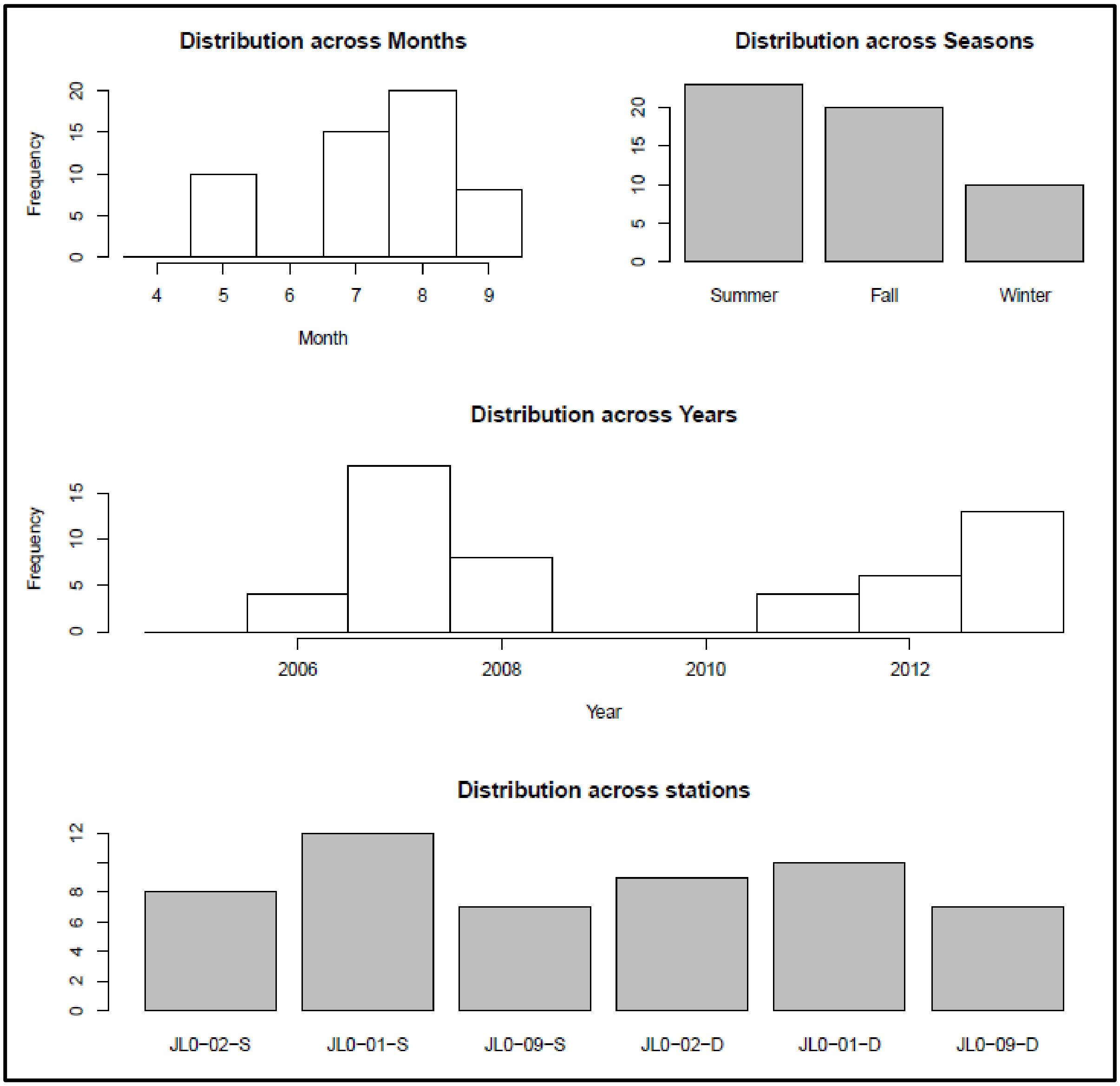


Figure B.3 Camp Lake - Graphical Summary of Sampling Events

The following summarizes the data review observations for the of the physical parameter data depicted in Figures B.4 and B.5.

pH (Figure B.4)

- Camp Lake is slightly alkaline, with total median pH of ~8.
- Measured median *In situ* pH at the deep stations (~7.6) was slightly lower compared to shallow samples (> 7.8).
- The lowest pH value was measured at the deep sample site JL0-01-D, located near the deepest portion of the lake.

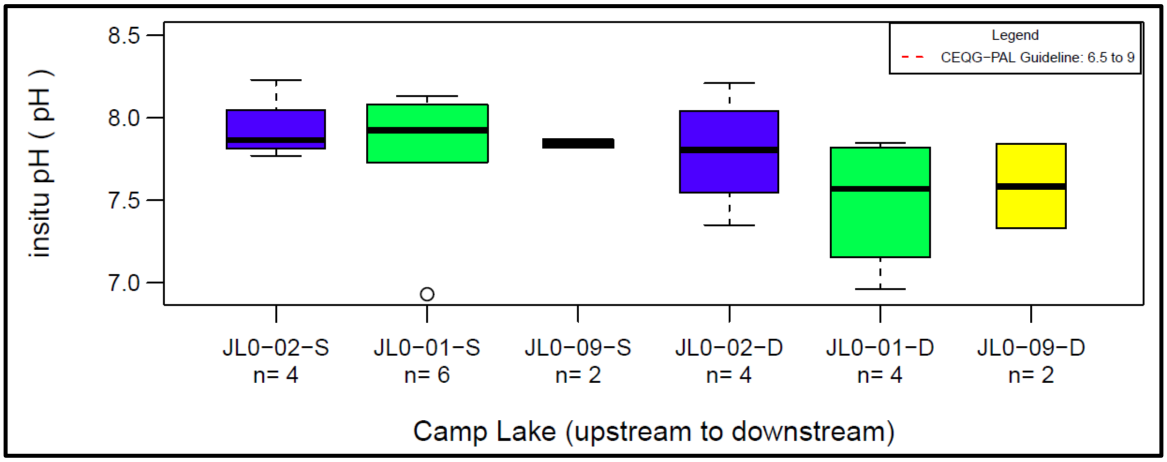


Figure B.4 Camp Lake – pH

Hardness (Figure B.5)

- Median hardness at stations within Camp Lake ranged from ~56 and 62 mg/L, classifying the lake water as “soft”. One station, JL0-02-D had a median hardness concentration that classifies the lake water as “medium hardness”.
- Hardness did not change meaningfully with depth, and portrayed trends very similar to alkalinity.
- 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.

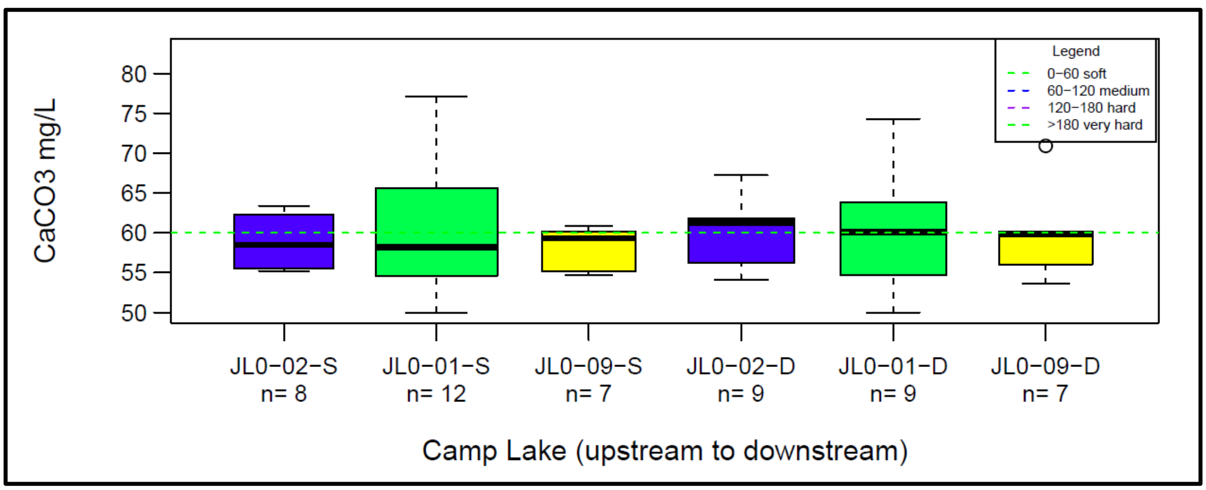
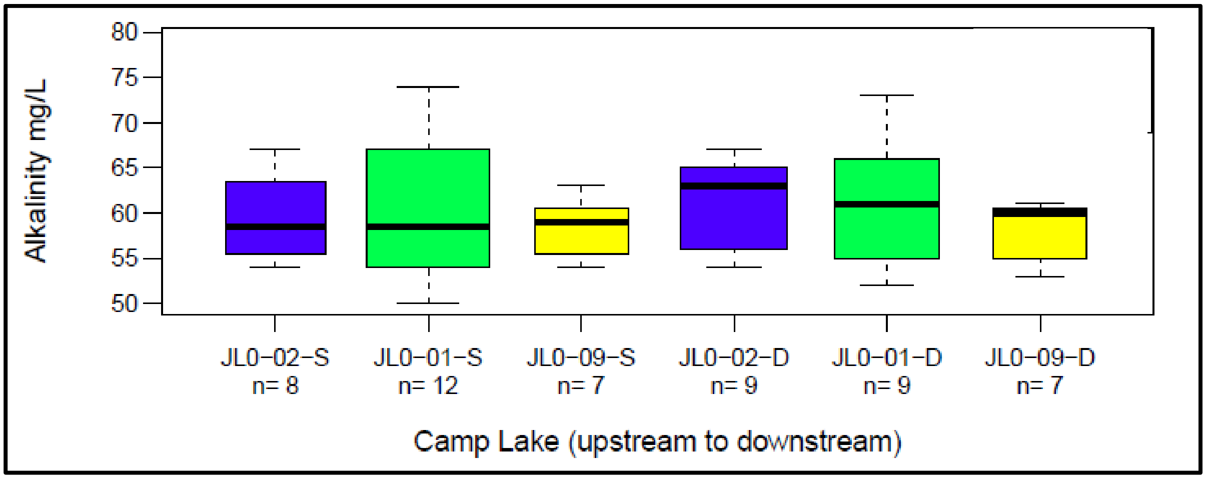


Figure B.5 Camp Lake – Hardness

Alkalinity (Figure B.6)

- Camp Lake sites have uniformly high median alkalinity values that range from 58 to 65 mg/L $CaCO_3$, classifying the lake water as having low sensitivity to acidic inputs.
- Discrete sites, regardless of depth, show similar measured alkalinity.



NOTES:

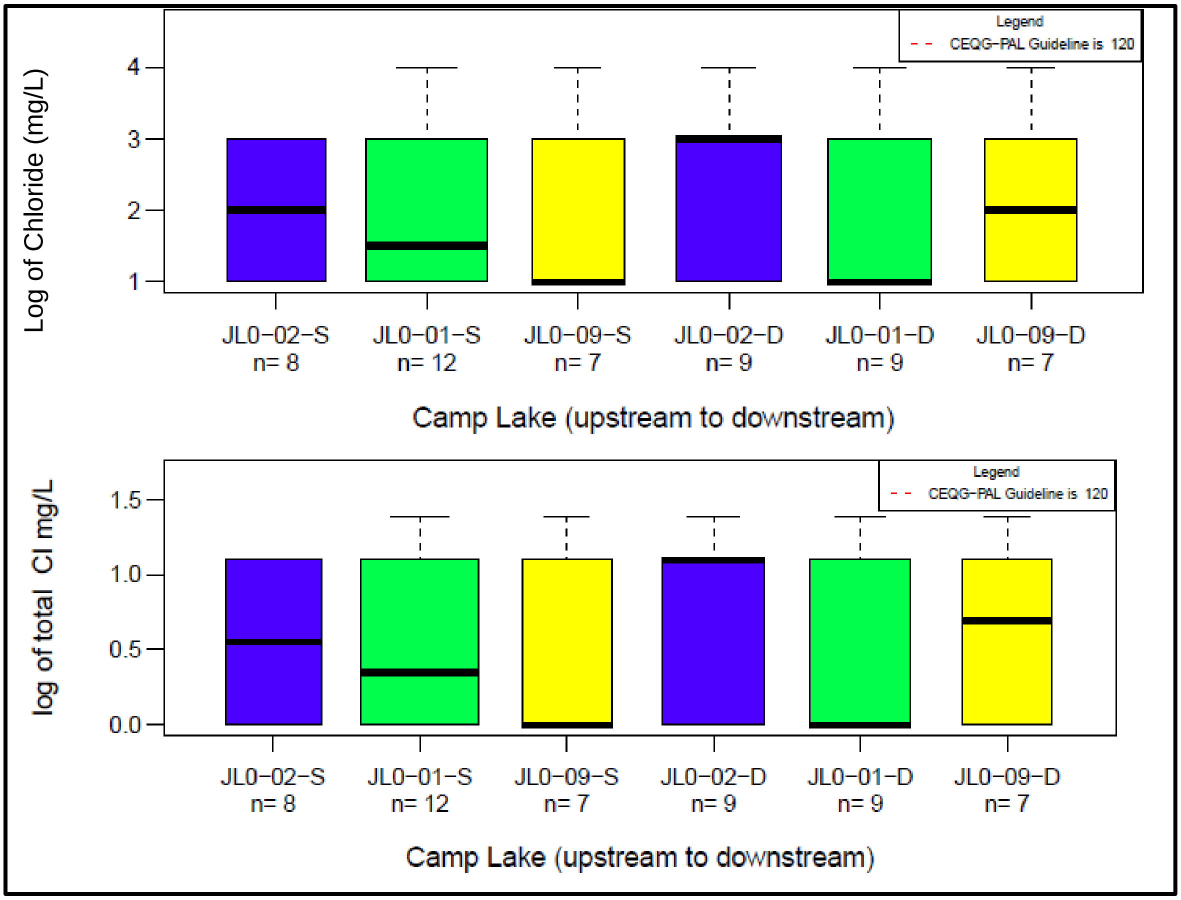
1. ALKALINITY VALUES BELOW 10 mg/L ARE HIGHLY SENSITIVE TO ACIDIC INPUTS; ALKALINITY VALUES BETWEEN 10 – 20 mg/L ARE MODERATELY SENSITIVE TO ACIDIC INPUTS AND ALKALINITY VALUES ABOVE 20 mg/L HAVE LOW SENSITIVITY TO ACIDIC INPUTS.

Figure B.6 Camp Lake – Alkalinity

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

Chloride (Figures B.7 and B.8)

The total sample size for chloride concentration samples collected ranges from seven to twelve, depending on the geographically distinct sampling site. Chloride concentrations are very low and range from maximum values of 4 mg/L to detection limit values of 1 mg/L (Figure B.7). These concentrations are far below the CWQG limit of 120 mg/L. All sites within Camp Lake have median values that range from 1 mg/L to 3 mg/L. No clear trends with respect to sample location are noted (Figure B.7). Raw data and log transformed data have identical distributions and therefore, chloride distributions remain unaffected by the lognormal data transformation.

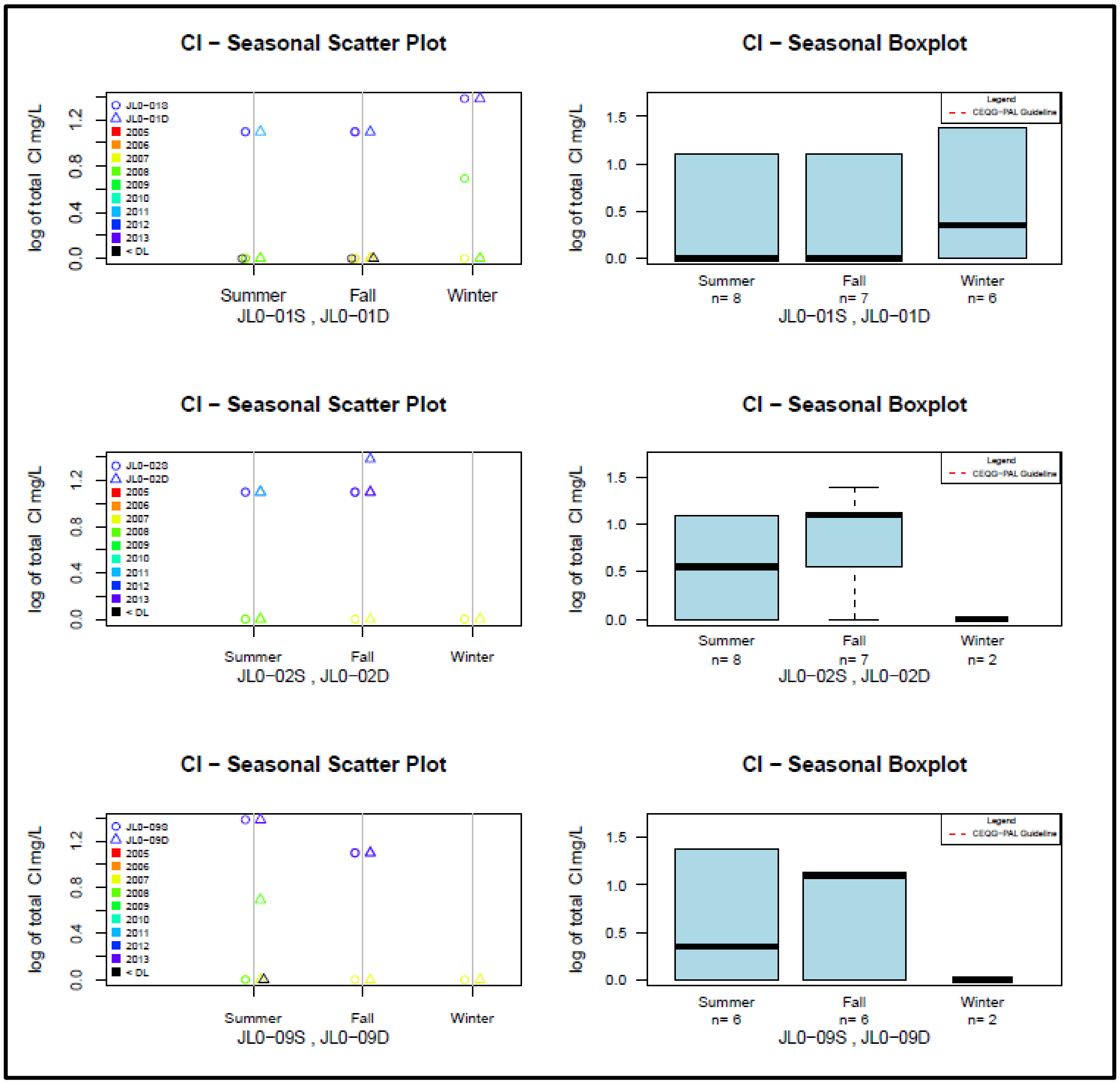


NOTES:

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

Figure B.7 Camp Lake – Chloride Concentrations in Water

Seasonal scatterplots and boxplots (Figure B.8) show that deep and shallow samples taken during the same year often had similar concentration values, which does not support the assumption that chloride concentration changes with depth.



NOTES:

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

Figure B.8 Camp Lake – Variability of Chloride in Water

The absence of greater chloride concentrations at deep sites may be explained by the very low chloride concentrations or the lack of winter under ice samples, and does not necessarily indicate the absence of stratification. The seasonal scatterplots indicate that 2011 through 2013 chloride concentrations are elevated compared to 2005 to 2010 concentrations. No distinct seasonal trends are noted.

Nitrate

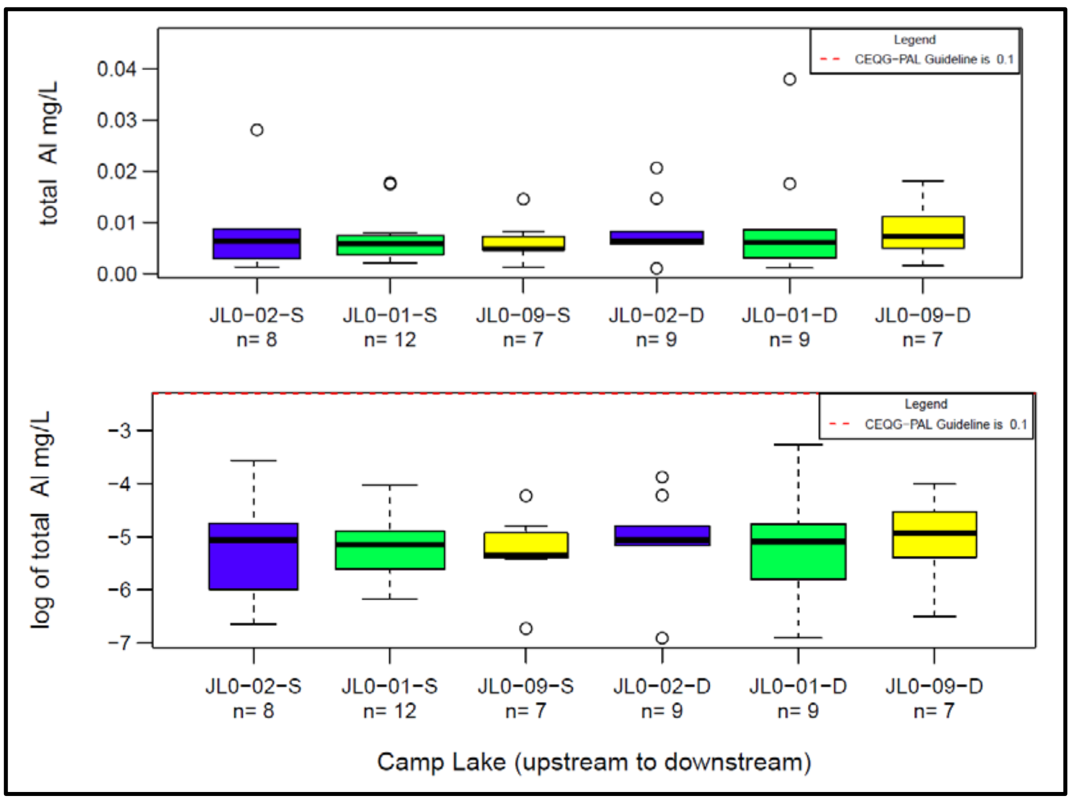
Fifty-two (52) nitrate concentration samples were collected at Camp Lake. All samples collected were at detection limit (0.10 mg/L) and occur well below the CWQG-PAL guideline (3 mg/L). Due to detection limit interference, no depth, seasonal or inter-annual variability is discernable and graphical depiction is not warranted.

The following sections summarize the results for the metal parameters of interest: aluminum, arsenic, cadmium, copper, iron, and nickel. Total metals concentrations for the parameters of interest have been presented on the basis that applicable guidelines are focused on total metals.

Total Aluminum (Figures B.9 and B.10)

Total aluminum values are uniformly above detection limits, but below the CWQG-PAL guideline across all sites in Camp Lake. Similar to nitrate and chloride, seasonal scatterplots and boxplots for aluminum show concentrations measured at deep and shallow samples taken during the same year have similar values (Figures B.9 and B.10).

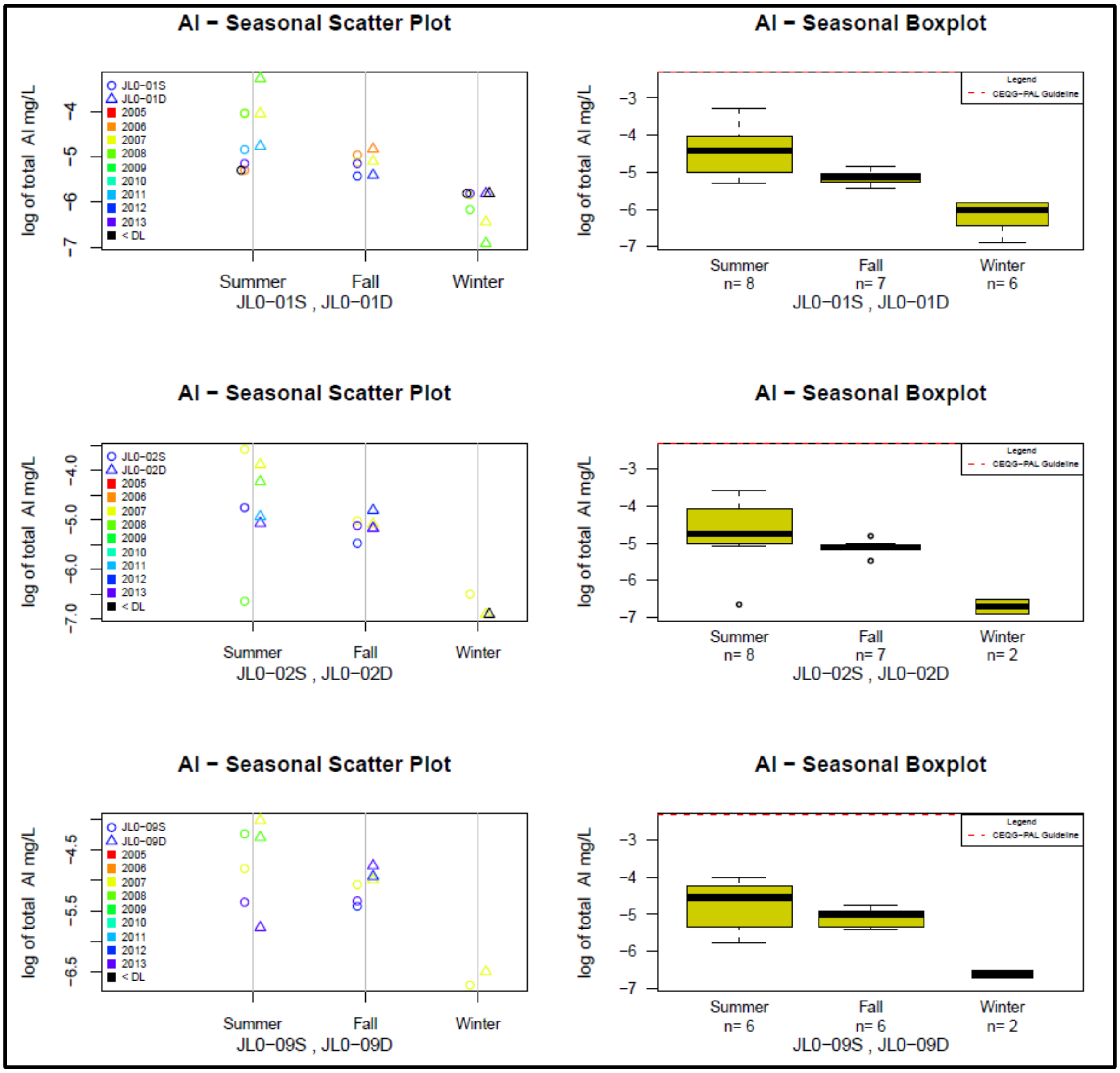
Seasonal plots show higher median values of aluminum measured during the summer, lower aluminum concentrations measured in the fall and the lowest aluminum concentrations measured in the winter. Due to the log scale of these graphs, the actual magnitude variation is small. This seasonal trend may be explained by a combination of natural and anthropogenic factors. Elevated summer concentrations may occur as result of increase summer water temperature, increased aluminum mobilization from rocks, soils and sediments by running water during summer and fall seasons or as a result of drilling activities that have occurred in vicinity to Camp Lake during the summer.



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.9 Camp Lake – 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.

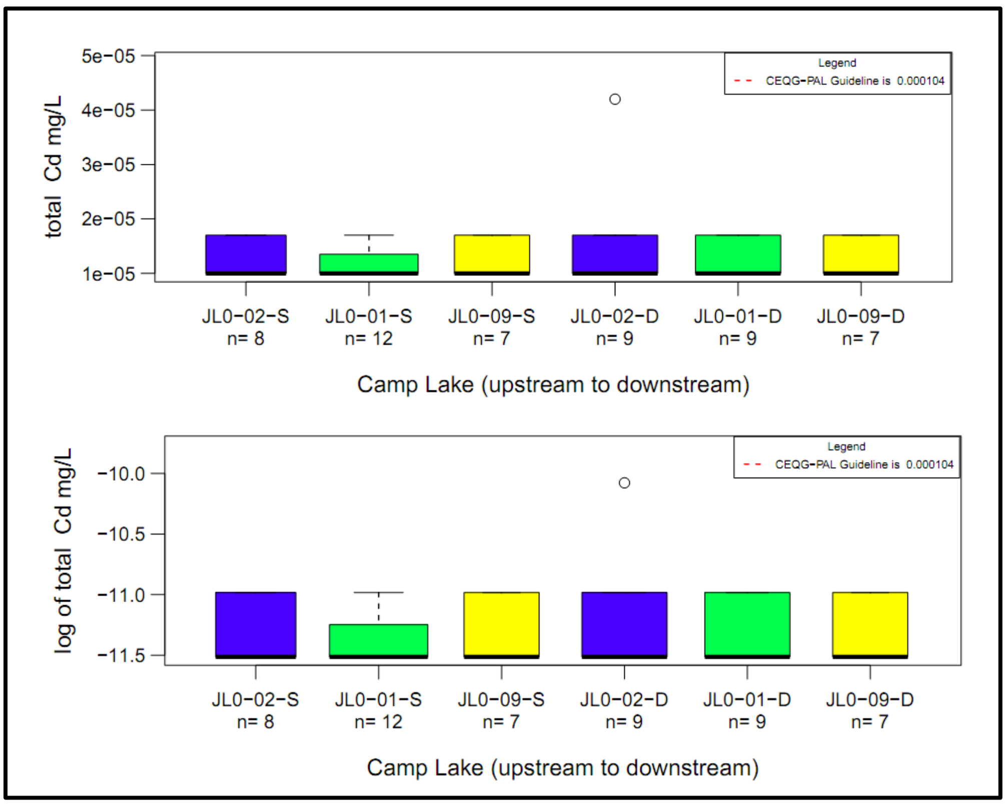
Figure B.10 Camp Lake – Variability of Total Aluminum in Water

Total Arsenic

Total arsenic concentrations were measured at the detection limit (0.0001 mg/L), consistently at all sampling locations within Camp Lake, throughout all seasons and during all years of sampling. As a result, graphical representation of data is not deemed necessary. The detection limit value is well below the appilcable CWQG-PAL guideline limit (0.005 mg/L).

Total Cadmium (Figures B.11 and B.12)

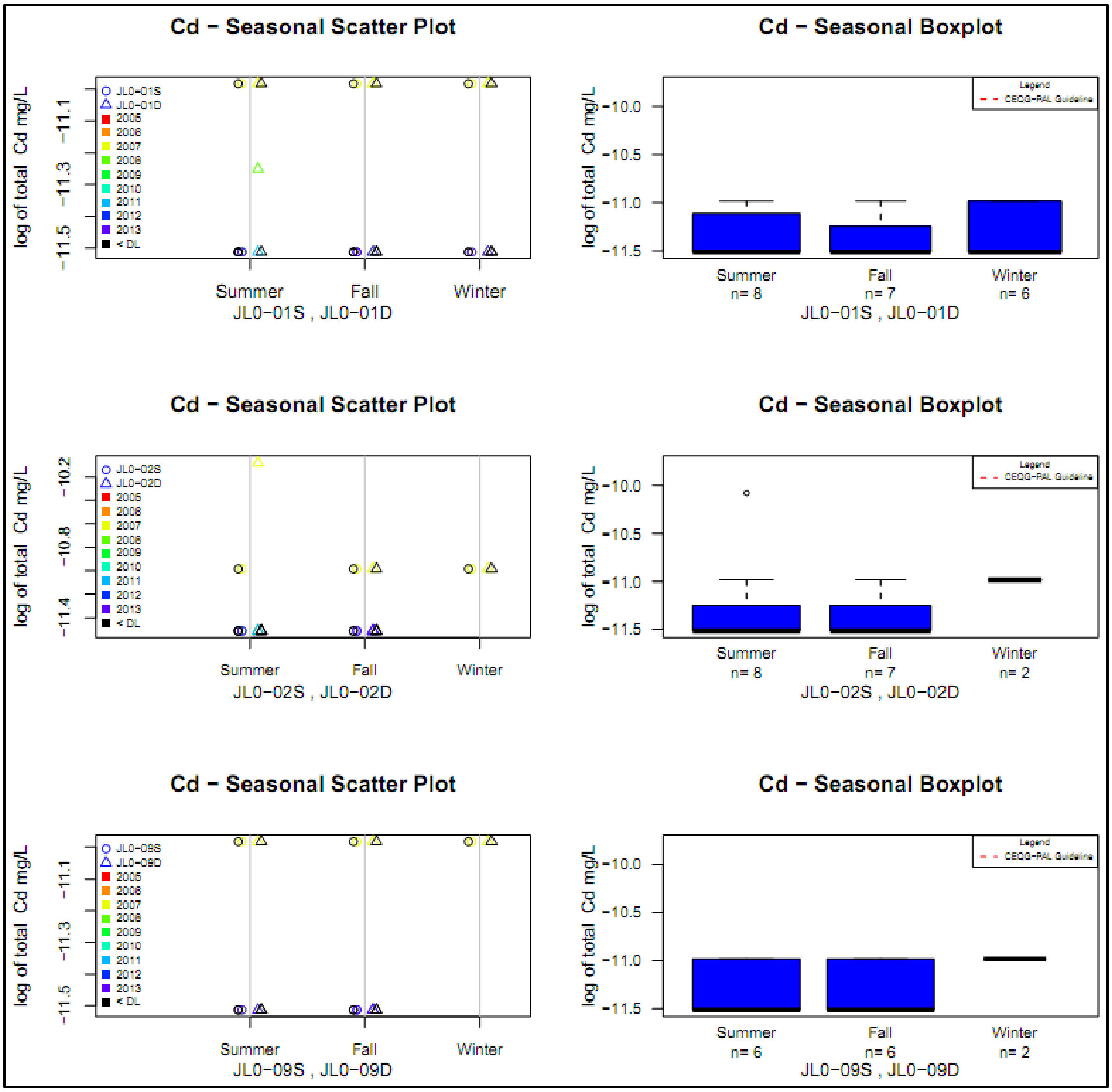
A total of 52 samples with measured cadmium concentrations were collected at Camp Lake, with seven to 12 samples collected at each of the sampling locations in Camp Lake (Figure B.11). Most total cadmium concentrations ranged from detection limit (0.00001 mg/L) to 0.00017 mg/L. One outlying value with a concentration of 0.00004 mg/L recorded in the summer, reported above the CWQG-PAL guideline (0.00018 mg/L, calculated using a median hardness of 50 mg/L $CaCO_3$). Seasonal scatter plots indicate that all measured cadmium concentrations are at a detection limit, with the exception of two data points. Seasonal box plots are obscured by artifact detection limits and do not show a consistent seasonal trend amoung the three sites sampled (Figure B.12). Definitive conclusions regarding depth and seasonal variability are obscured by artificially high detection limits.



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.11 Camp Lake – Total Cadmium Concentrations in Water



NOTES:

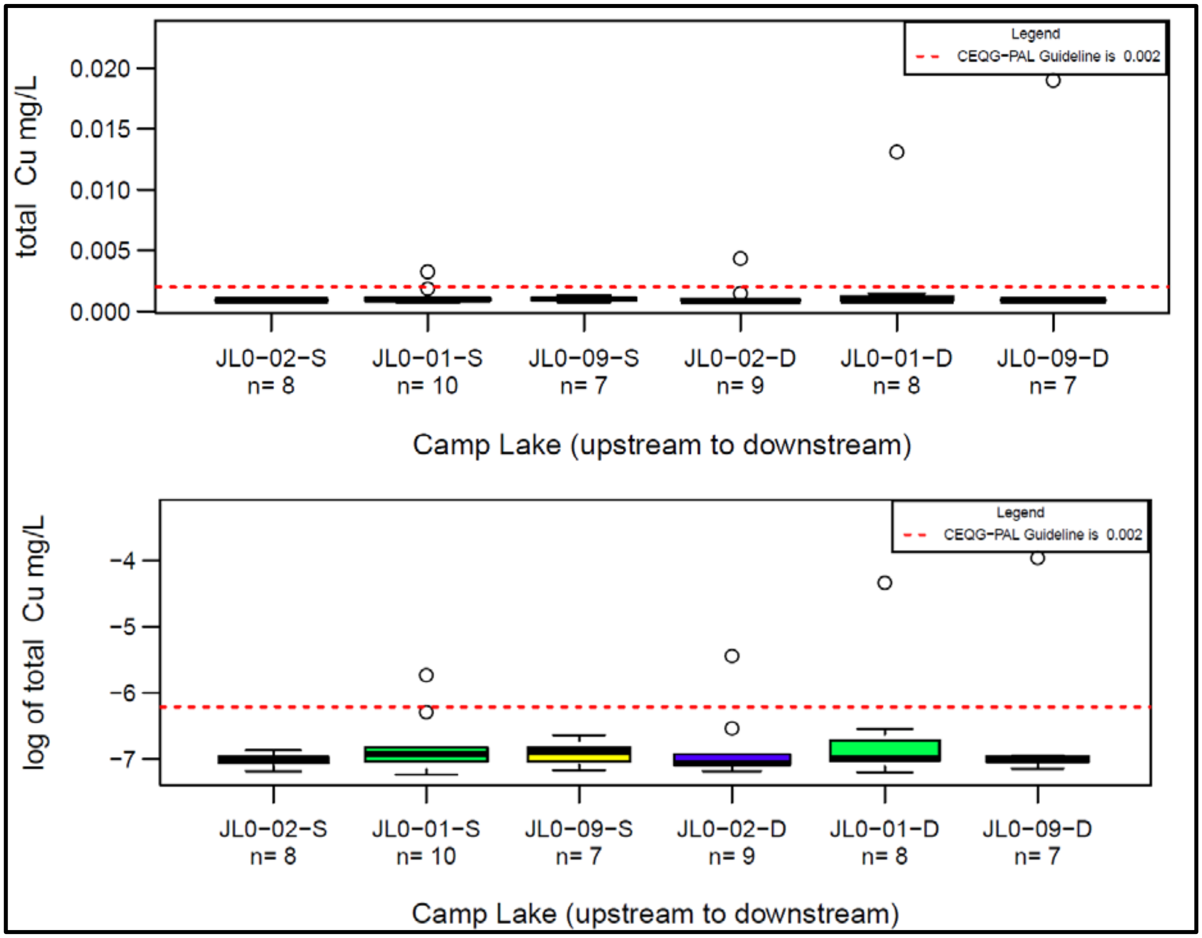
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.12 Camp Lake – Variability of Total Cadmium in Water

Total Copper (Figures B.13 and B.14)

The total sample size for copper samples in Camp Lake is 49, with between seven through ten samples collected at each sampling location. Median values for total copper at all sites occur below 0.002 mg/L (Figure B.13). Log values indicate a distribution of samples with low concentrations, below the guideline limit, that are not obscured by detection limits. Outlying values occur for several sites, to a maximum concentration of approximately 0.018 mg/L. Four outlying values exceed the CWQG-PAL guideline (0.002 mg/L).

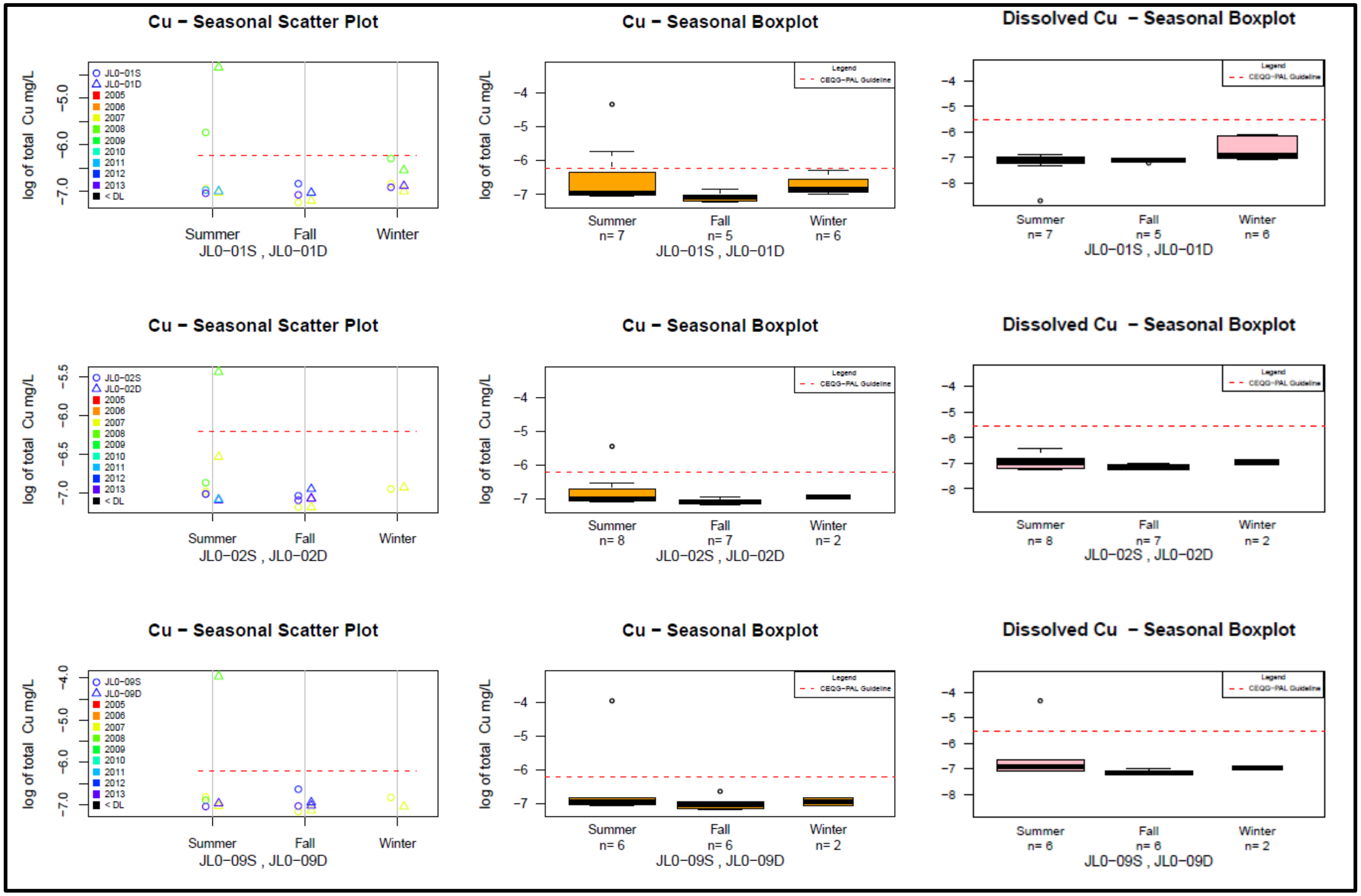
The seasonal copper scatterplot indicates that, with the exception of deep samples taken in 2008, shallow and deep concentrations are quite similar and do not show a consistent trend with depth (Figure B.14). In contrast to other parameters, seasonal trends indicates slightly higher concentrations are measured in summer and winter, when compared to fall. Further investigation into this seasonal trend revealed that winter total concentrations are almost entirely composed of the dissolved fraction, and not the particulate fraction (Figure B.14).



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.13 Camp Lake –Total Copper Concentrations in Water



NOTES:

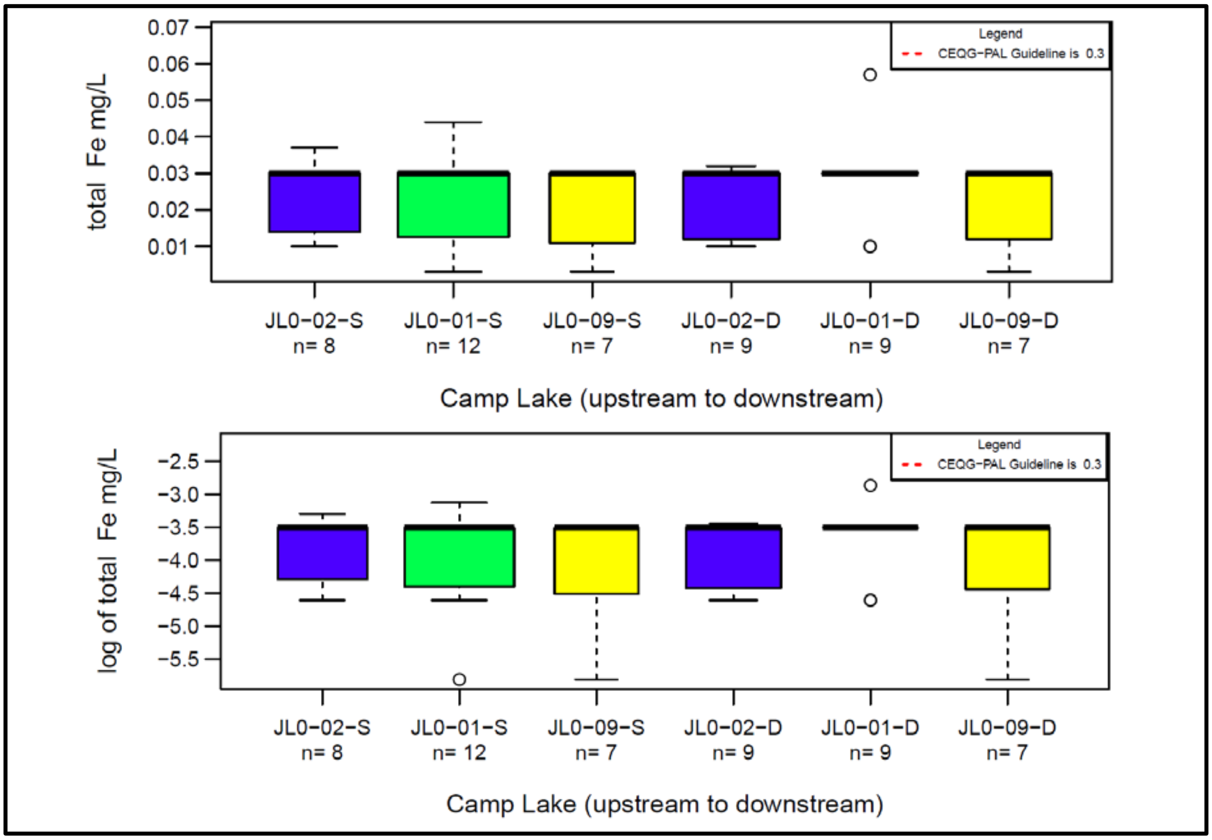
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.14 Camp Lake – Variability of Copper in Water

Total Iron (Figures B.15 and B.16)

Fifty-two (52) samples of total iron were taken within Camp Lake, with between 7 to 12 samples taken at each site within Camp Lake (Figure B.15). Median total iron concentrations at all sites was 0.03 mg/L, below the most stringent water quality guideline, CWQG-PAL at 0.3 mg/L (or the Interim SSWQO of 0.77 mg/L; see Section 2.4 of the main report). Raw and lognormal data show very similar trends, indicating that transformation may not be required for statistical tests and that graphical representation of outliers is not affected. Seasonal scatterplots of iron concentrations indicate that artificially elevated detection limits may be influencing the data and no distinct seasonal trends are noted.

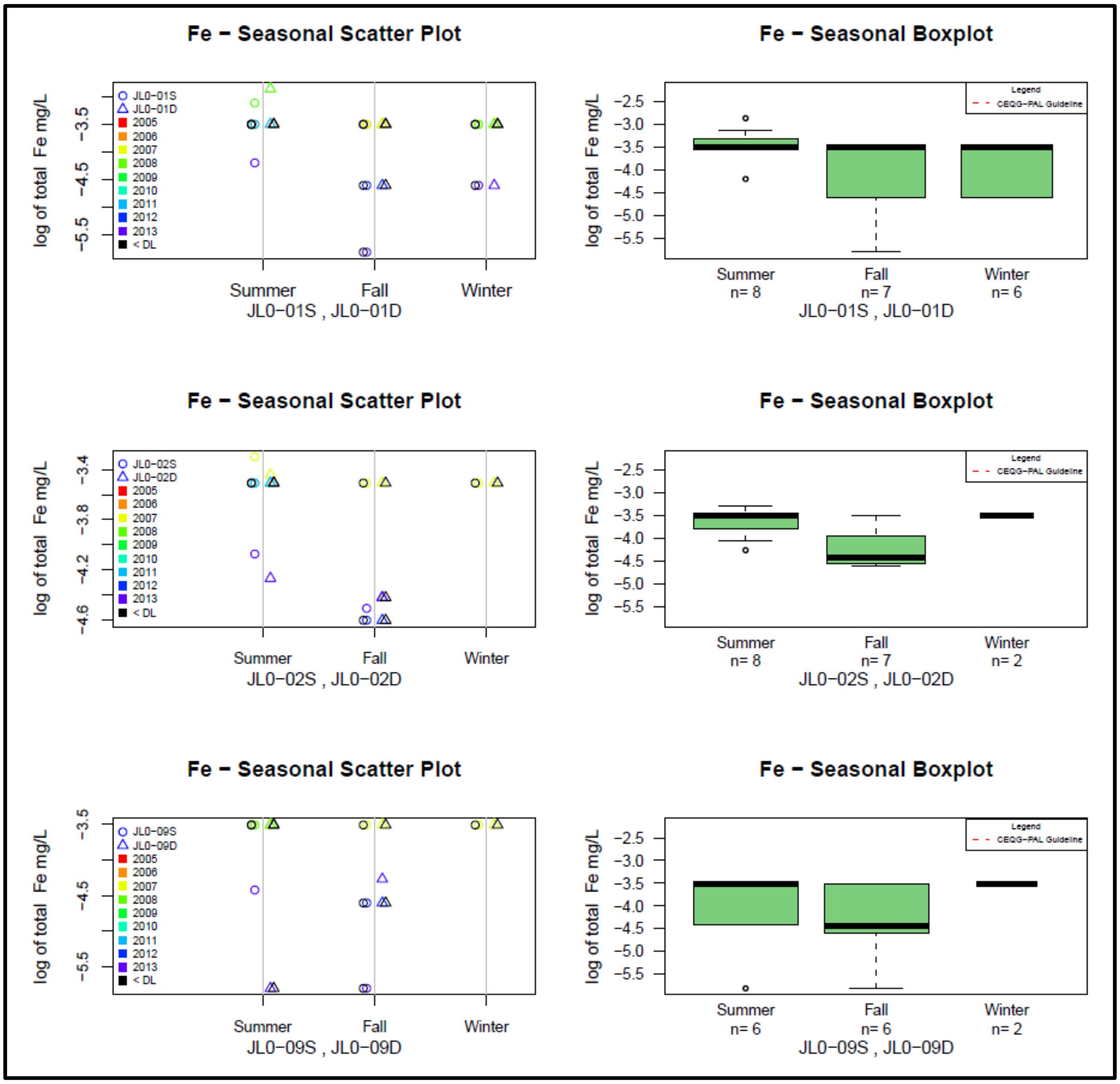
Due to interaction with detection limits during early years of sampling, definitive seasonal or depth trends are difficult to define (Figure B.16). Of note are the slightly lower iron concentrations during fall sampling events.



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.15 Camp Lake – Total Iron Concentrations in Water



NOTES:

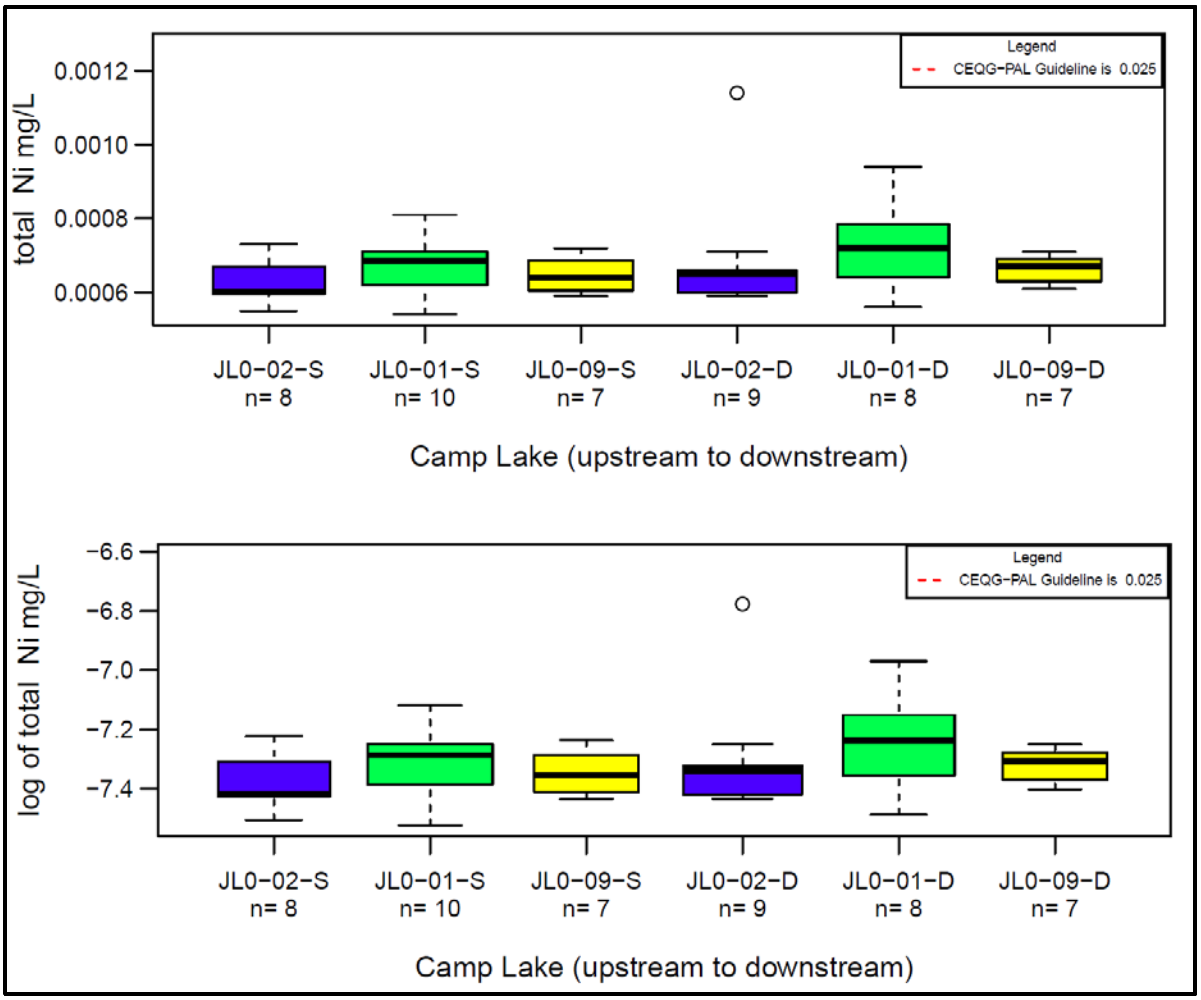
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.16 Camp Lake – Variability of Total Iron in Water

Total Nickel (Figures B.17 and B.18)

Forty-nine (49) nickel samples were collected at Camp Lake, with between seven to ten samples collected at each discrete sampling location. Median total nickel concentrations at each site are low and range from 0.0006 mg/L to 0.00075 mg/L (Figure B.17). All values are well below the CWQG-PAL guideline calculated to be 0.025 mg/L based on 50 mg/L $CaCO_3$ hardness.

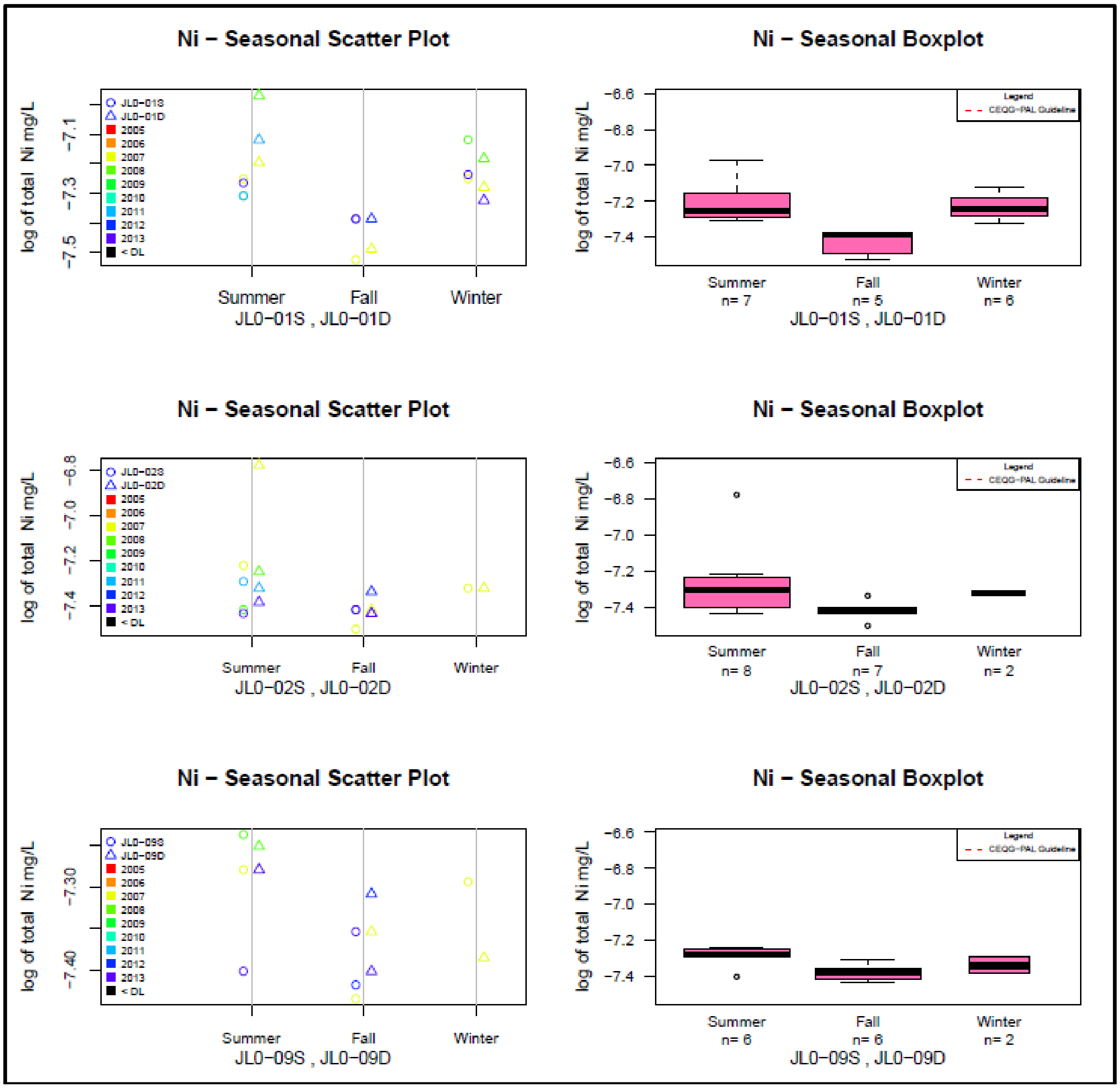
No distinct temporal trends over the course of yearly sampling are noted, although variation in site location is greater than variation as a result of depth (Figure B.18). JL0-01 has a very low magnitude elevation of nickel concentrations when compared to other sites. Seasonal trends are noted that are similar to those observed for copper, with very similar median summer and winter concentrations and lower fall sampling concentrations. Similar to copper, investigation into total versus dissolved concentration reveal that almost all total nickel is present in the dissolved form during the winter months, although summer and fall have more particulate data.



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.17 Camp Lake – Total Nickel Concentrations in Water



NOTES:

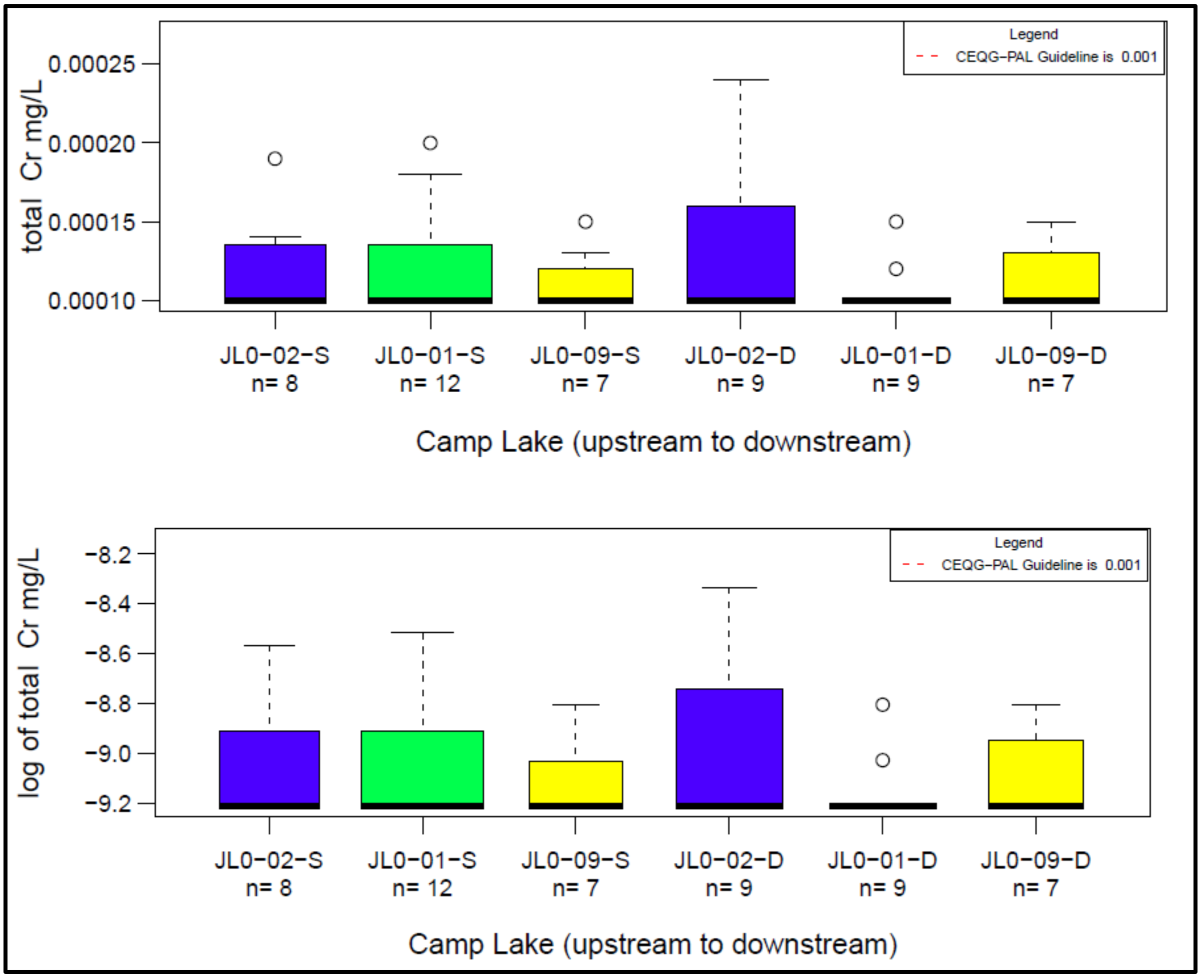
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.18 Camp Lake – Variability of Total Nickel in Water

Total Chromium (Figures B.19 and B.20)

Fifty-two (52) chromium samples were collected at Camp Lake, with between seven to twelve samples collected at each discrete sampling location. Median total chromium concentrations at each site are low and range from 0.0001 mg/L to 0.00024 mg/L (Figure B.19). All values are well below the CWQG-PAL guideline (0.001 mg/L).

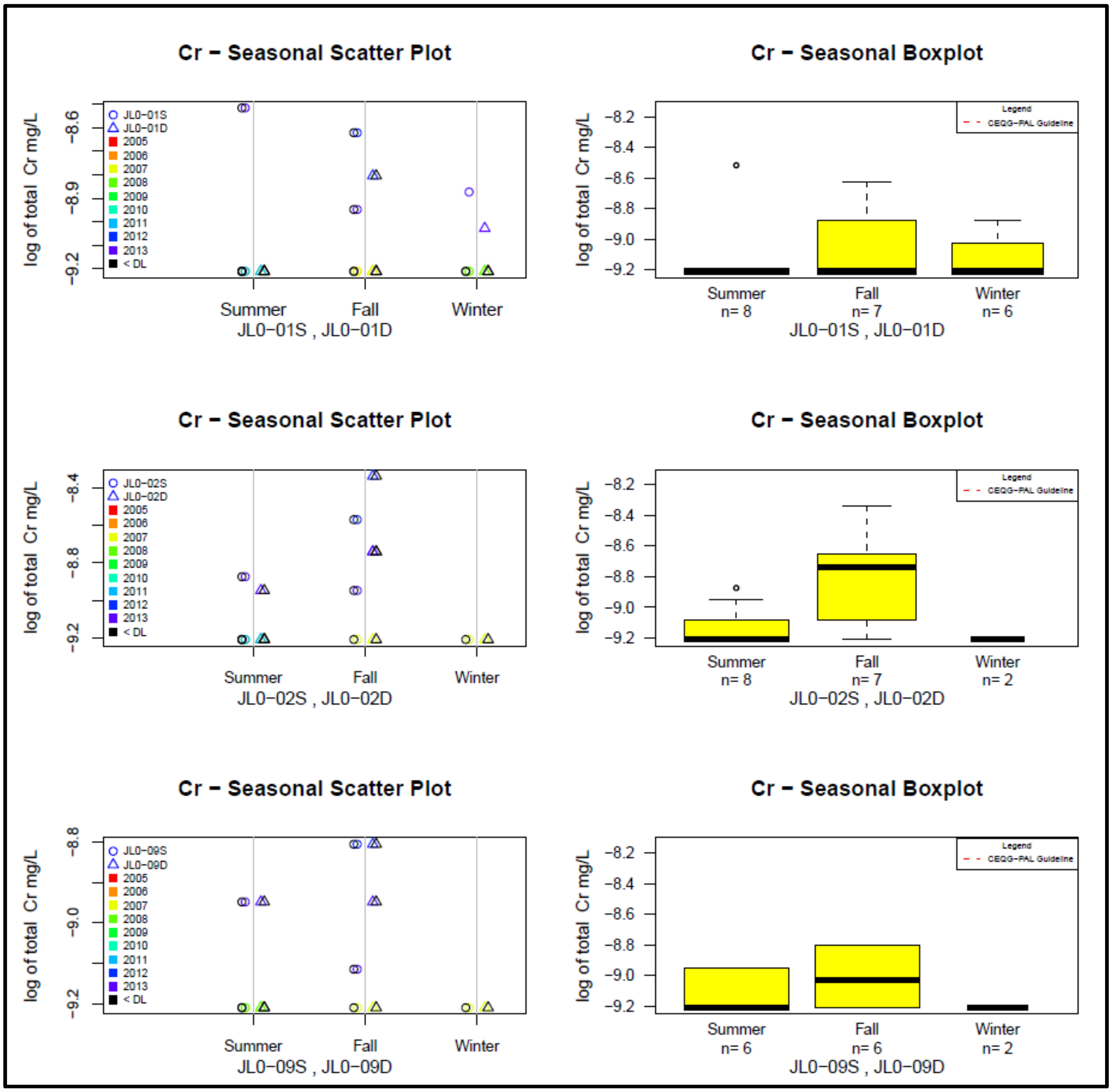
Samples from 2012 and 2013 are slightly elevated when compared to previous sampling years (Figure B.20). Slightly greater concentrations during the fall are noted for chromium



NOTES:

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

Figure B.19 Camp Lake – Total Chromium Concentrations in Water



NOTES:

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

Figure B.20 Camp Lake – Variability of Total Chromium in Water

Summary of Camp Lake Water Quality

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

- Distinct depth trends are not observed for Camp Lake, which suggests that the lake is completely mixed through much of the year. Review of data above suggests aggregation of deep and shallow sites may be appropriate.
- Geographic trends between discrete sampling sites were not observed for any parameters.

- With the exception of chloride and chromium, parameters did not show any distinct inter-annual trends/variability over the six year sampling history. Chloride and chromium concentrations in Camp Lake measured from 2011 through 2013 are elevated compared to earlier samples from 2005 to 2010.
- Parameters with MDL interference and/or that do not show seasonal trends include: cadmium, chloride, arsenic, iron and nitrate.
- Parameters that have maximum concentrations occurring in the summer: nitrate and aluminum. This is likely as a result of the spring runoff period caused by rapid melt of winter snowpack.
- Parameters that have maximum concentrations occurring in the winter: copper and nickel. Most of this concentration occurs in a dissolved form, not as particulate.
- Parameters that have maximum concentrations occurring in the fall: chromium.

B.2.2 Sheardown Lake

Sheardown Lake is separated into two basins, referred to as the northwest basin and southeast basin. Sheardown Lake NW has been the receiving water for treated sewage from the exploration camp. In addition, stockpiling and crushing of ore occurred in 2008 near the lake and the primary tributary to the lake. As such, the concentrations within the lake may have already been affected by construction and mining activities. Findings from both lakes will be discussed in the subsequent sections.

B.2.2.1 Sheardown Lake NW

A total of 92 lake samples were collected from the northwest basin of Sheardown Lake from 10 sampling stations over the sampling period. Most sampling was completed during the open water season, from July through September (summer and fall). Late winter sampling (May) was carried out only in 2007, 2008, 2012 and 2013. Ten stations are reported in detail (Figures B.1 and B.2):

- DL0-01-1-S and DL0-01-1-D - Shallow and deep; located in the centre of Sheardown Lake NW.
- DL0-01-2-S and DL0-01-2-D - Shallow and deep; located in the south centre of Sheardown Lake NW.
- DL0-01-4-S and DL0-01-4-D - Shallow and deep; located on the northeast bay within Sheardown Lake NW.
- DL0-01-5-S and DL0-01-5-D - Shallow and deep; located near the northwest shore within Sheardown Lake NW.
- DL0-01-7-S and DL0-01-7-D - Shallow and deep; located near the southern outlet of Sheardown Lake NW.

D-Lake-01, -02, -03, -04 and -05 were also established, but each has only one sampling point. A summary of the data collected during each season, with respect to year and site are included in Table B.2. A graphical representation of the sampling events within Sheardown Lake for the ten station reported in detail is provided in Figure B.21.

Table B.2 Sheardown Lake NW Sample Size

Year	Summer	Fall	Winter
2006	2	2	0
2007	10	10	4
2008	11	10	2
2011	6	6	0
2012	0	6	2
2013	13	8	6
Site	**Summer**	**Fall**	**Winter**
DL0-01-1-S	5	6	2
DL0-01-1-D	5	6	2
DL0-01-2-S	3	3	0
DL0-01-2-D	3	3	0
DL0-01-4-S	5	2	0
DL0-01-4-D	2	3	0
DL0-01-5-S	4	5	2
DL0-01-5-D	4	5	2
DL0-01-7-S	4	5	0
DL0-01-7-D	7	4	0

NOTES:

1. WINTER SAMPLING OCCURRED DURING APRIL AND MAY; SPRING SAMPLING OCCURRED DURING JUNE; SUMMER SAMPLING OCCURRED FROM JULY TO AUGUST 17; FALL SAMPLING OCCURRED FROM AUGUST 18 THROUGH SEPTEMBER 30.
2. LAKE SAMPLING DID NOT OCCUR DURING SPRING, DUE TO SAFETY CONCERNS OF SAMPLING OVER MELTING ICE.
3. DURING WINTER 2013, SAMPLES WERE COLLECTED WITHIN SHEARDOWN LAKE AT D-LAKE-05.

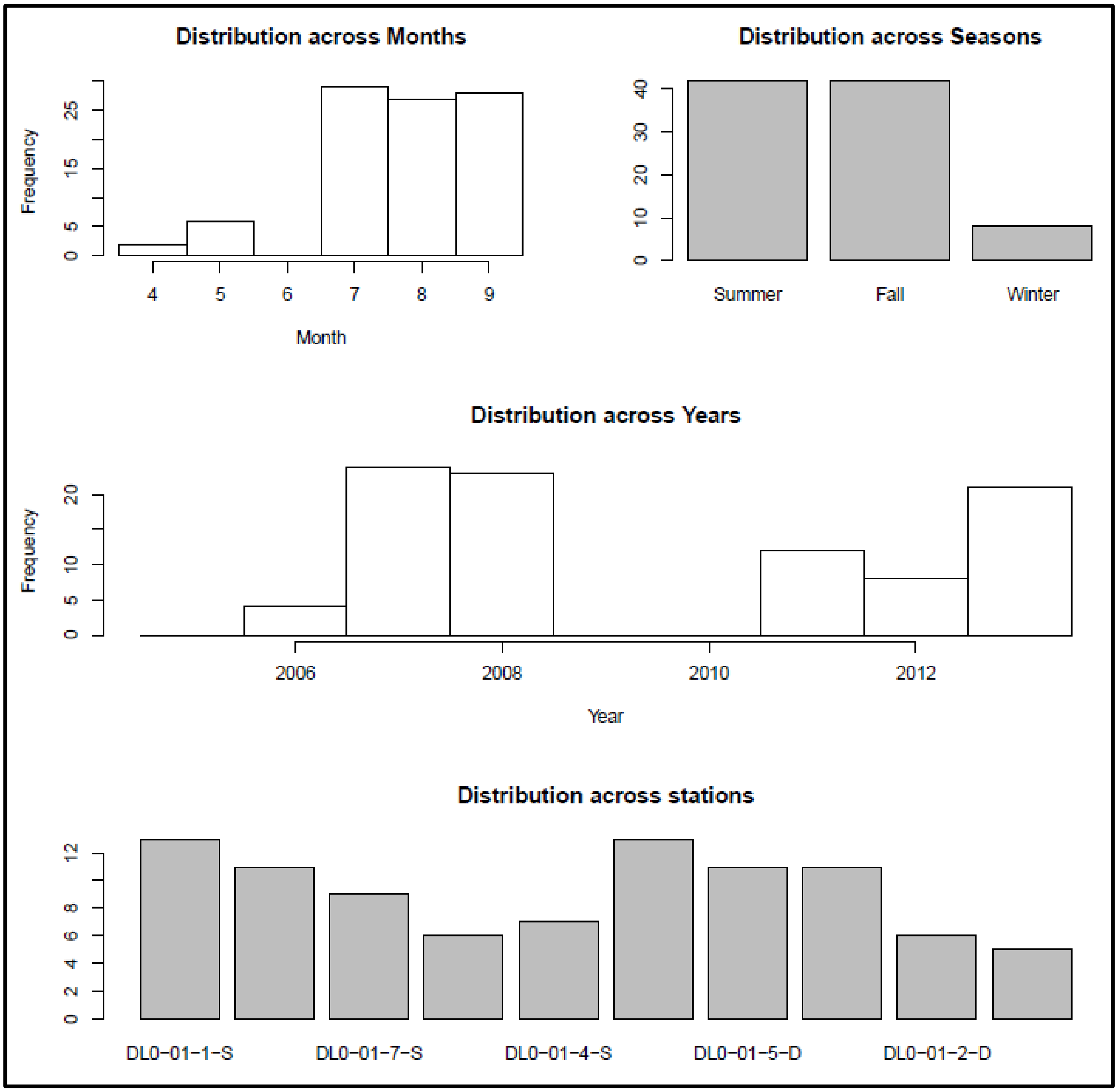


Figure B.21 Sheardown Lake NW – Graphical Summary of Sampling Events

The following summarizes the data review observations for Sheardown Lake NW.

pH (Figure B.22)

- Sheardown Lake NW is slightly alkaline with a median in-situ pH of ~7.6.
- A slight influence of depth on pH is observed with a measured median *in situ* pH at the deep stations is slightly lower compared to shallow stations.

Alkalinity (Figure B.22)

- Sheardown Lake sites are fairly uniform with median alkalinity values that range from 50 to 60 mg/L $CaCO_3$, classifying the lake water as having low sensitivity to acidic inputs.

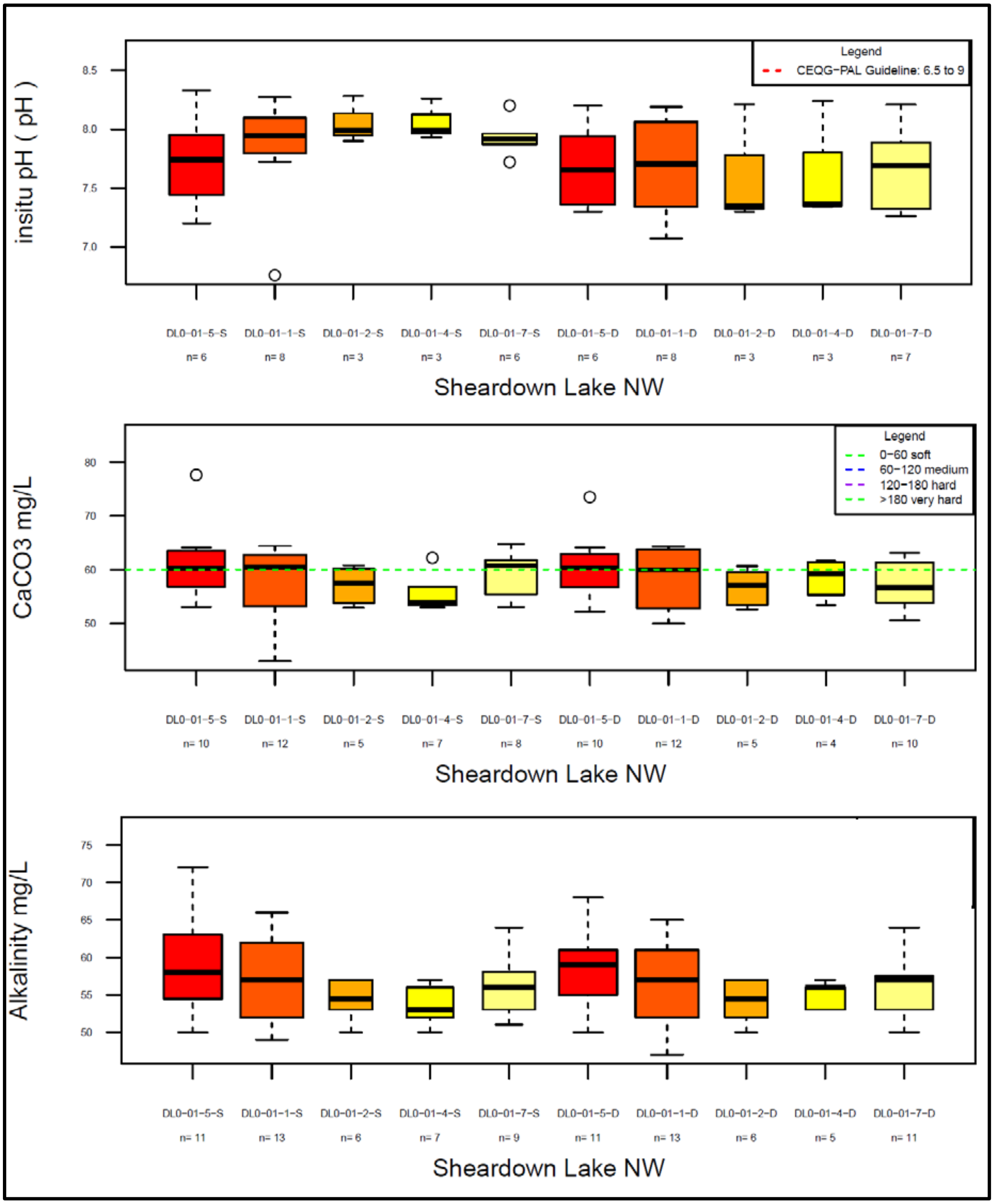


Figure B.22 Sheardown Lake NW – *In situ* pH, Alkalinity and Hardness

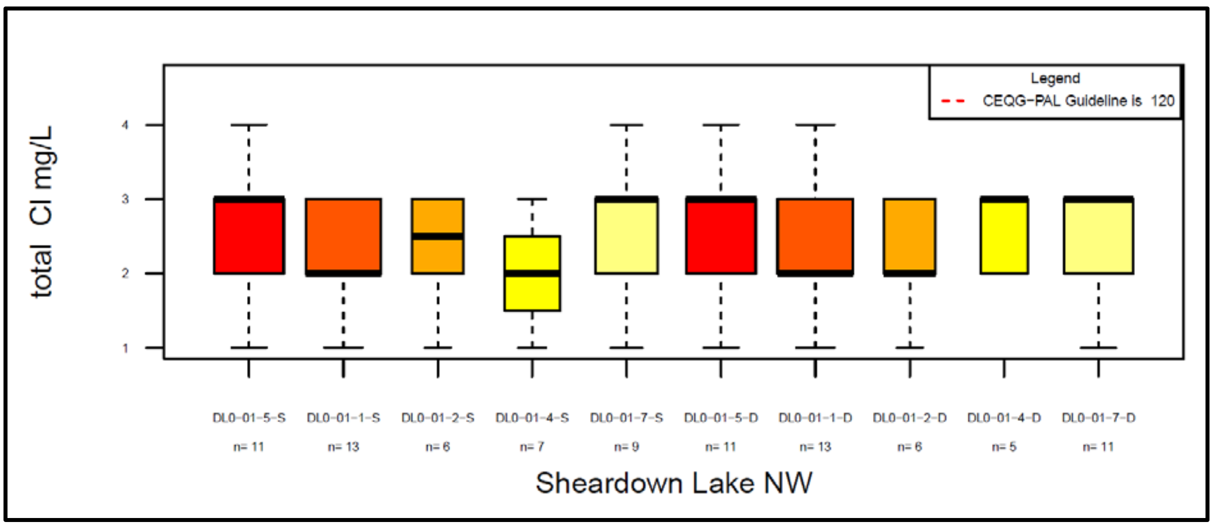
Hardness (Figure B.22)

- Median hardness ranged from 54 and 61 mg/L, putting Sheardown Lake NW right on the border of water that is considered “soft” or “medium” hardness.
- Hardness did not change meaningfully with depth, and showed more variation with station than with depth.
- 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 B.23 and B.24)

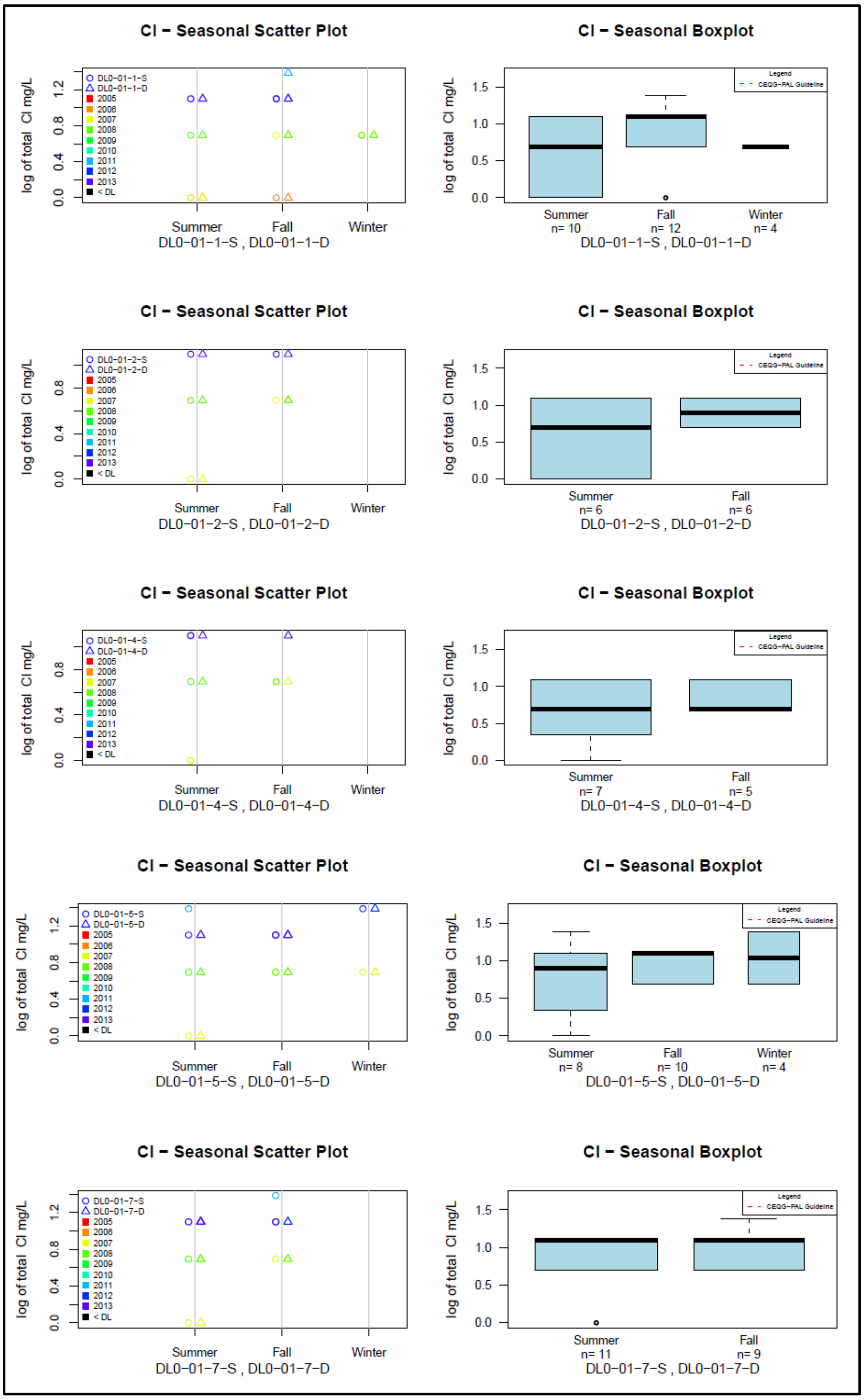
Ninety-two (92) chloride concentration samples were collected at Sheardown Lake NW. Chloride concentrations in Sheardown Lake NW are very low and have maximum values of 4 mg/L, well below the CWQG-PAL limit of 120 mg/L (Figure B.23). All sites within Sheardown Lake NW have very similar median chloride concentrations that range between 2 to 3 mg/L. Comparison of raw data and log values reveals the occurrence of low concentration outlying data, at a MDL. Seasonal scatterplots indicate that detection limit interference is occurring for chloride concentrations and that distinct trends with depth are not apparent (Figure B.24).



NOTES:

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

Figure B.23 Sheardown Lake NW – Chloride Concentrations in Water



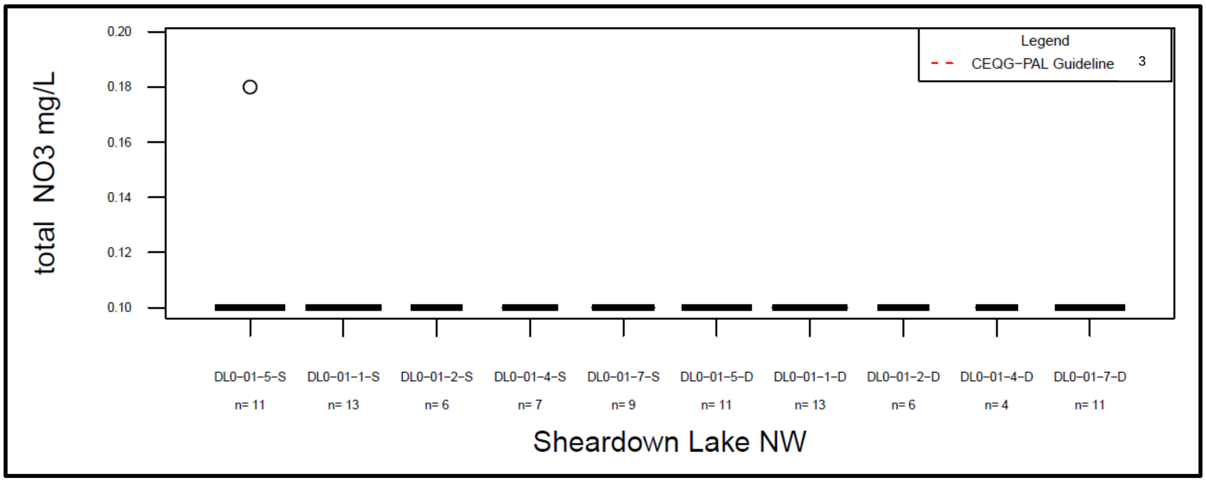
NOTES:

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

Figure B.24 Sheardown Lake NW – Variability of Chloride in Water

Nitrate (Figure B.25)

Eighty-seven (87) nitrate concentration samples were collected from Sheardown Lake over the course of eight years. All nitrate concentrations were measured at the detection limit (0.10 mg/L), except for one outlying concentration equal to 0.18 mg/L (Figure B.25). As a result, no seasonal, inter-annual or depth variation can be determined.



NOTES:

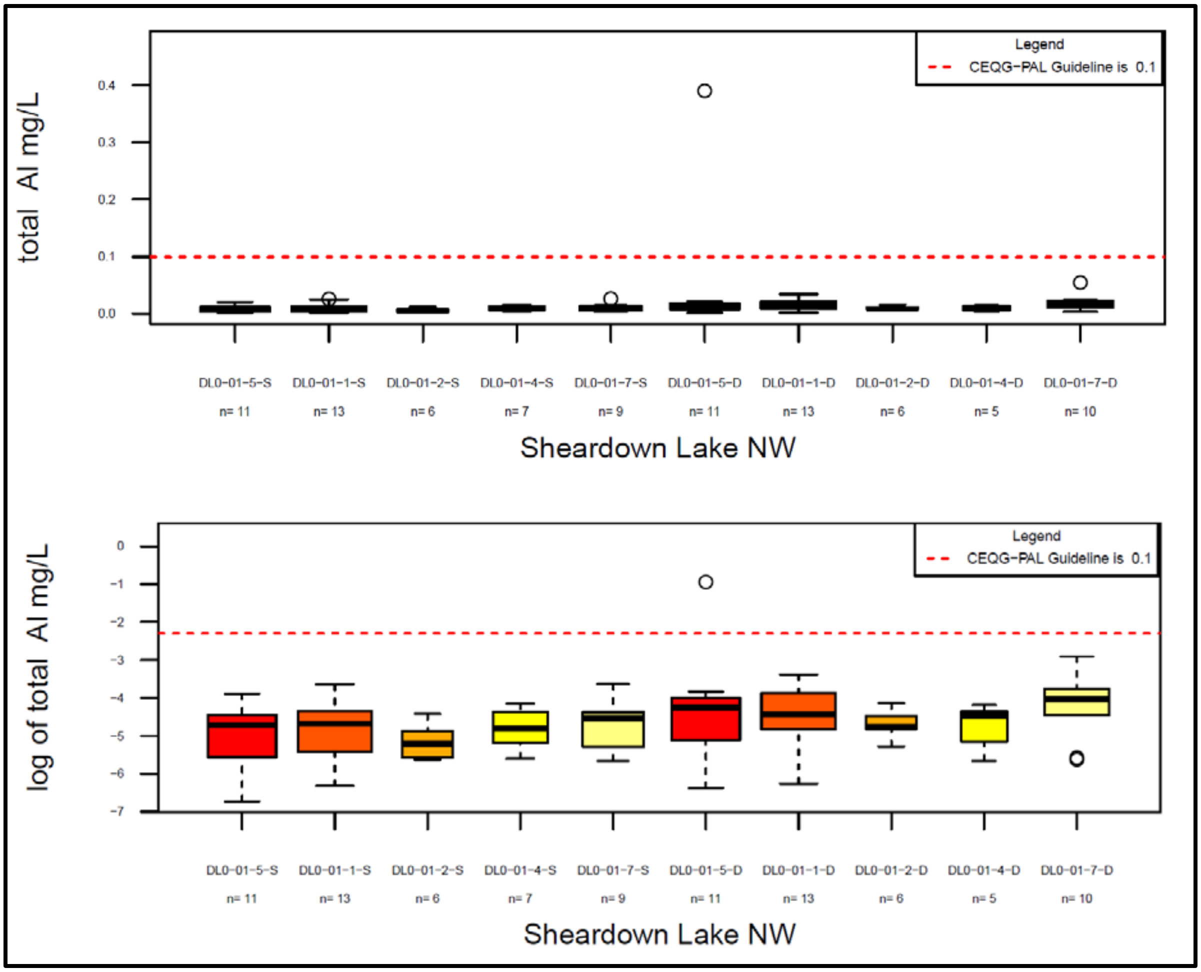
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.25 Sheardown Lake NW – Nitrate Concentrations 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 to match the relevant applicable guidelines.

Total Aluminum (Figures B.26 and B.27)

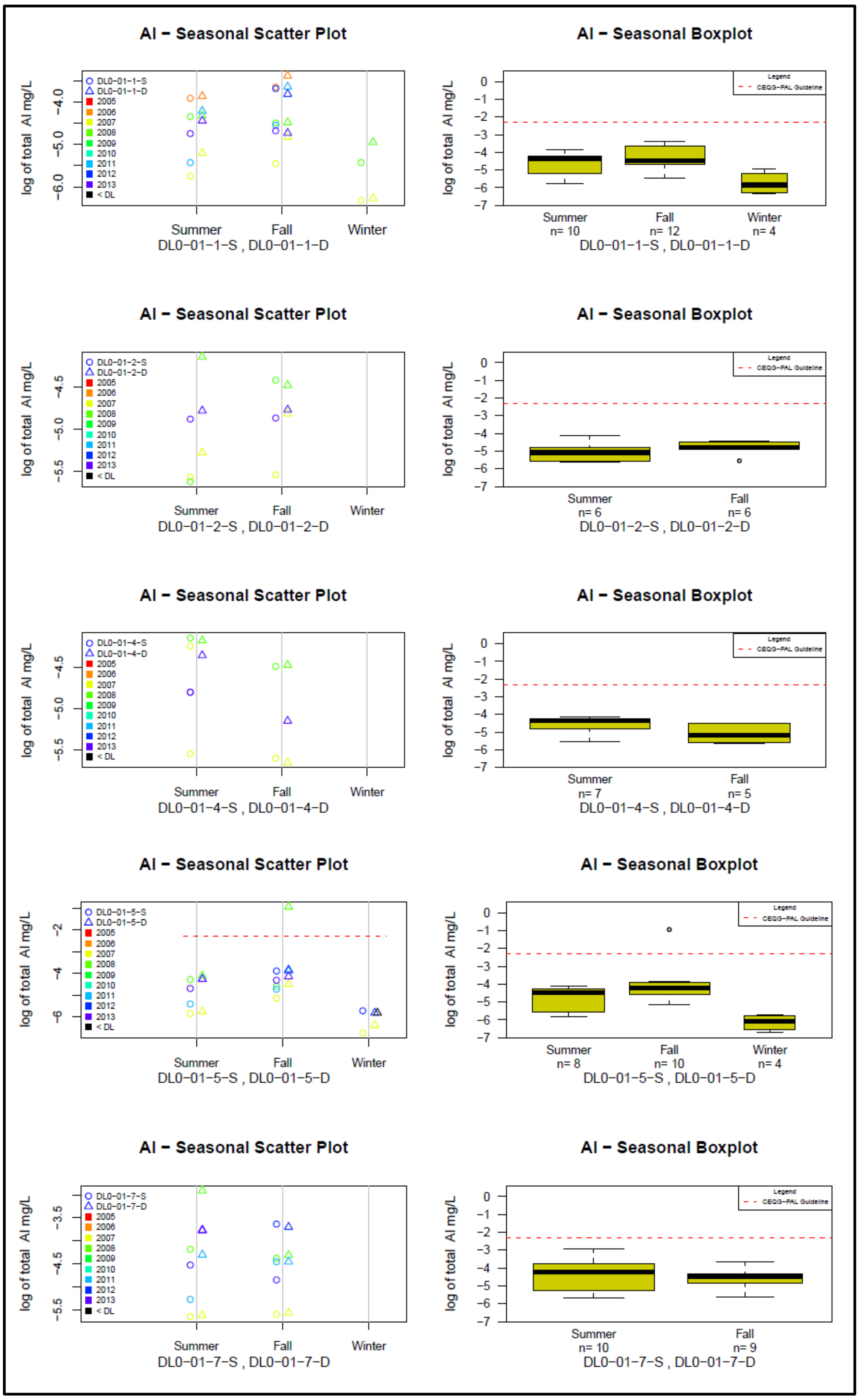
Ninety-one (91) total aluminum concentration samples were collected from Sheardown Lake NW over the course of eight years. Total aluminum concentrations consistently report above MDLs, and are consistently below the CWQG-PAL guideline, with the exception of one sample (Figure B.26). All stations within Sheardown Lake have similar median aluminum concentrations that are less than 0.05 mg/L. Deeper sampling stations show slightly elevated concentrations when compared to shallow stations. Comparison of raw data and log values reveals fewer outliers within the log transformed data, as expected. Seasonal scatterplots indicate that summer and fall concentrations of aluminum remain fairly elevated, while winter concentrations are reduced in comparison (Figure B.27).



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.26 Sheardown Lake NW – 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 B.27 Sheardown Lake NW – Variability of Total Aluminum in Water

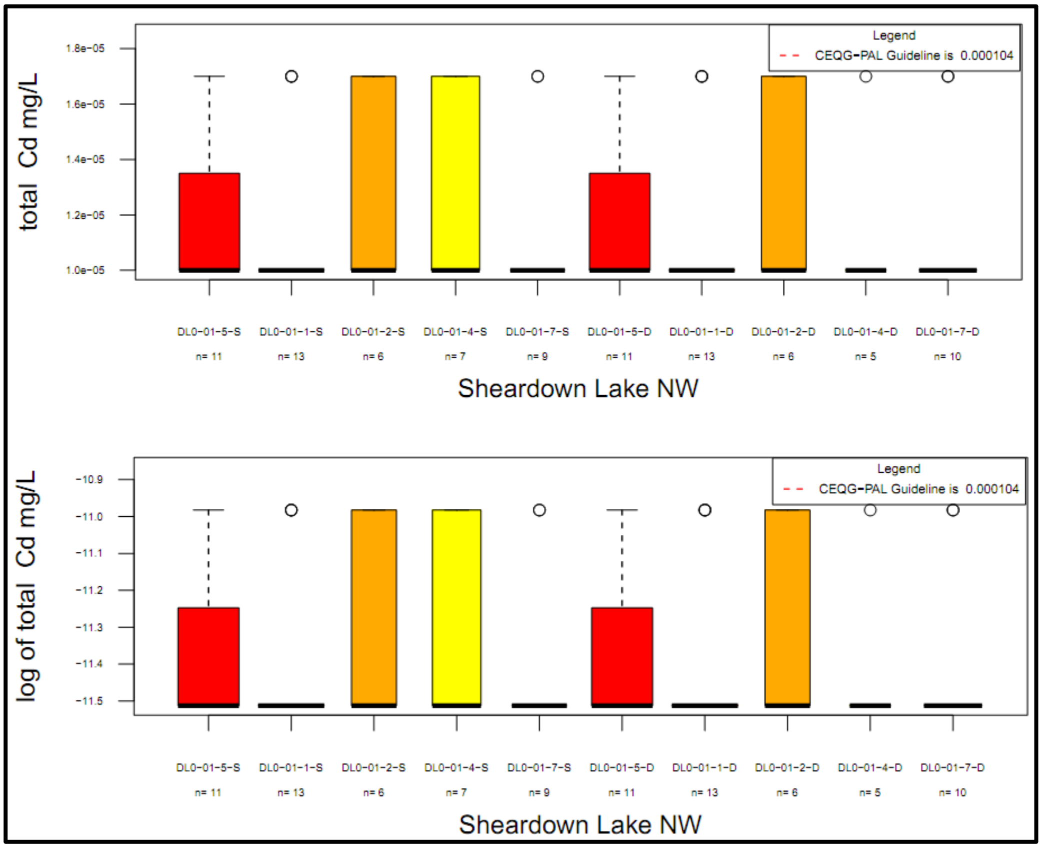
Total Arsenic

All (ninety-one) measured total arsenic levels report at detection limit and are therefore not not portrayed via graphical representation. The detection limit (0.00010 mg/L) is far below the CWQG-PAL guideline limit (0.005 mg/L).

Total Cadmium (Figures B.28 and B.29)

Ninety-one (91) total cadmium concentration samples were collected from Sheardown Lake over the course of eight years. Cadmium concentrations consistently report at or below MDLs, and are consistently below the CWQG-PAL guideline (Figure B.28). Although total boxplots of all data seem to indicate a range of values at each sampling point, this is as a result of two different detection limits. Seasonal scatterplots reveal that earlier data from 2007 had a detection limit of 0.000017 mg/L and later data from 2009 onwards had a detection limit of 0.00001 mg/L.

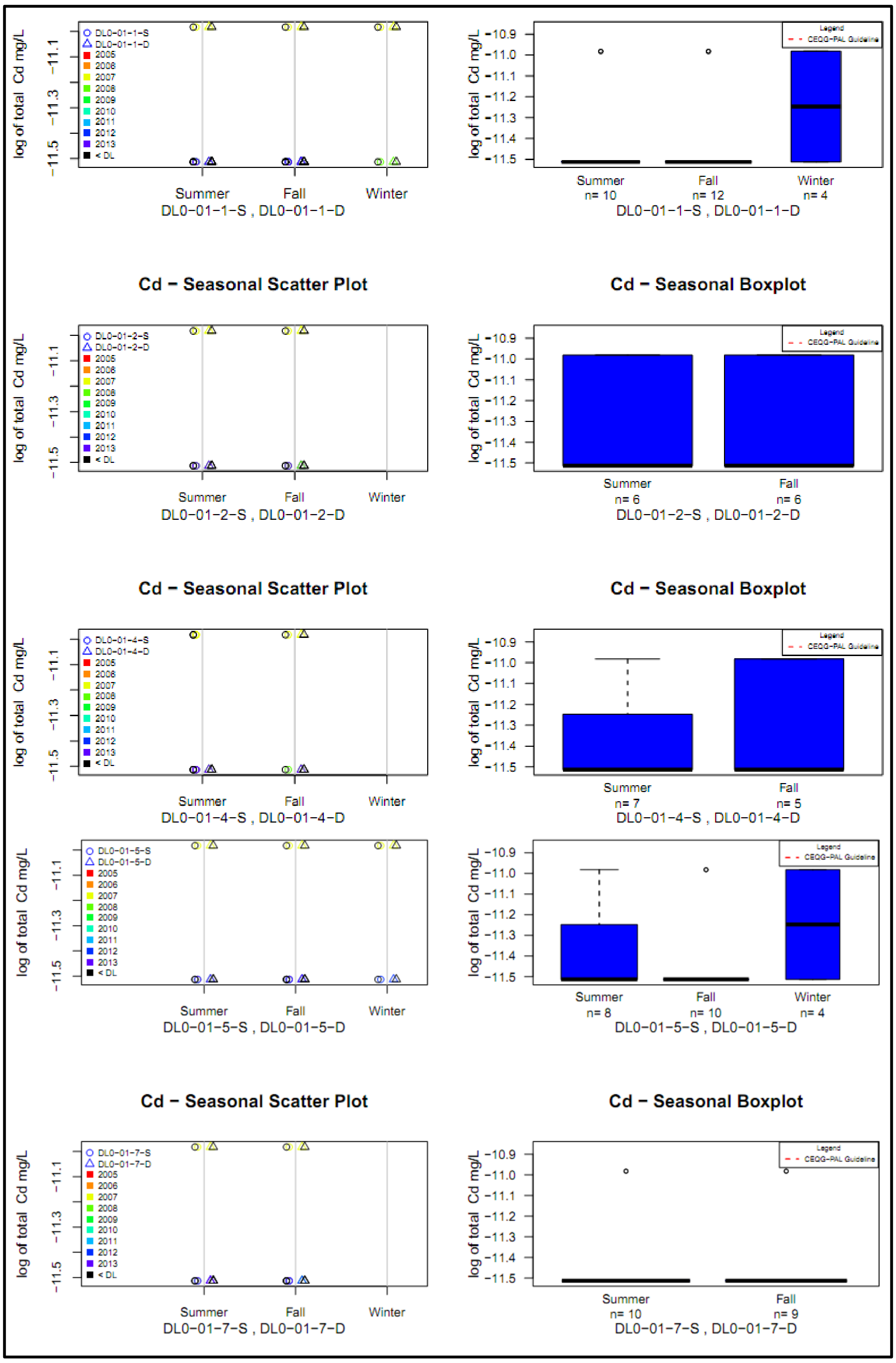
Seasonal scatterplots that combine data from deep and shallow sampling stations show no difference in values between the two stations, as a result of MDL interference (Figure B.29). Similarly, seasonal differences are not noted as a result of MDL interference.



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.28 Sheardown Lake NW – Total Cadmium Concentrations in Water



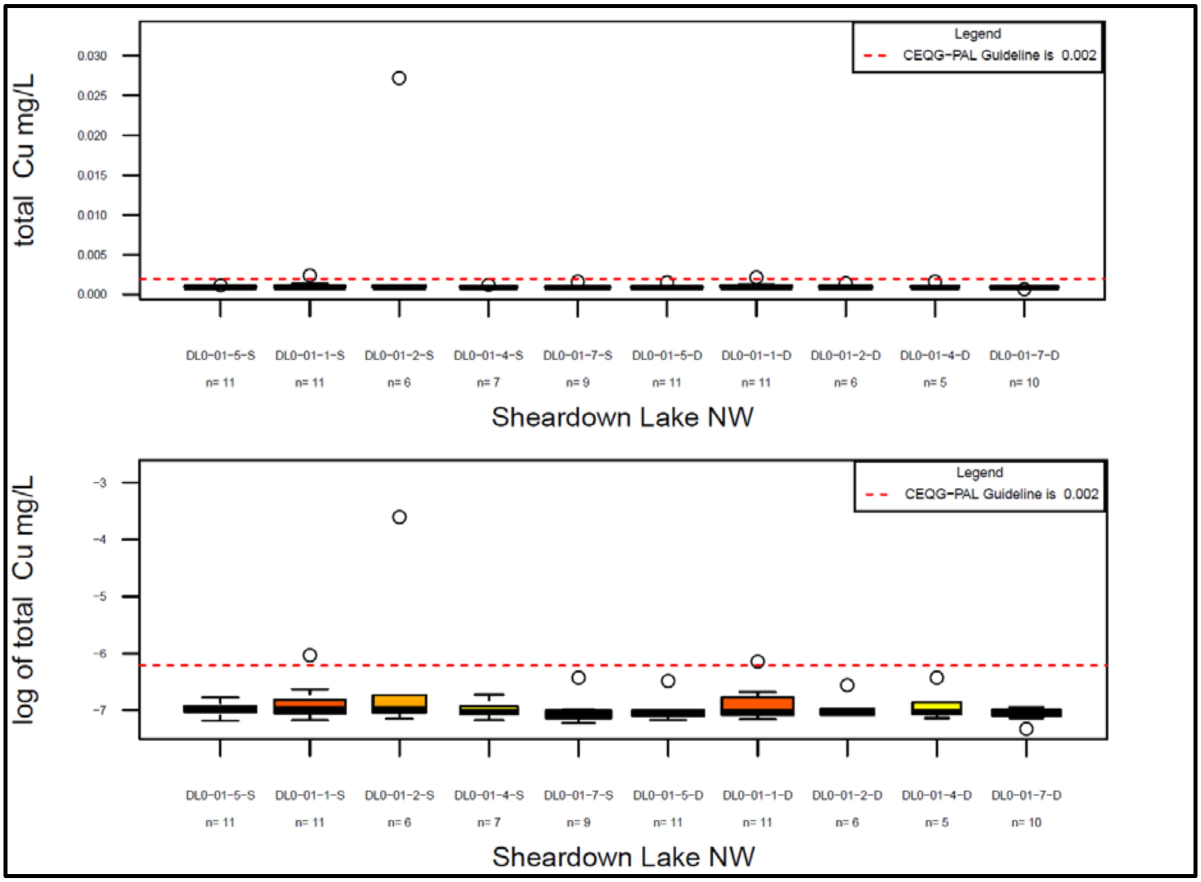
NOTES:

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.29 Sheardown Lake NW – Variability of Total Cadmium in Water

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

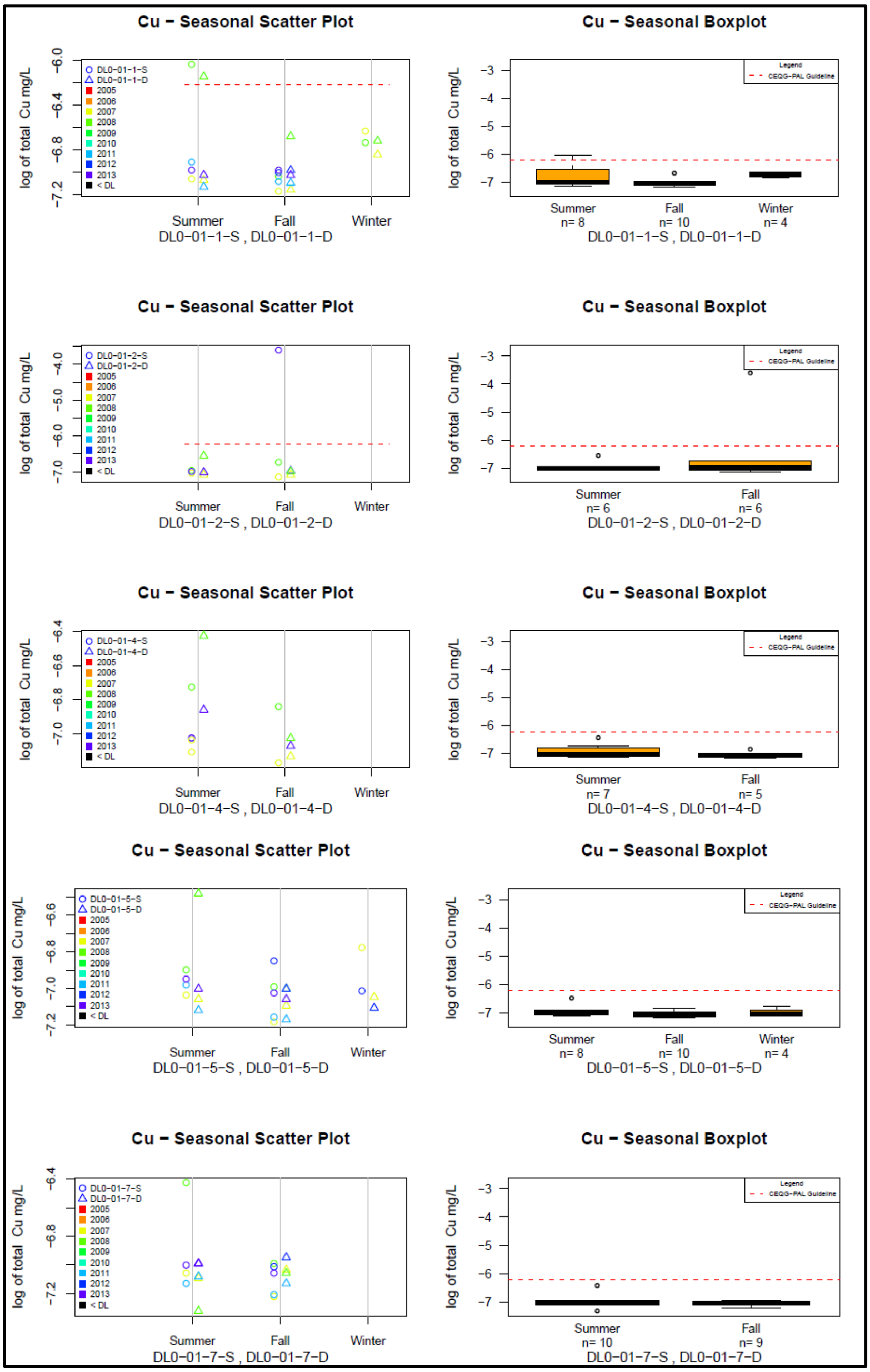
Eighty-seven (87) total copper concentration samples were collected from Sheardown Lake NW over the course of eight years. Total copper concentrations are slightly elevated, but usually below the CWQG-PAL guideline (Figure B.30). Seasonal scatterplots that combine data from deep and shallow sampling stations show little difference in values between the two stations (Figure B.31). No distinct seasonal differences are observed.



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.30 Sheardown Lake NW – Total Copper Concentrations in Water



NOTES:

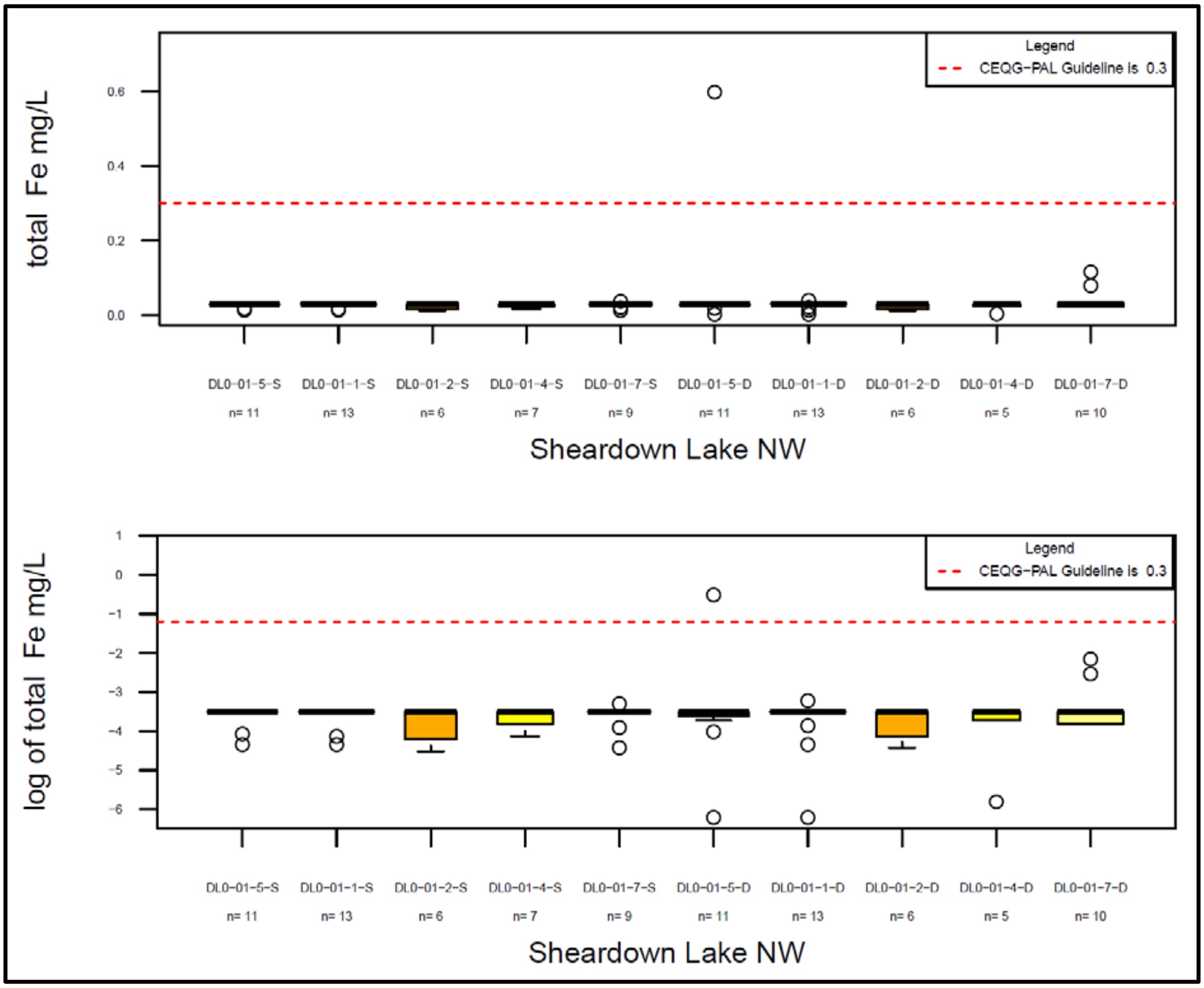
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.31 Sheardown Lake NW – Variability of Total Copper in Water

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

Ninety-one (91) total iron concentration samples were collected from Sheardown Lake NW over the course of eight years. Total iron concentrations consistently report at or below MDLs, with the exception of one outlier (Figure B.32). Only one outlying data point, from DL0-01-5-D, reports above the CWQG-PAL guideline (0.002 mg/L). Seasonal scatterplots indicate samples prior to 2010 reported at or below the MDL. During 2013, detection limits were lowered and total iron concentrations consistently occurred below the 2010 MDL.

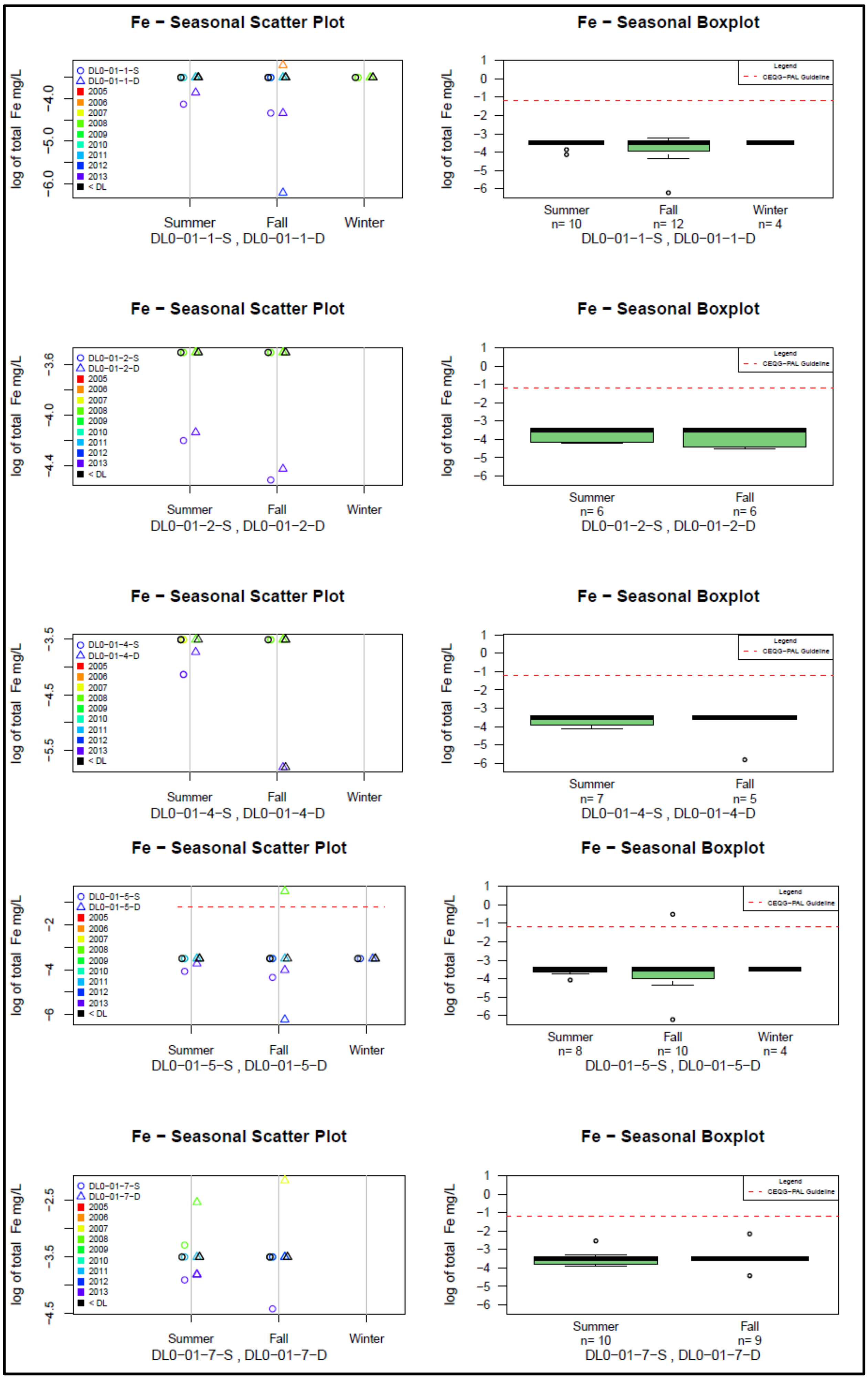
Seasonal scatterplots that combine data from deep and shallow sampling stations show no difference in values between the two stations (Figure B.33). Seasonal differences are not noted as a result of MDL interference.



NOTES:

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

Figure B.32 Sheardown Lake NW – Total Iron Concentrations in Water



NOTES:

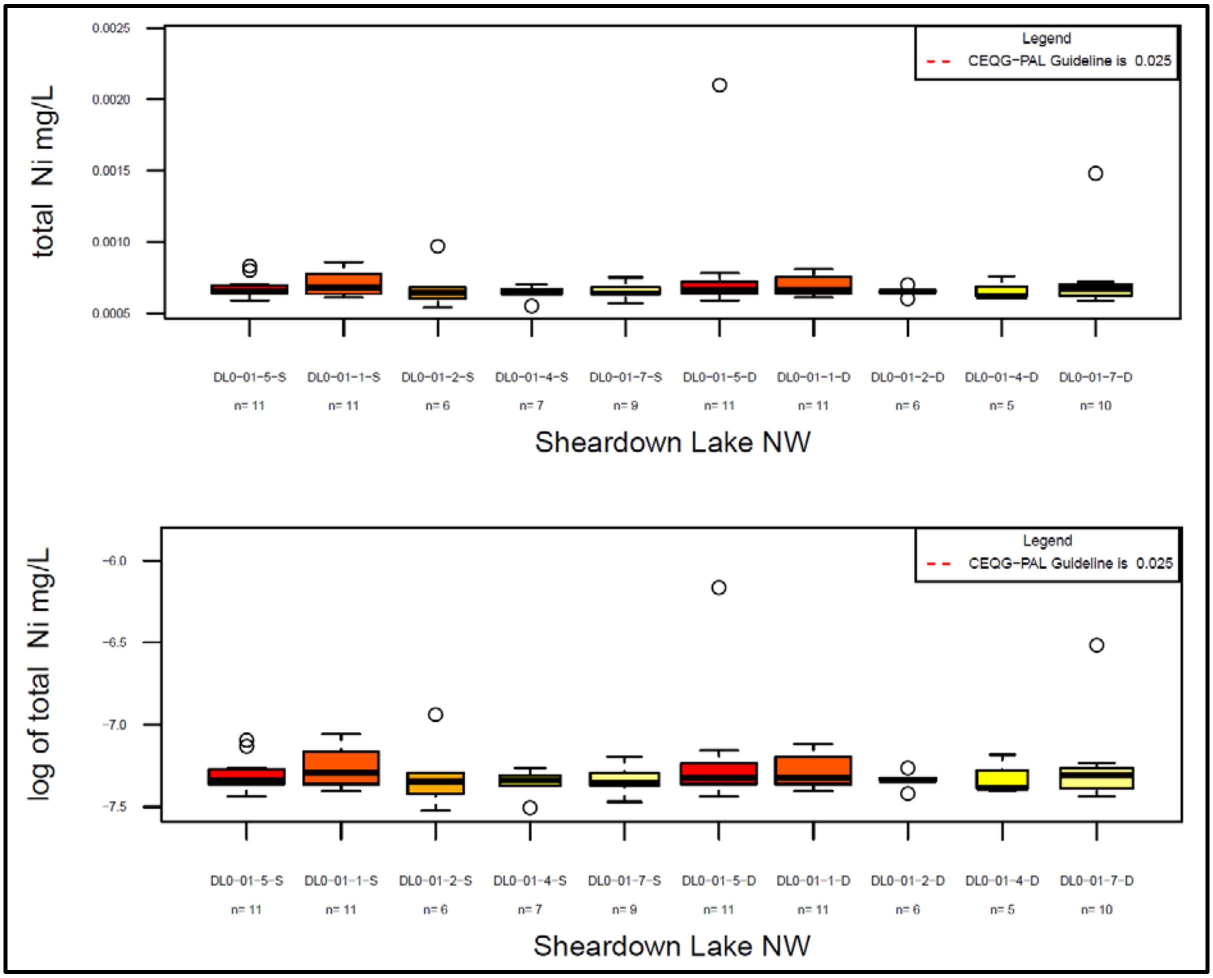
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.33 Sheardown Lake NW – Variability of Total Iron in Water

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

Eighty-seven (87) total nickel concentration samples were collected from Sheardown Lake NW over the course of eight years. Nickel concentrations consistently report above MDLs, but below the CWQG-PAL guideline (0.025 mg/L) (Figure B.34). Median total nickel concentrations are consistent throughout the geographically distinct sampling stations, and occur around 0.0007 mg/L; however, certain stations have a greater distribution of values. DL0-01-1-S and DL0-01-1-D show the greatest range of values, but also have the largest sample size.

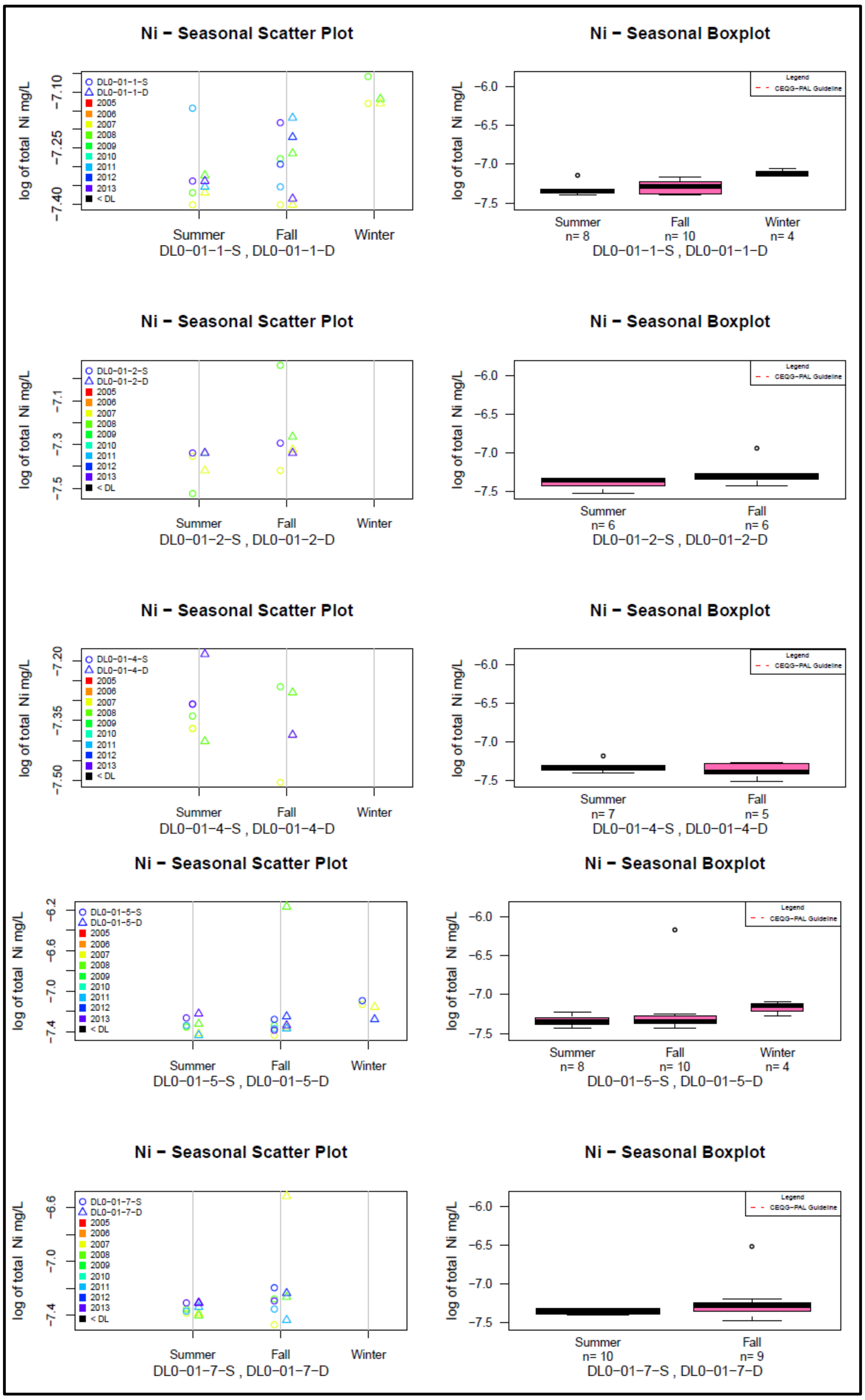
Seasonal scatterplots show that outlying data points tend to originate from sampling in 2008/2009 (Figure B.35). Seasonal boxplots show that the winter dataset for Sheardown lake nickel samples is limited. Historical summer and fall data have similar median values. The limited data collected for winter indicates winter samples have slightly higher concentrations; however, additional sampling is required to determine if this is a true 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 B.34 Sheardown Lake NW – Total Nickel Concentrations in Water



NOTES:

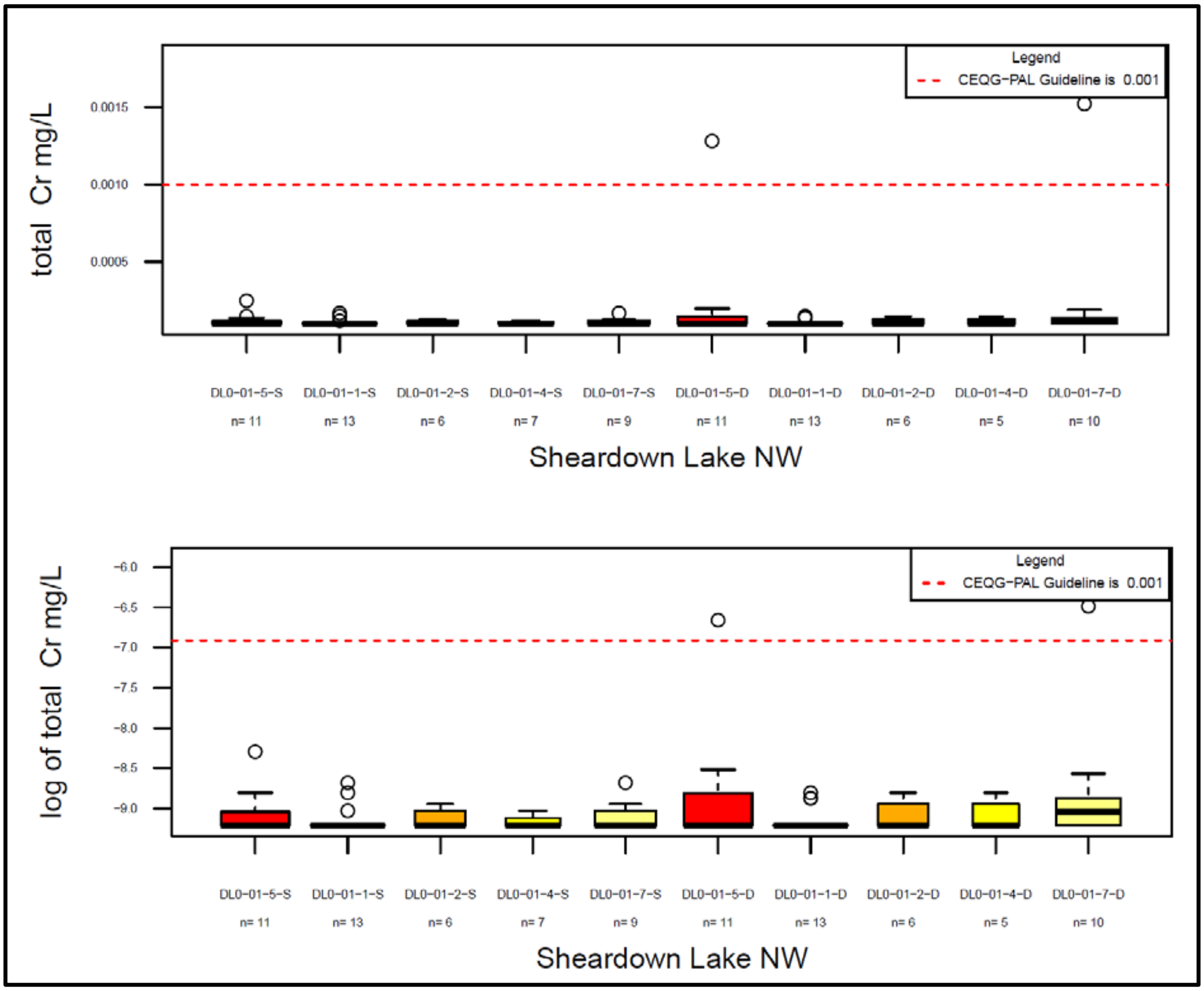
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.35 Sheardown Lake NW – Variability of Total Nickel in Water

Total Chromium (Figure B.36 and Figure B.37)

Ninety-one (91) total chromium concentration samples were collected from Sheardown Lake NW over the course of eight years. Chromium concentrations are low, with the exception of one outlier sampled at DL0-05-D (Figure B.36). Deep sites showed slightly elevated concentrations when compared with shallow samples.

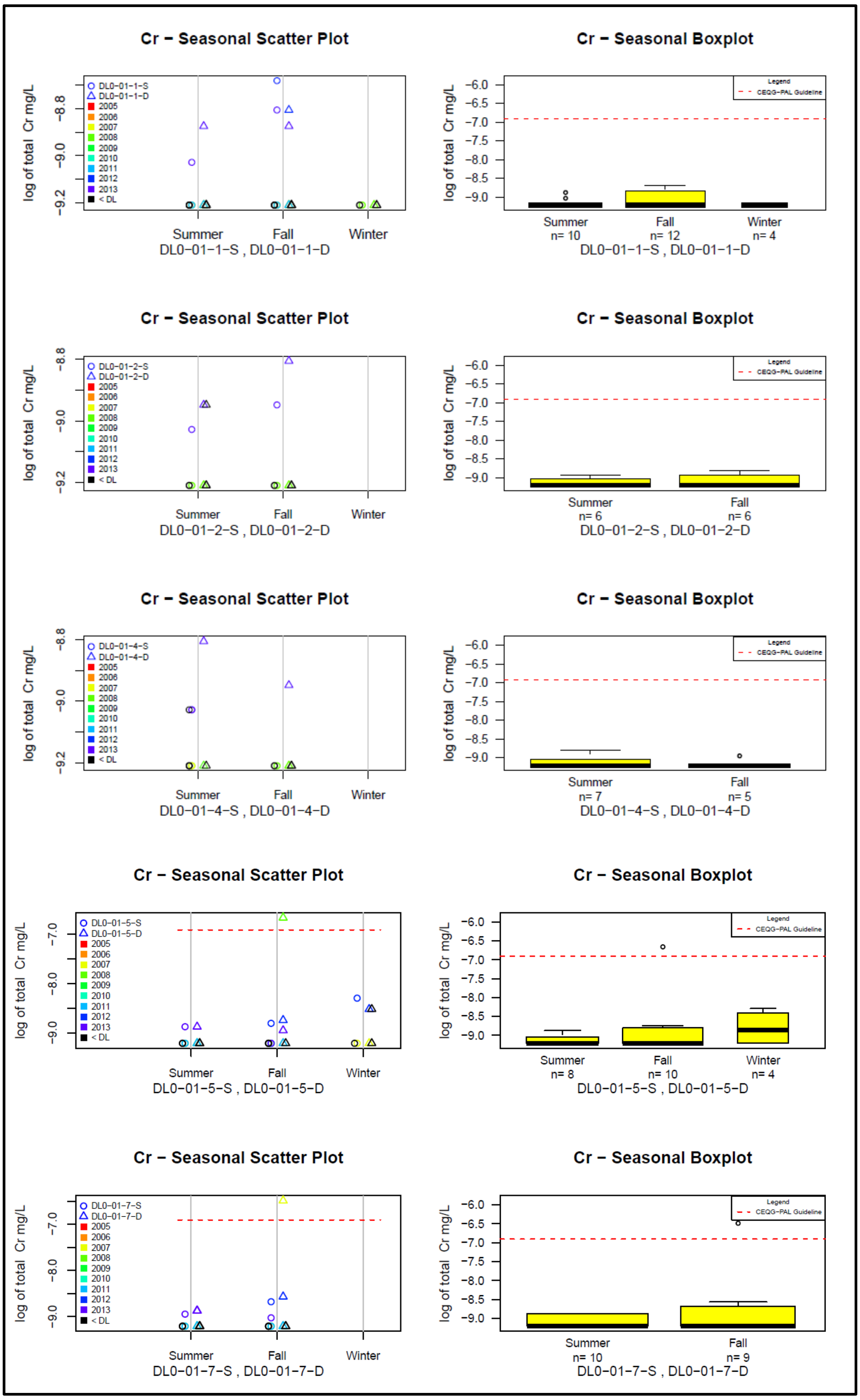
Seasonal scatterplots show 2012 and 2013 data is generally elevated when compared to older data (Figure B.37). Seasonal boxplots do not show a consistent seasonal trend.



NOTES:

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

Figure B.36 Sheardown Lake NW – 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 B.37 Sheardown Lake NW – Variability of Total Chromium in Water

Summary of Sheardown Lake NW Water Quality

Summary of trends observed during review of Sheardown Lake NW baseline data:

- Deeper sampling stations show slightly elevated concentrations of aluminum. Distinct depth trends are not observed for other parameters within Sheardown Lake, which suggests that lake is completely mixed throughout the year, despite winter ice. As a result, aggregation of deep and shallow stations is appropriate for all parameters except aluminum.
- Detection limits decreased over the course of sampling and their decrease is particularly apparent in the copper and iron concentration data.
- Little variability was observed between geographically distinct sampling stations.
- Parameters below MDLs and/or do not show any seasonal trends: arsenic, cadmium, chloride, chromium, copper, nitrate and iron.
- Parameters with highest concentration occurring in the fall: aluminum.
- Parameters with highest concentrations occurring in the winter: nickel. The majority of the elevated nickel and copper total concentrations are as a result of dissolved metals.

B.2.2.2 Sheardown Lake SE

A total of forty-six (46) lake samples were collected from the southeast basin of Sheardown Lake from 8 sampling stations over the sampling period (Figures B.1 and B.2):

- DL0-02-1-S and DL0-02-1-D - Shallow and deep; located in west portion of Sheardown Lake SE.
- DL0-02-3-S and DL0-02-3-D - Shallow and deep; located in the centre of Sheardown Lake SE.
- DL0-02-4-S and DL0-02-4-D - Shallow and deep; located on the eastern lobe of Sheardown Lake SE.
- DL0-02-6-S and DL0-02-6-D - Shallow and deep; located in the most westerly portion of Sheardown Lake SE.

Most sampling was completed during the open water season, from July through September (summer and fall). Late winter sampling (May) was carried out only in 2007, 2008, 2012 and 2013. Six stations are reported in detail. Only one sample was taken at DL0-06-S and DL0-02-6-D, and therefore, these sites are excluded from graphical representation.

A summary of the data collected during each season, with respect to year and site are included in Table B.3. A graphical representation of the sampling events within Sheardown Lake for the six stations reported in detail is provided in Figure B.38.

Table B.3 Sheardown Lake SE Sample Size

Year	Summer	Fall	Winter
2006	1	1	0
2007	6	6	4
2008	8	6	2
2011	2	0	0
2012	0	2	2
2013	2	2	2
Site	**Summer**	**Fall**	**Winter**
DL0-02-1-S	3	2	1
DL0-02-1-D	5	3	1
DL0-02-3-S	3	4	3
DL0-02-3-D	3	4	3
DL0-02-4-S	3	2	0
DL0-02-4-D	2	2	0
DL0-02-6-S	0	0	1
DL0-02-6-D	0	0	1

NOTES:

1. WINTER SAMPLING OCCURRED DURING APRIL AND MAY; SPRING SAMPLING OCCURRED DURING JUNE; SUMMER SAMPLING OCCURRED FROM JULY TO AUGUST 17; FALL SAMPLING OCCURRED FROM AUGUST 18 THROUGH SEPTEMBER 30TH.
2. LAKE SAMPLING DID NOT OCCUR DURING SPRING, DUE TO SAFETY CONCERNS OF SAMPLING OVER MELTING ICE.
3. DURING WINTER 2013, SAMPLES WERE COLLECTED WITHIN SHEARDOWN LAKE AT D-LAKE-05.

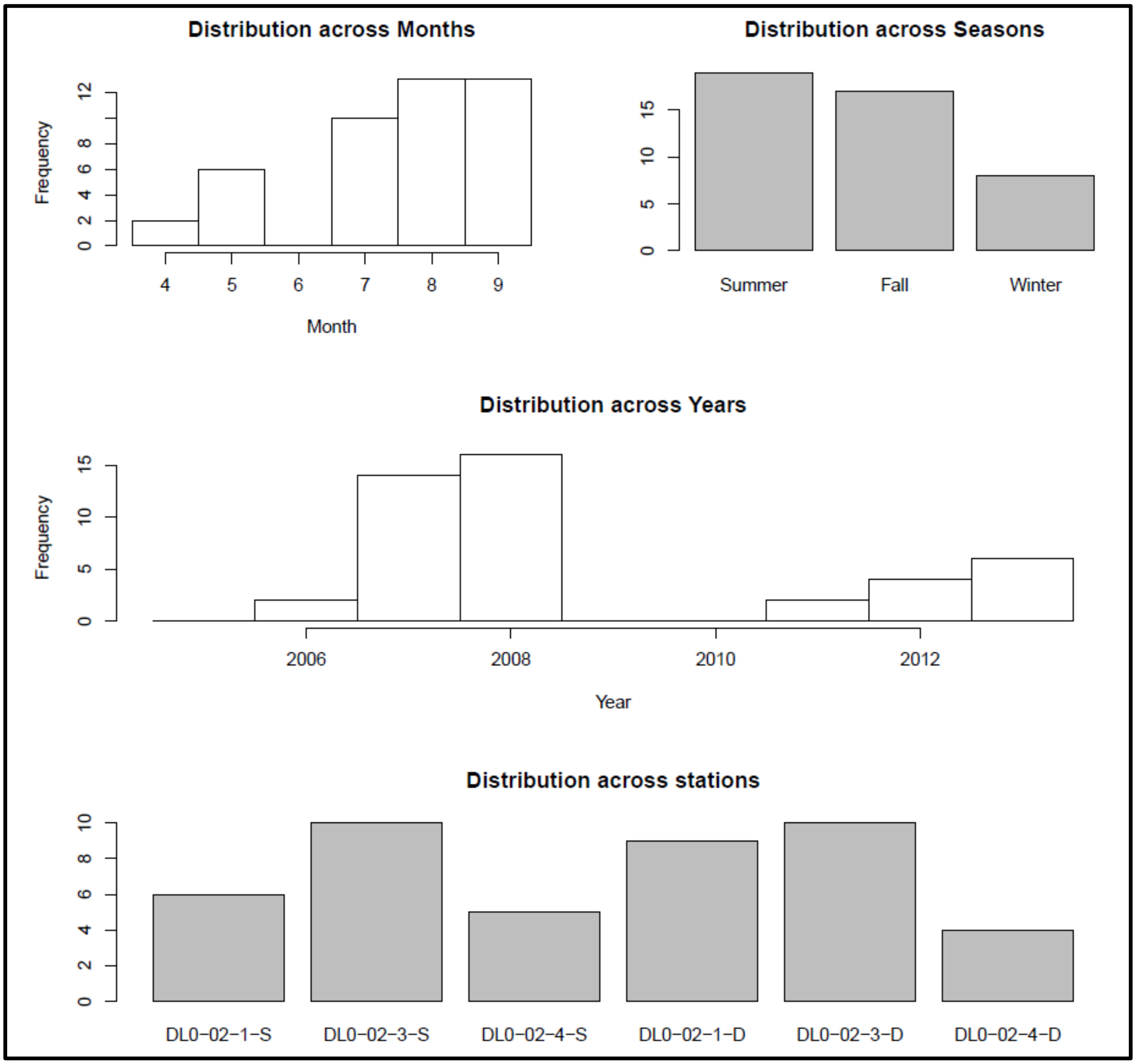


Figure B.38 Sheardown Lake SE – Graphical Summary of Sampling Events

The following summarizes the data review observations for Sheardown Lake NW.

pH (Figure B.39)

- Sheardown Lake NW is slightly alkaline with a median in-situ pH of 7.57 (range from 6.41 to 8.32).
- A slight influence of depth on pH is observed with a measured median in-situ pH at the deep stations of ~7.5, slightly lower compared to shallow samples (> 7.9).

Alkalinity (Figure B.39)

- Sheardown Lake sites are fairly uniform with median alkalinity values that range from 53 to 57 mg/L $CaCO_3$, classifying the lake water as having low sensitivity to acidic inputs.

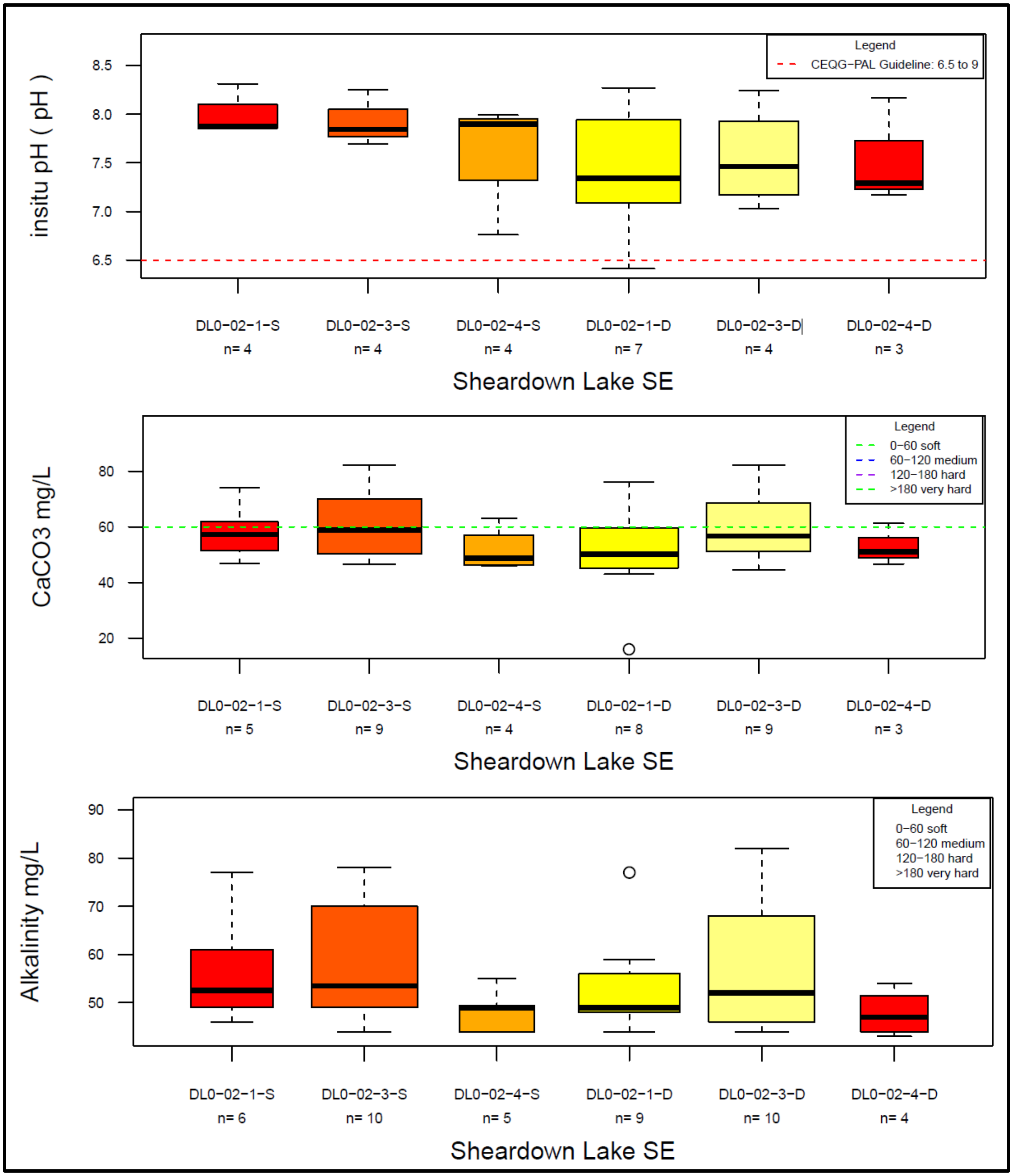


Figure B.39 Sheardown Lake SE – *In situ* pH, Alkalinity and Hardness

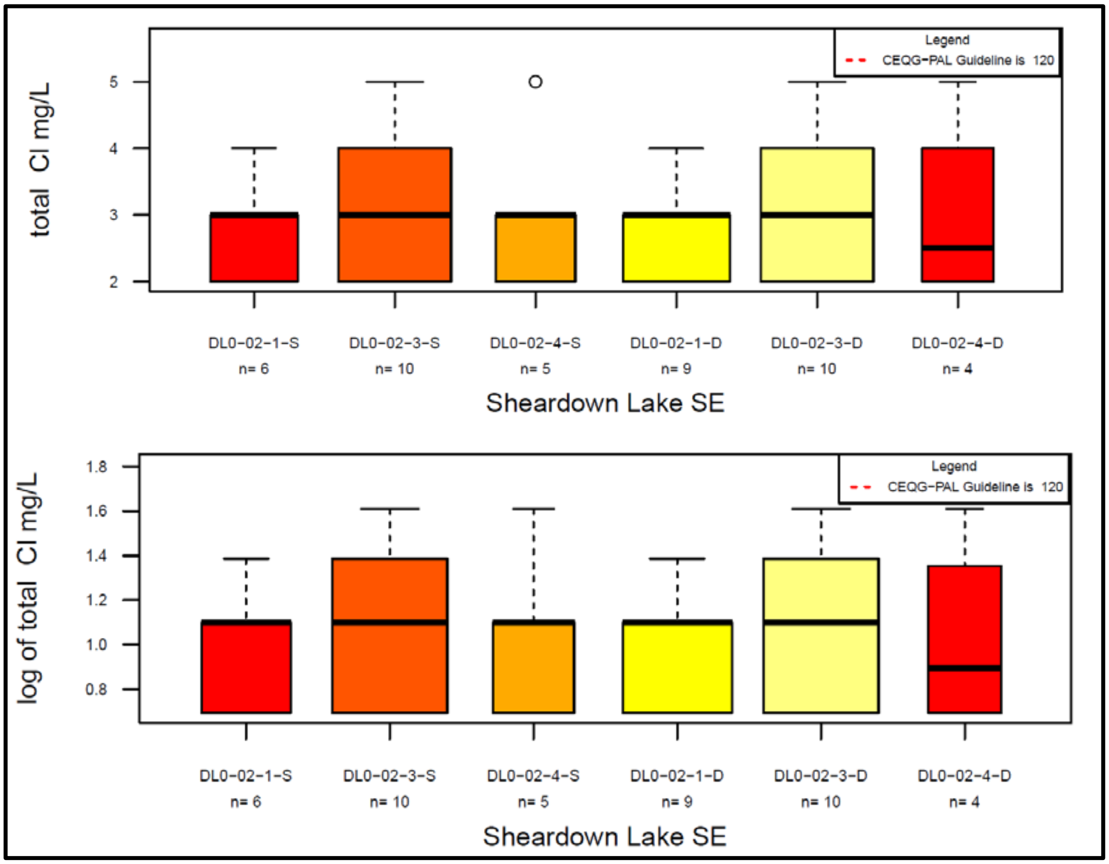
Hardness (Figure B.39)

- Median hardness ranged from 54 and 61 mg/L, classifying the lake water as "soft".
- Hardness did not change meaningfully with depth, and portrayed trends very similar to alkalinity.
- 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 B.40 and B.41)

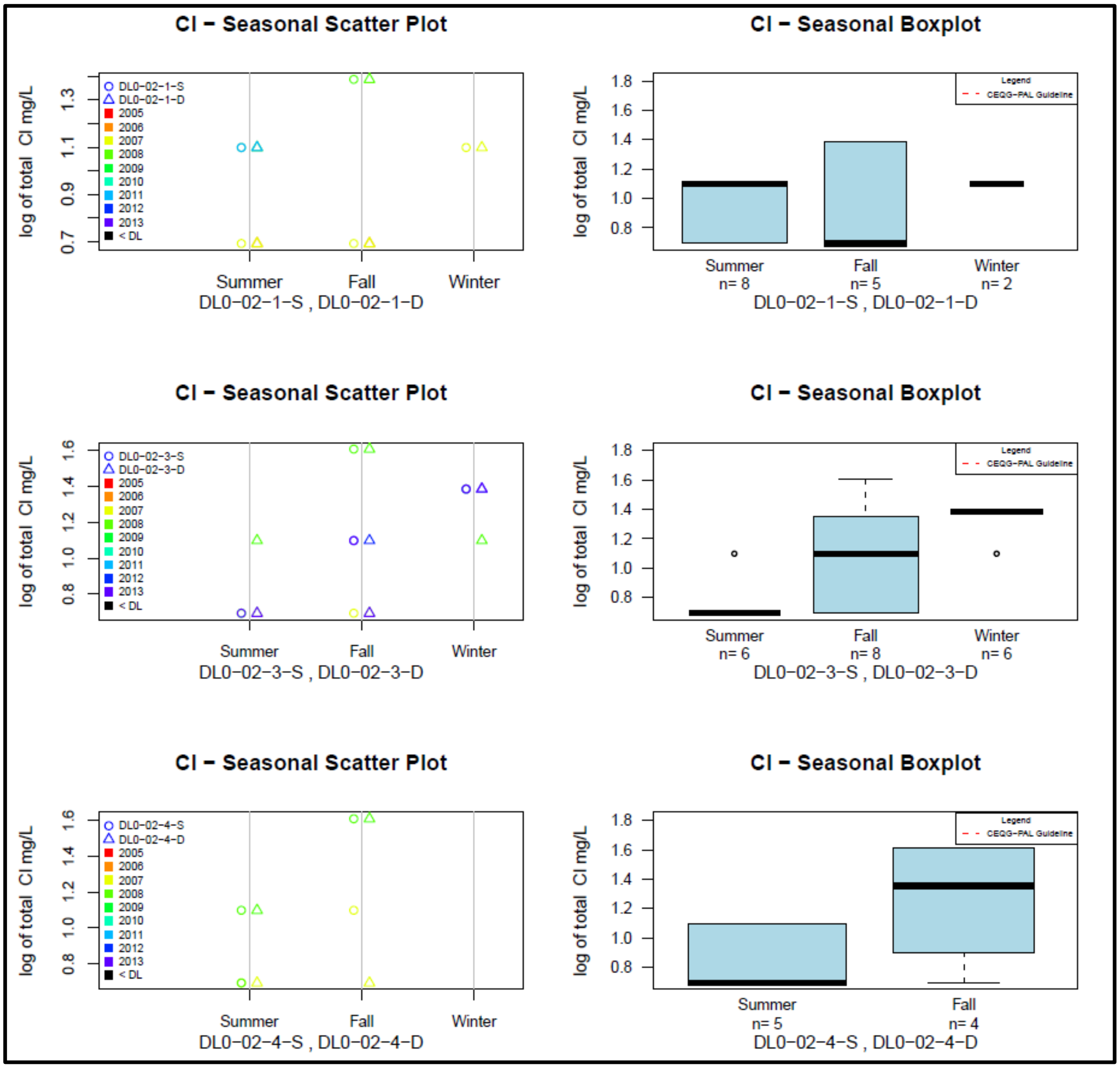
Forty-four (44) chloride concentration samples were collected at Sheardown Lake SE. Chloride concentrations in Sheardown Lake SE are very low and have maximum values of 5 mg/L, well below the CWQG-PAL limit of 120 mg/L (Figure B.40). All sites within Sheardown Lake SE have very similar median chloride concentrations that range between 0.9 mg/L to 1.1 mg/L. Log transformation does not reveal any outlying values in the data. Seasonal scatterplots indicate possible elevations of chloride concentrations in the winter. Additional baseline sampling will help to reveal this trend.



NOTES:

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

Figure B.40 Sheardown Lake SE – Chloride Concentrations in Water



NOTES:

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

Figure B.41 Sheardown Lake SE – Variability of Chloride in Water

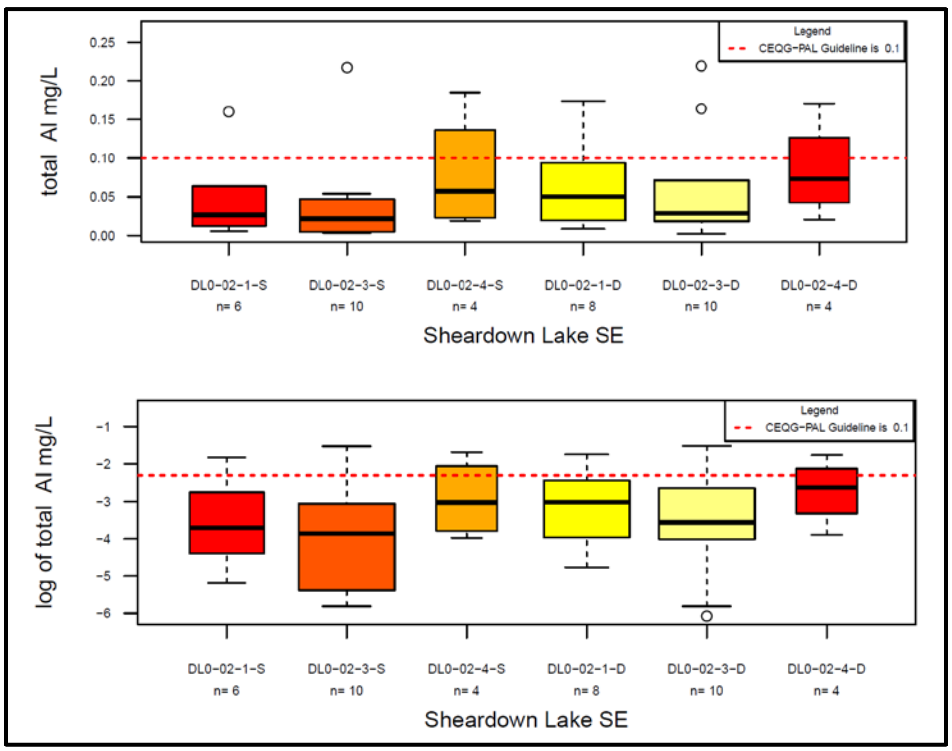
Nitrate

Forty-four (44) nitrate concentration samples were collected from Sheardown Lake SE over the course of eight years. All nitrate concentrations were measured at the detection limit (0.10 mg/L). As a result, no seasonal, inter-annual or depth variation can be determined and further graphical analyses are not warranted.

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 to reflect the applicable guidelines.

Total Aluminum (Figures B.42 and B.43)

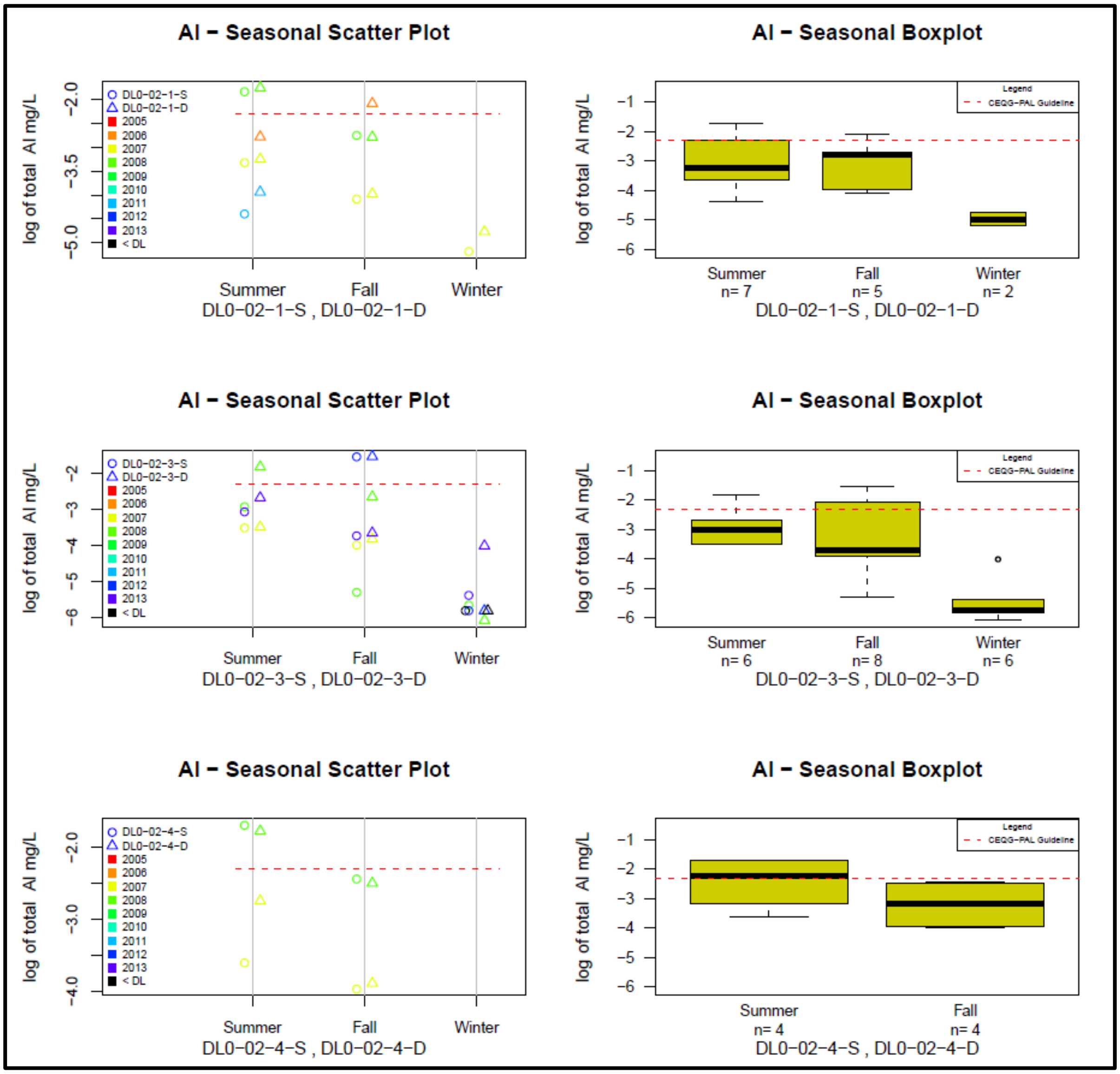
Forty-two (42) total aluminum concentration samples were collected from Sheardown Lake SE over the course of eight years. Total aluminum concentrations consistently report above MDLs and have 75th percentile values that exceed the CWQG-PAL guidelines of 0.1 mg/L (Figure B.42). All stations within Sheardown Lake have median aluminum concentrations that range from 0.02 mg/L to 0.06 mg/L. Deeper sampling stations show slightly elevated concentrations when compared to shallow stations. Comparison of raw data and log values reveals fewer outliers within the log transformed data, as expected. Similar to Sheardown NW, Sheardown SE data shows summer and fall concentrations of aluminum remain fairly elevated, while winter concentrations are reduced in comparison (Figure B.43).



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.42 Sheardown Lake SE – 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 B.43 Sheardown Lake SE – Variability of Total Aluminum in Water

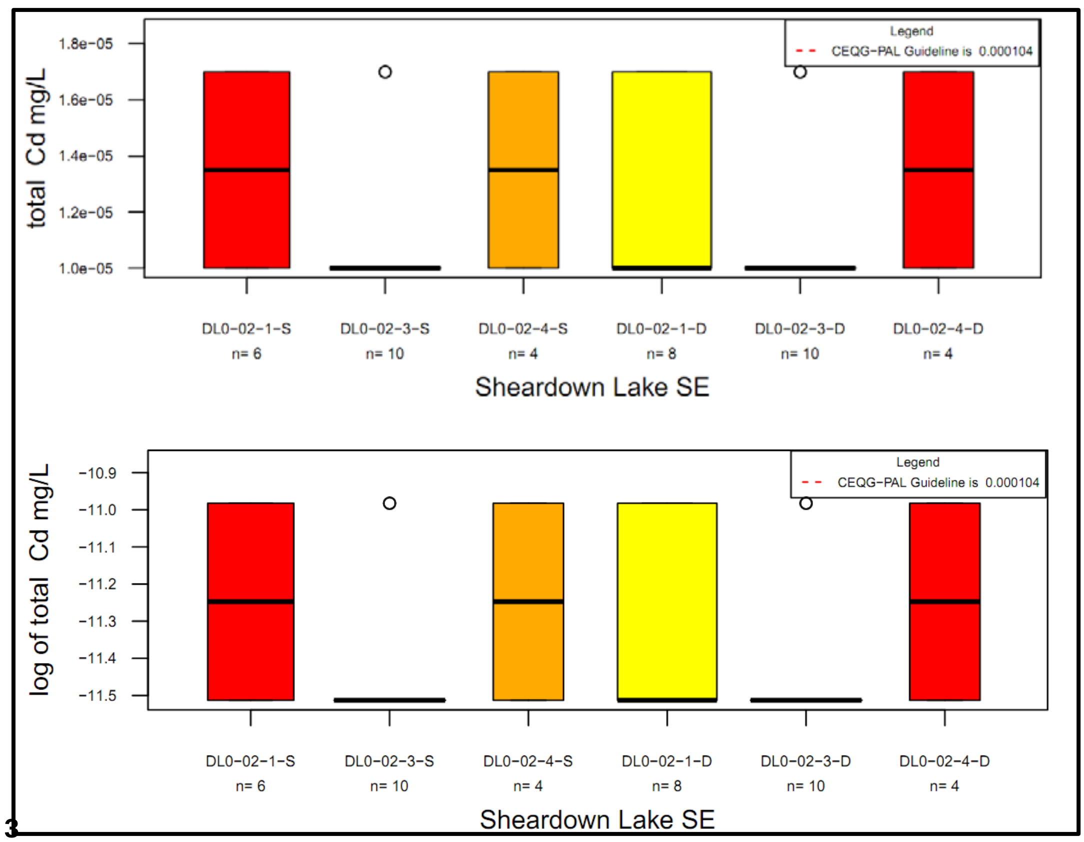
Total Arsenic

With the exception of one sample, the remaing (forty-one) measured total arsenic levels report at detection limit and are therefore not not portrayed via graphical representation. The detection limit (0.00010 mg/L) and the one outlying value (0.00011 mg/L) are far below the CWQG-PAL guideline limit (0.005 mg/L).

Total Cadmium (Figures B.44 and B.45)

Forty-two (42) total cadmium concentration samples were collected from six sites in Sheardown Lake SE over the course of eight years. Cadmium concentrations consistently report at or below MDLs, and are consistently below the CWQG-PAL guideline (Figure B.44). Although total boxplots of all data seem to indicate a range of values at each sampling point, this is as a result of two different detection limits. Seasonal scatterplots reveal that earlier data from 2007 had a detection limit of 0.000017 mg/L and later data from 2009 onwards had a detection limit of 0.00001 mg/L.

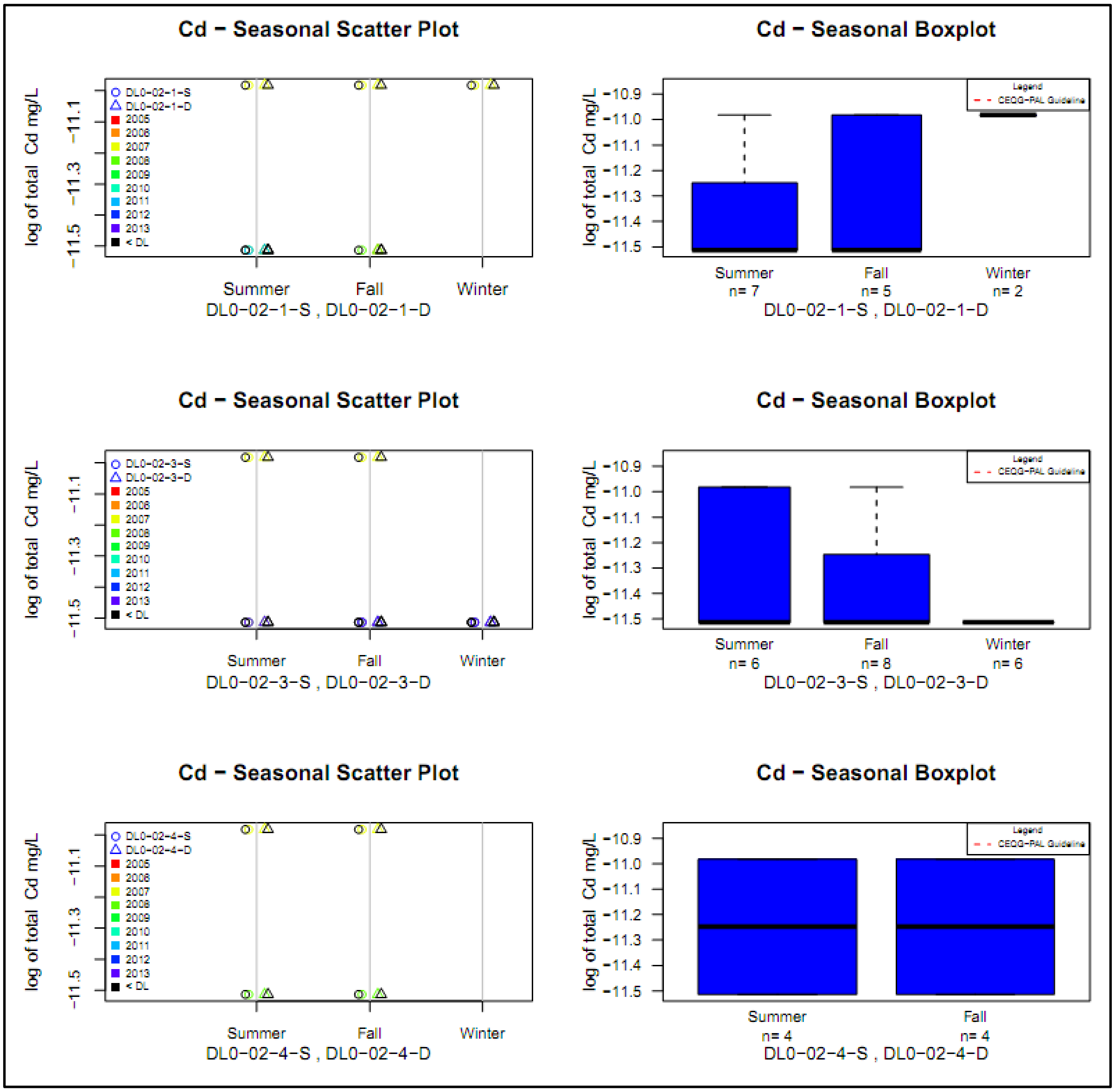
Seasonal scatterplots that combine data from deep and shallow sampling stations show no difference in values between the two stations, as a result of MDL interference (Figure B.45). Similarly, seasonal differences are not noted as a result of MDL interference.



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.44 Sheardown Lake SE – Total Cadmium Concentrations in Water



NOTES:

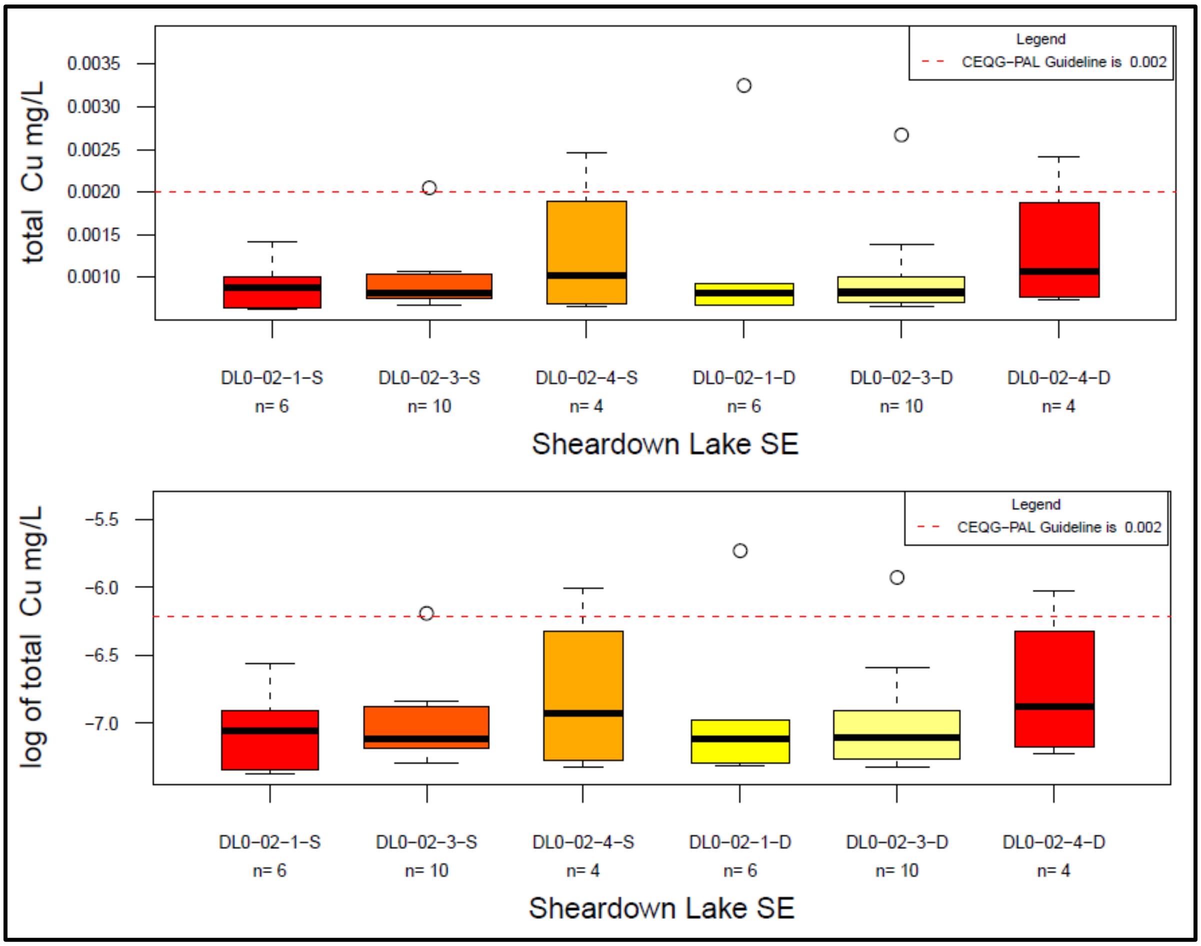
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.45 Sheardown Lake SE – Variability of Total Cadmium in Water

Total Copper (Figures B.46 and B.47)

Forty (40) total copper concentration samples were collected from six stations in Sheardown Lake SE over the course of eight years. Total copper concentrations consistently report above MDLs, and, with the exception of a few outliers, below the CWQG-PAL guideline (Figure B.46). Outliers at two deep and one shallow station just exceed the CWQG-PAL guideline of 0.002 mg/L, with a maximum outlying value of 0.0032 mg/L. Concentrations at DL0-02-4 are elevated compared to the other sites, which indicates inputs from D-Stream-3 might be higher in total copper concentrations than inputs from Sheardown NW. Log transformation of the data does not remove outliers observed in data.

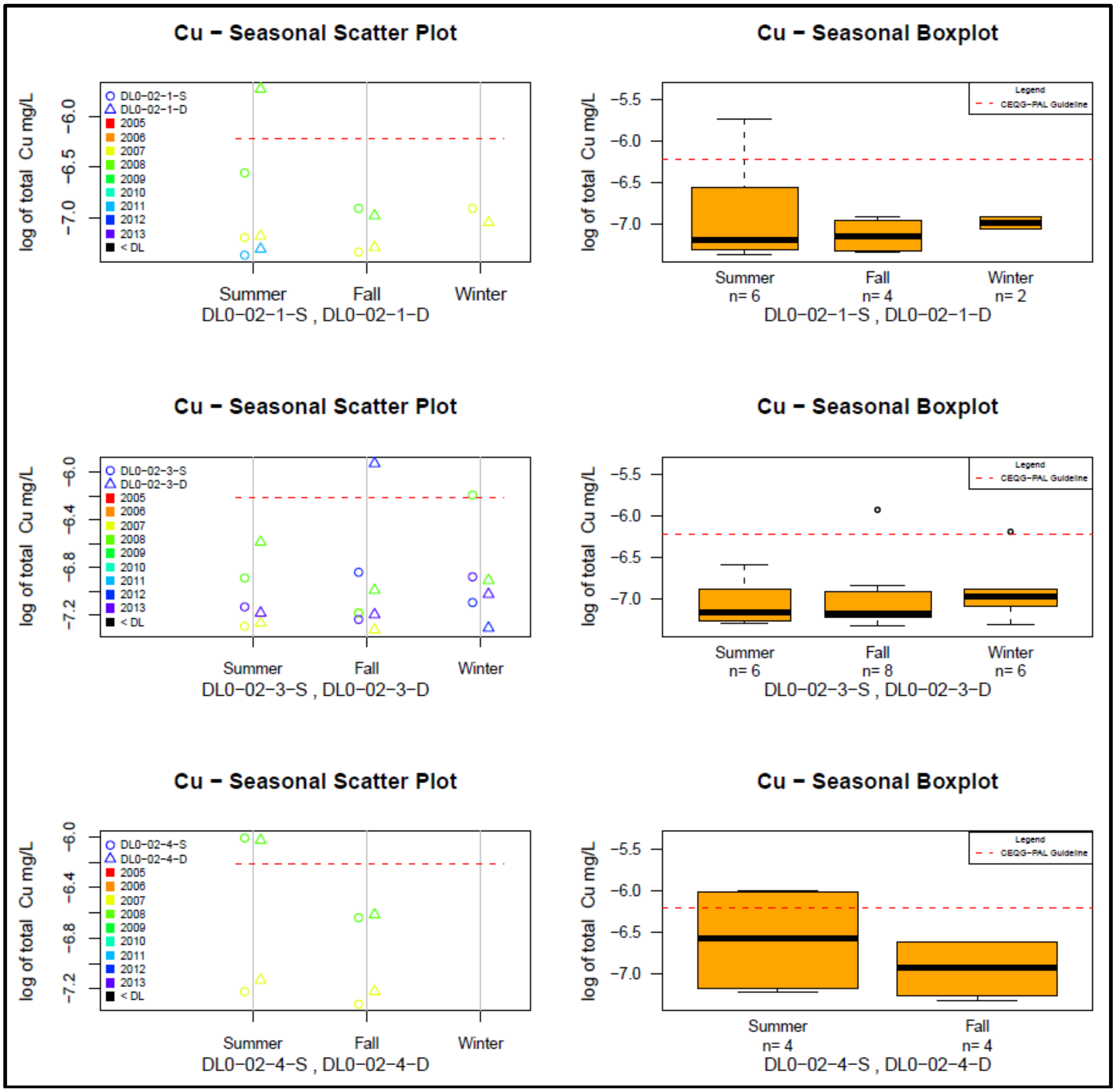
Seasonal scatterplots that combine data from deep and shallow sampling stations do not show a consistent trend across stations (Figure B.47). Data from 2008 appears to be slightly elevated when compared to later data. With the data available, distinct seasonal trends are not observed.



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.46 Sheardown Lake SE – Total Copper Concentrations in Water



NOTES:

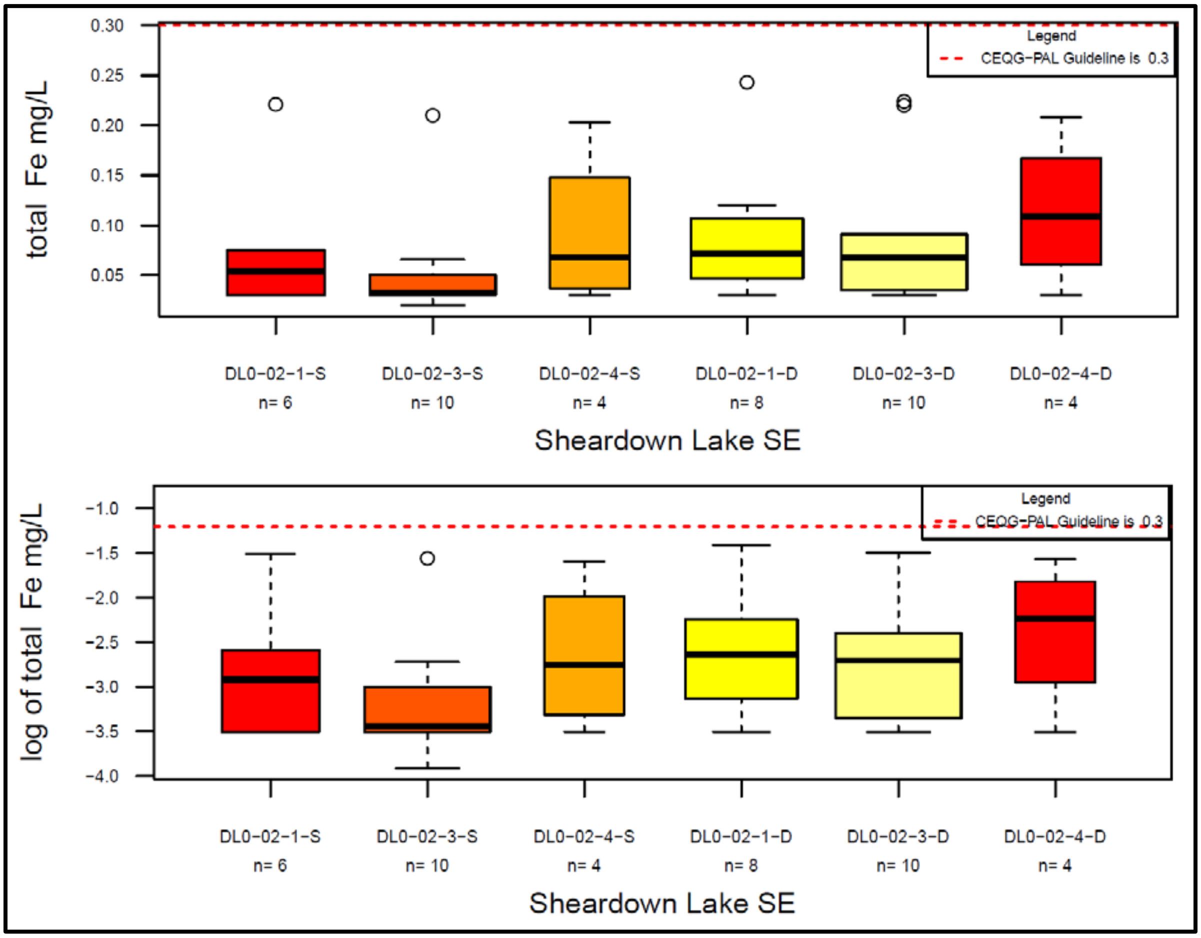
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.47 Sheardown Lake SE – Variability of Total Copper in Water

Total Iron (Figures B.48 and B.49)

Forty-two (42) total iron concentration samples were collected from Sheardown Lake SE at six stations over the course of eight years. The majority of total iron concentrations report above MDLs, band all samples report below the CWQG-PAL guideline of 0.3 mg/L (Figure B.48). Similar to copper, station DL0-02-4 has slightly elevated total iron concentrations when compared to the other stations in Sheardown Lake SE.

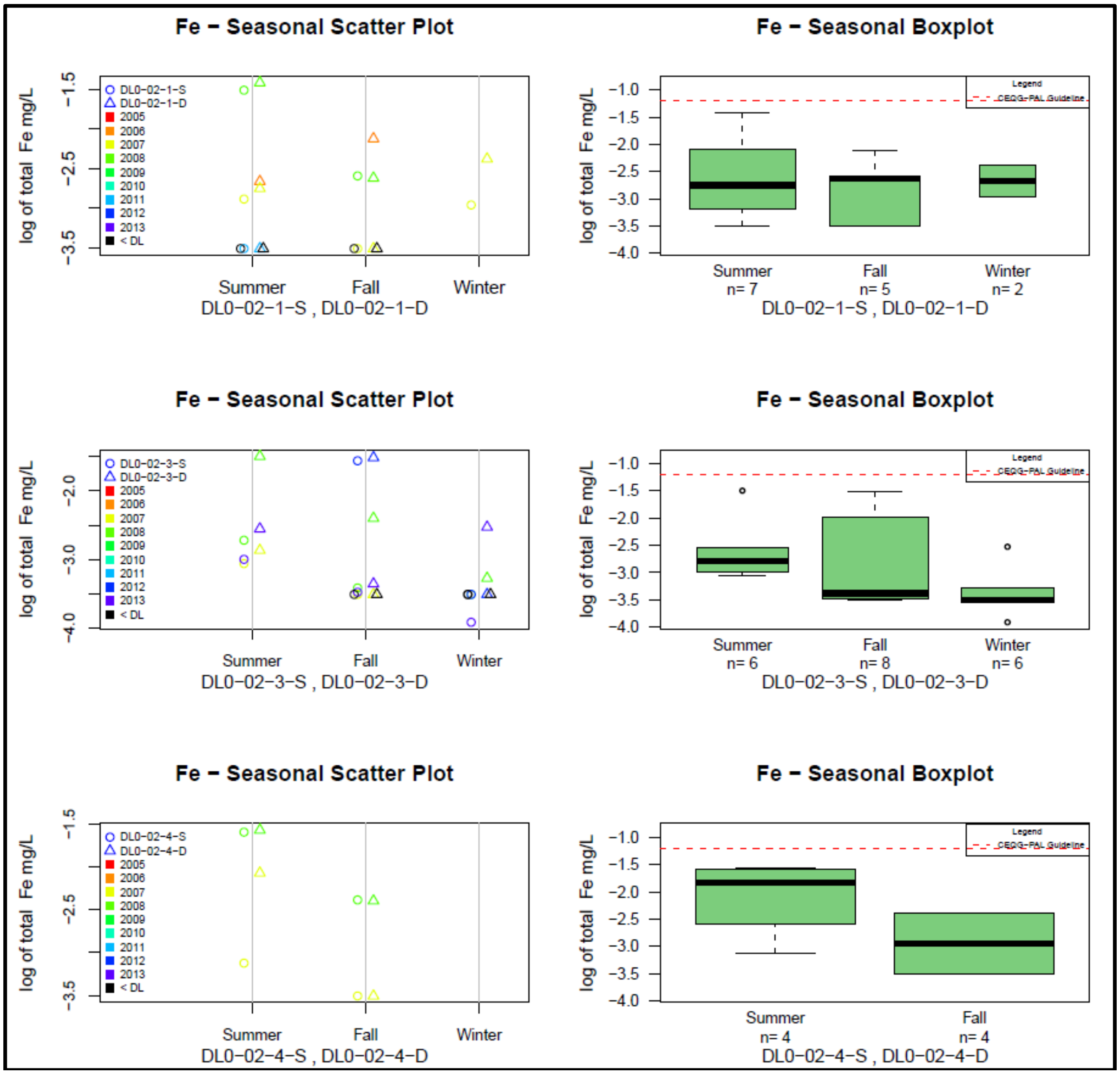
Seasonal scatterplots that combine data from deep and shallow sampling stations show no difference in values between the two stations (Figure B.49). Slightly elevated summer concentrations are noted; however, more samples are required to understand magnitude of seasonal trend.



NOTES:

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

Figure B.48 Sheardown Lake SE – Total Iron Concentrations in Water



NOTES:

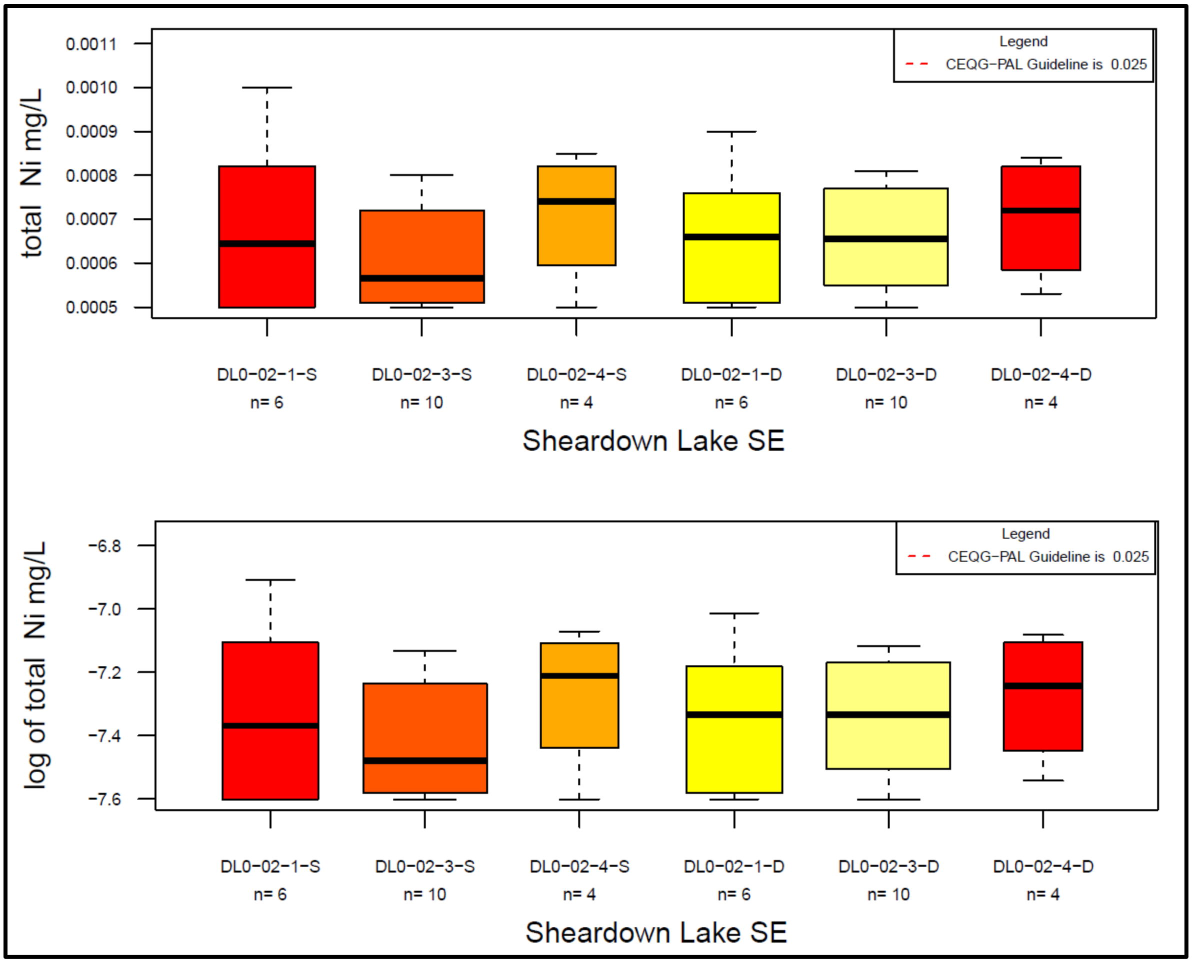
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.

Figure B.49 Sheardown Lake SE – Variability of Total Iron in Water

Total Nickel (Figures B.50 and B.51)

Forty (40) total nickel concentration samples were collected from Sheardown Lake SE at six sample stations over the course of eight years. Nickel concentrations consistently report above MDLs, but well below the CWQG-PAL guideline (0.025 mg/L) (Figure B.50). Median total nickel concentrations are consistent throughout the geographically distinct sampling stations and range from 0.00055 mg/L through 0.00075 mg/L. Similar to other iron, nickel concentrations are slightly elevated at the DL0-02-4 station.

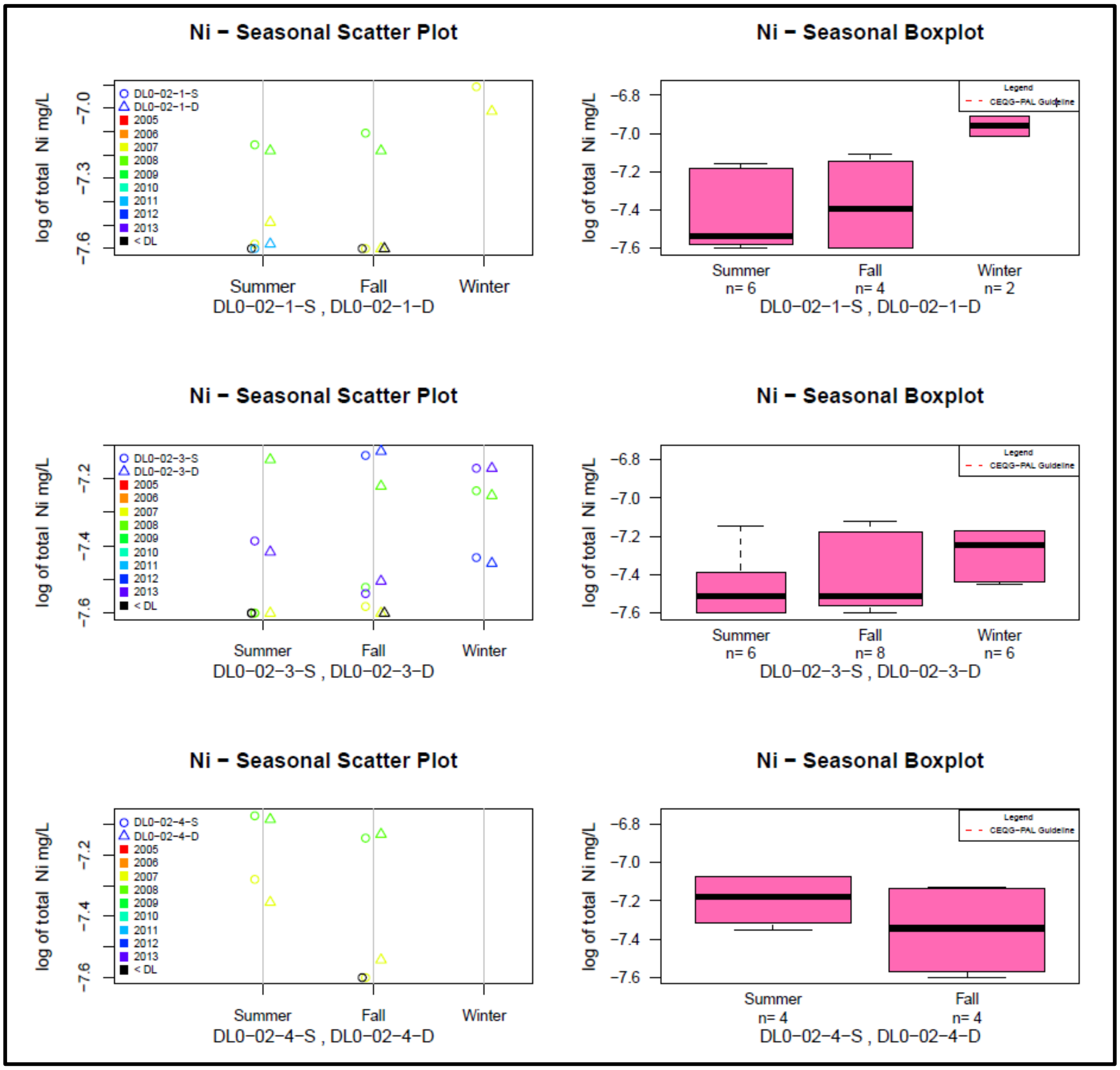
Seasonal scatterplots show that elevated concentrations are derived from early sampling (2007 and 2008), especially at DL0-02-1 and DL0-02-4 (Figure B.51). Although the winter dataset is limited, the current data indicates concentration peaks for nickel occur during the winter.



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.50 Sheardown Lake SE – Total Nickel Concentrations in Water



NOTES:

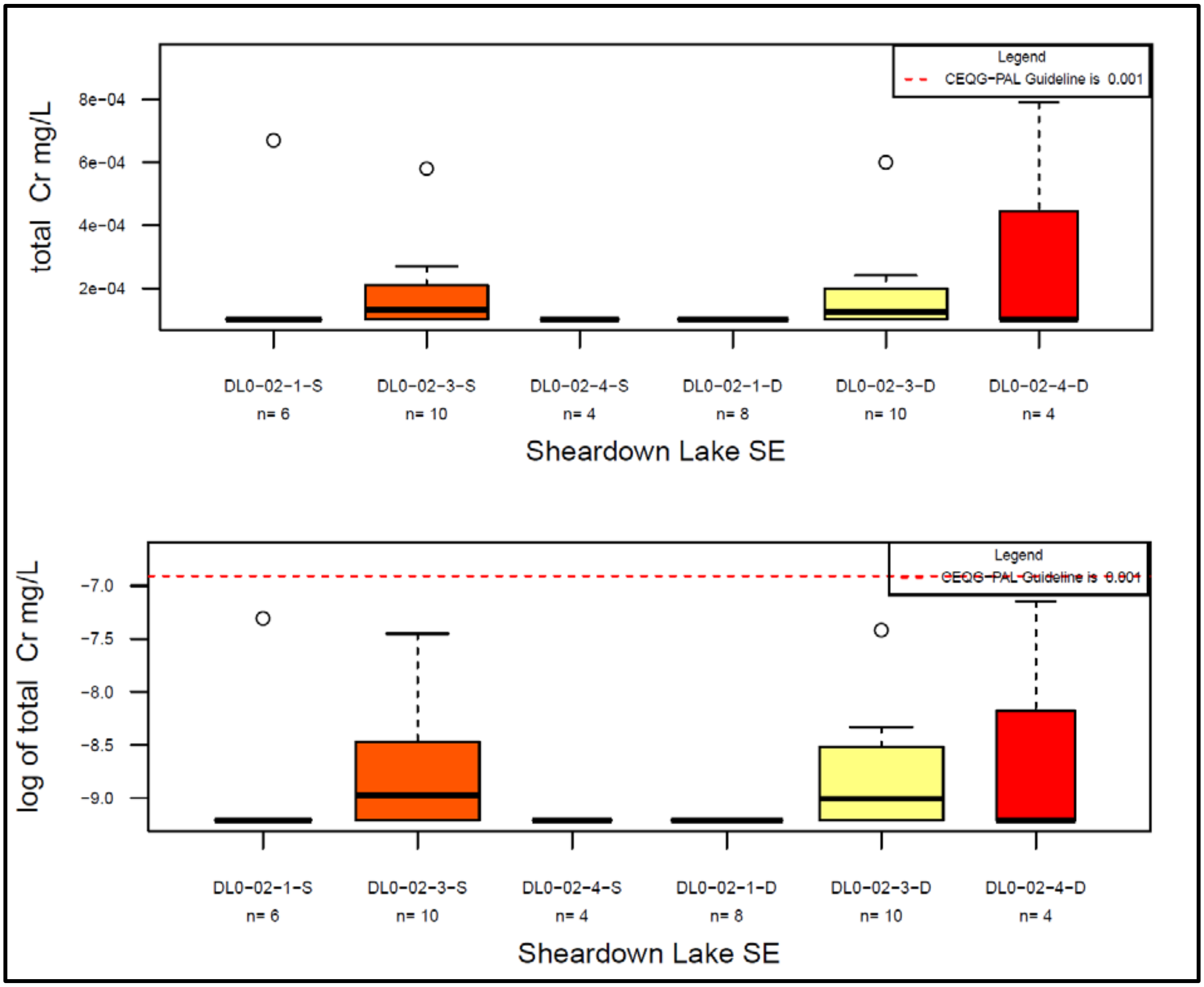
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure B.51 Sheardown Lake SE– Variability of Total Nickel in Water

Total Chromium (Figures B.52 and B.53)

Forty-two (42) total chromium concentration samples were collected from Sheardown Lake SE at six sample stations over the course of eight years. Chromium concentrations are generally low, but concentrations are certain sites approach the CWQG-PAL guideline (0.001 mg/L) (Figure B.52). Samples from DL0-02-3/D and DL0-02-4-D are slightly elevated compared to the other stations with Sheardown Lake SE, but the trend is so muted, it is not considered important.

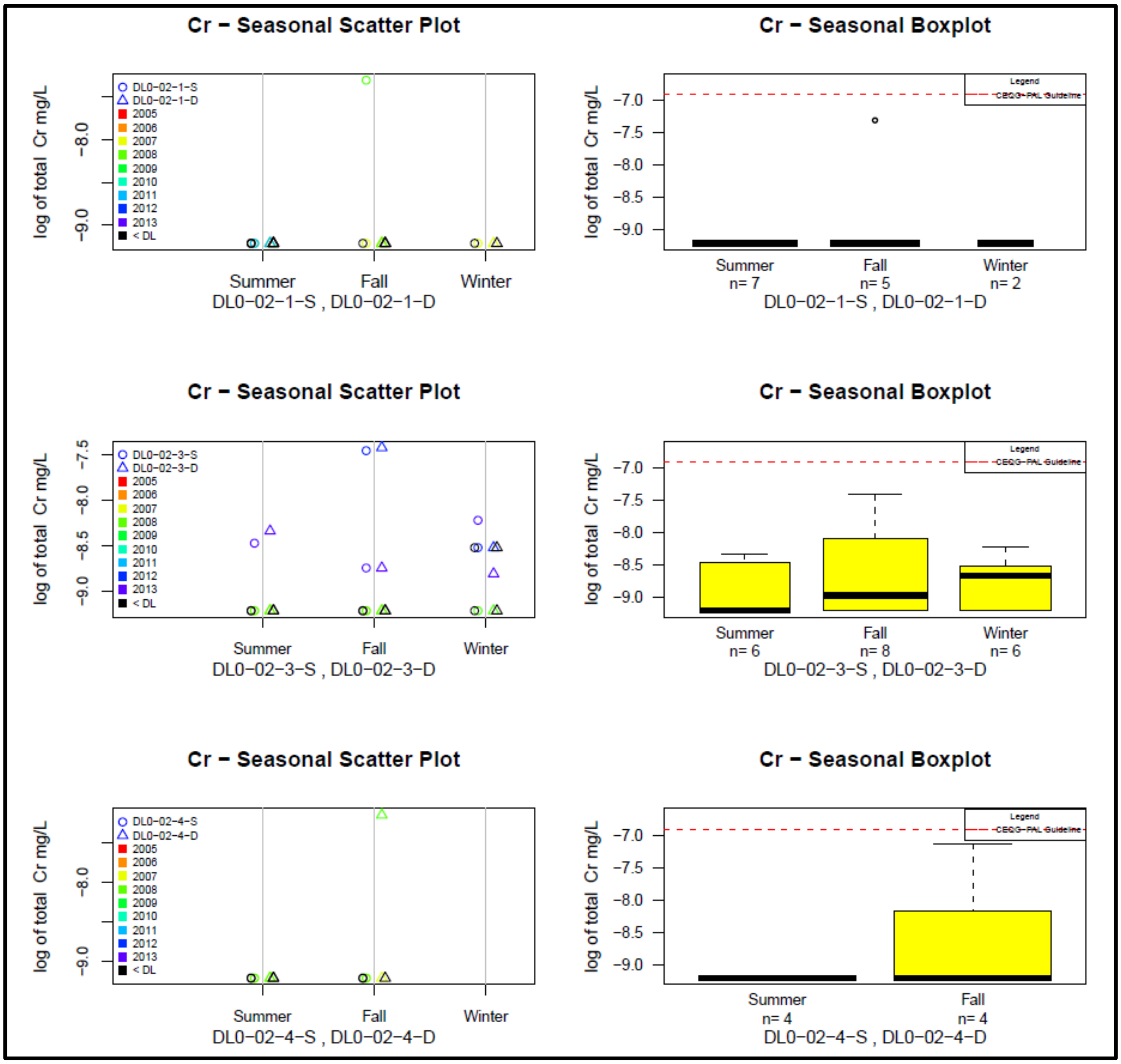
Seasonal scatterplots show that elevated concentrations at DL0-02-3-D are derived from recent sampling, during 2012 and 2013 (Figure B.53). No consistent seasonal trend was noted between sites.



NOTES:

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

Figure B.52 Sheardown Lake SE – 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 B.53 Sheardown Lake SE– Variability of Total Chromium in Water

Summary of Sheardown Lake SE Water Quality

Summary of trends observed during review of Sheardown Lake SE baseline data:

- Distinct depth trends are not observed for any parameters within Sheardown Lake SE, which suggests that lake is completely mixed throughout the year, despite winter ice.
- Elevated concentrations observed at DL0-02-4 compared to other sites: copper, iron and nickel.
- Early data (2007, 2008) appears elevated when compared to more recent data: copper and nickel.

- Parameters below MDLs and/or do not show any seasonal trends: nitrate, arsenic, cadmium, chromium and copper.
- Parameters with highest concentration occurring in the summer and/or fall: aluminum and iron.
- Parameters with highest concentrations occurring in the winter: chloride and nickel.

B.2.3 Mary Lake

A total of eighty-five (85) lake samples were collected at twelve stations over the eight-year sampling history at Mary Lake (Figures B.1 and B.2):

- BL0-01-D and S - Within a small basin at the north end of the northern arm of Mary Lake to which Camp Lake drains.
- BL0-03-D and S - Located at the centre of Mary Lake.
- BL0-04-D and S - Located in the centre of the main basin of Mary Lake.
- BL0-05-D and S - Located within the main basin of Mary Lake near the mouth of the Mary River.
- BL0-05-B4-D and S - Located at the inlet of Mary Lake.
- BL0-06-D and S - Located within the southern portion of Mary Lake.

Most samples were collected in 2007 and no samples were collected during 2009 and 2010. Most samples occurred in the summer, and the least number of samples were collected in the winter.

A summary of the data collected during each season, with respect to year and site are presented in Table B.4 and a graphical representation of the sampling events is provided in Figure B.54. Note that for the purposes of graphical analysis, data from BL0-05-B4 has been pooled with data from BL0-05.

Table B.4 Mary Lake Sample Size

Year	Summer	Fall	Winter
2006	8	4	0
2007	10	14	8
2008	10	0	4
2011	4	0	0
2012	0	2	0
2013	10	6	5
Site	**Summer**	**Fall**	**Winter**
BL0-01-S	4	3	2
BL0-01-D	4	2	4
BL0-03-S	4	2	1
BL0-03-D	4	2	1
BL0-04-S	4	2	2
BL0-04-D	4	2	2
BL0-05-S	5	5	2
BL0-05-D	5	5	2
BL0-05-B4-S	1	0	0
BL0-05-B4-D	1	0	0
BL0-06-S	3	2	0
BL0-06-D	3	2	0

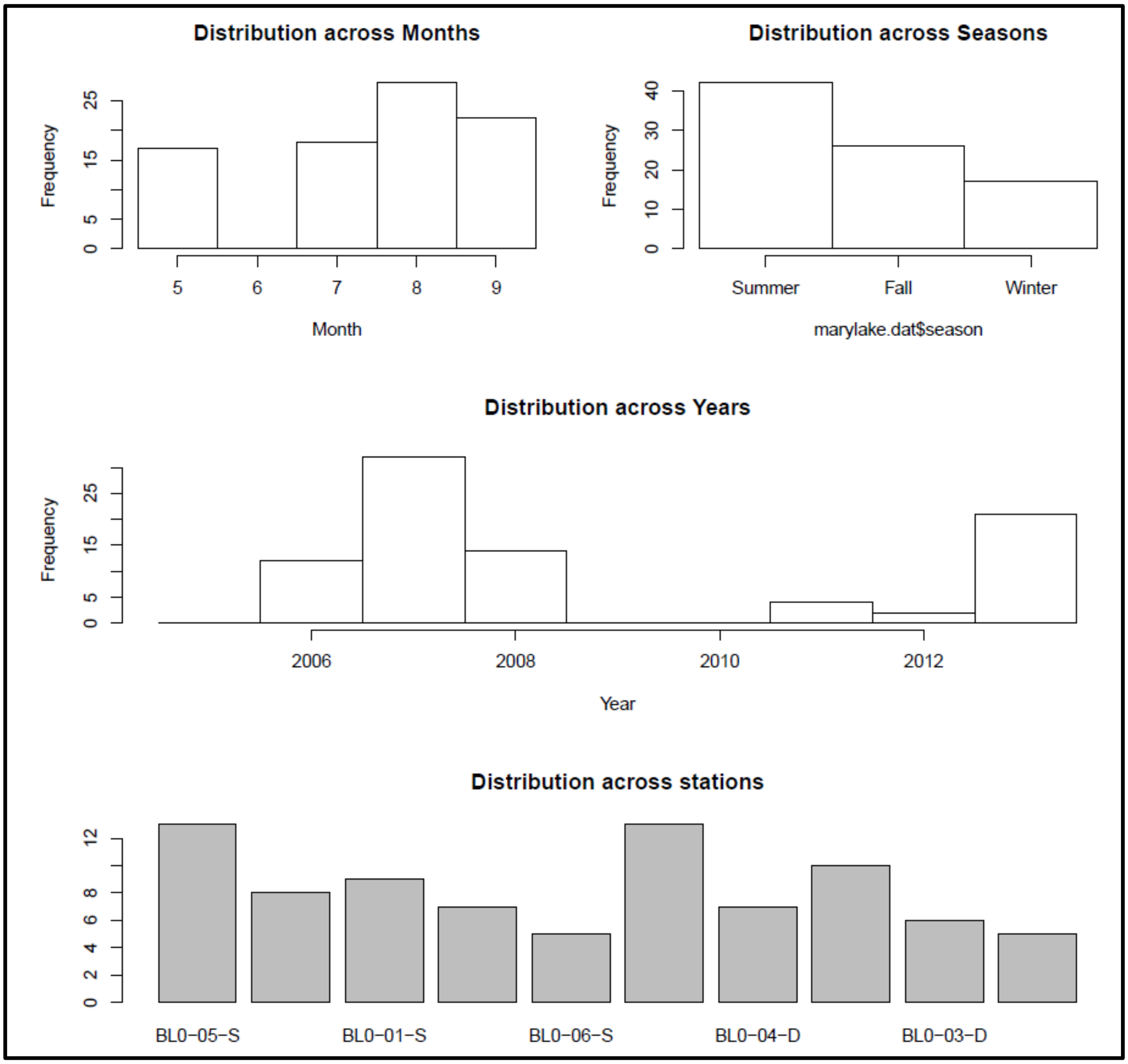


Figure B.54 Mary Lake – Graphical Summary of Sampling Events

The following summarizes the data review observations of the physical parameter data for Mary Lake.

pH (Figure B.55)

- The median pH from all samples collected in Mary Lake is ~7.5. Median values for pH at station within Mary Lake range from 6.6 to 8.3.

Alkalinity (Figure B.55)

- Mary Lake stations generally have alkalinity values that are below 40 mg/L $CaCO_3$; however, BL0-01-S/D show elevated median alkalinity values equal to approximately 70 mg/L $CaCO_3$.
- Differences between deep and shallow stations are not noted.

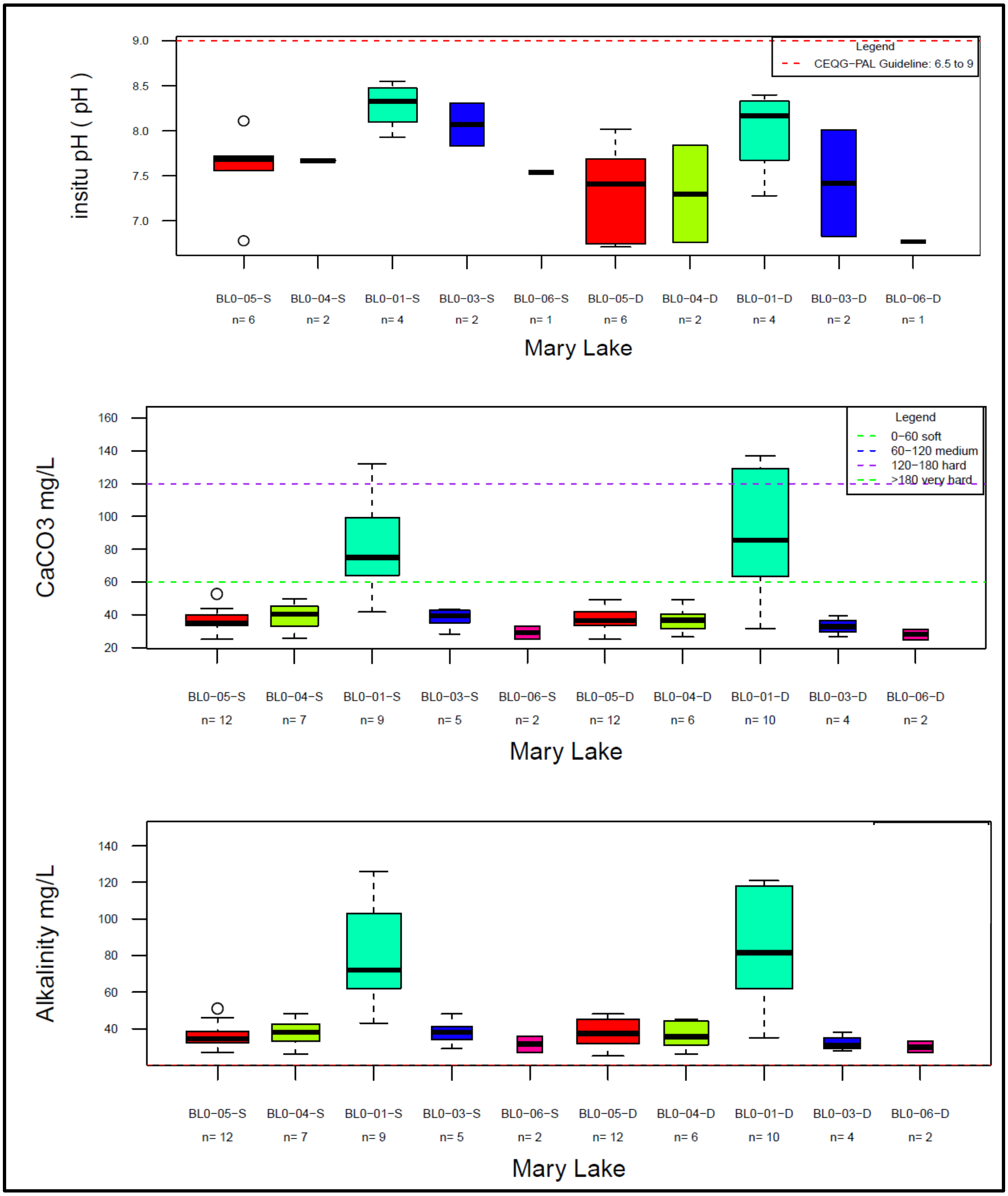


Figure B.55 Mary Lake – In-situ pH, Alkalinity and Hardness

Hardness (Figure B.55)

- Mary Lake stations have “soft water” and generally have alkalinity values that are below 40 mg/L hardness measured as $CaCO_3$, with the exception of BL0-01-S/D which has elevated median alkalinity values equal to ~80 mg/L $CaCO_3$.
- Differences between deep and shallow stations are not noted.
- Hardness portrayed trends very similar to alkalinity and suggests 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 B.56 and B.57)

Sixty-nine (69) chloride concentration samples were collected from Mary Lake over the course of eight years. Chloride concentrations are consistently low, and each geographically distinct site in Mary Lake has a median than ranges from 2 to 2.5 mg/L (Figure B.56). This is well below the CWQG-PAL limit of 120 mg/L. A comparison of total data and seasonal scatterplots reveals that deep and shallow stations located at the same location vary little in reported concentrations. BL0-01-S and BL0-01-D show the greatest variability and have the largest sample size. These stations have outlying values recorded around 11 mg/L to 14 mg/L. The BL0 sampling stations are located in a small basin at the north end of the north arm of the lake, which receives flows from Camp Lake as well as the Tom River (Figure B.1).

Seasonal boxplots show lower chloride concentrations occur in the summer and higher concentrations occur in the winter (Figure B.57).

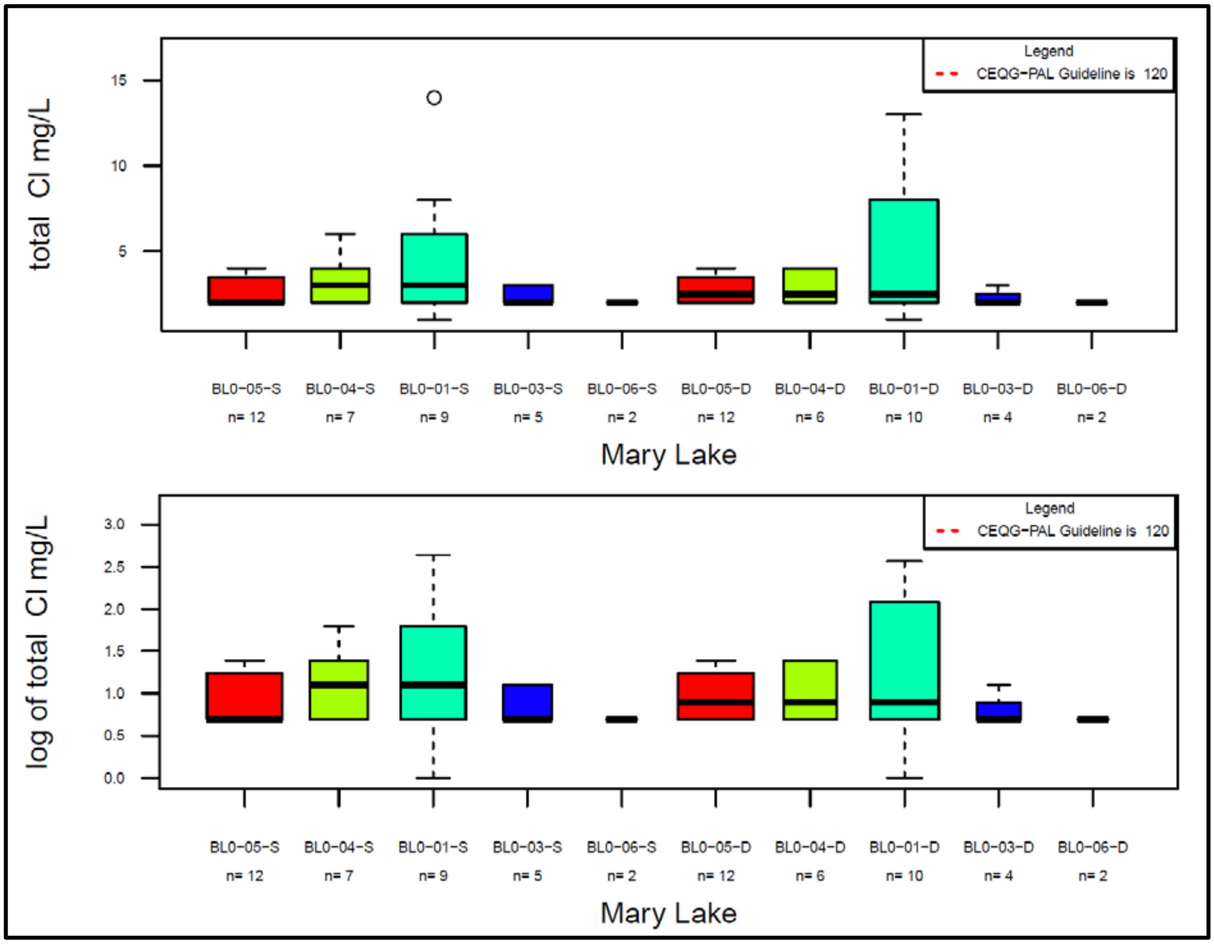
Nitrate

Sixty-nine (69) nitrate concentration samples were collected from Mary Lake over the course of eight years. All nitrate concentrations were measured at the detection limit (0.10), which is well below the CWQG-PAL limit (3 mg/L). As a result, no seasonal, inter-annual or depth variation can be determined and further graphical analyses are not warranted.

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 (Figure B.58 and Figure B.59)

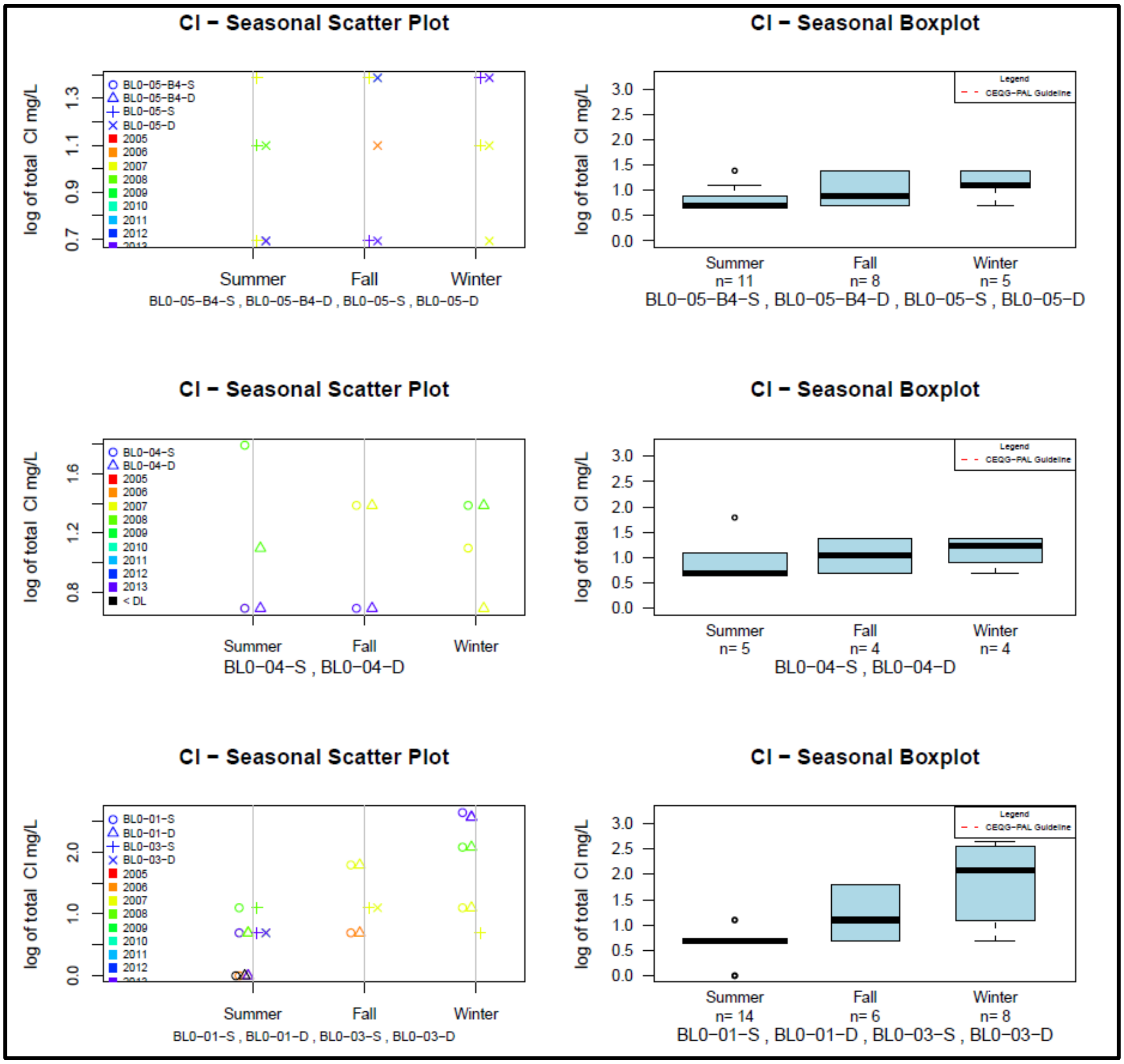
Sixty-nine (69) total aluminum concentration samples were collected from Mary Lake over the course of eight years. Total aluminum concentrations tend to occur above detection limits, and are elevated to concentrations above, or close to the CWQG-PAL limit (0.10 mg/L). Maximum aluminum concentrations exceed the CWQG-PAL limit at all sites except BL0-03-D/S and BL0-6S/D (Figure B.58). Median total aluminum concentrations at each geographically distinct sampling station in Mary Lake range from 0.03 mg/L to 0.06 mg/L. Sampling stations close to inlets, such as BL0-01 and BL0-05, show slightly higher aluminum concentrations when compared to other stations, indicating that upstream aluminum inputs may be occurring from waters flowing into the lake at these locations (the Mary River and Camp Lake). Elevated total aluminum concentrations measured in various watercourses across the mine site area.



NOTES:

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

Figure B.56 Mary Lake – Chloride Concentrations in Water

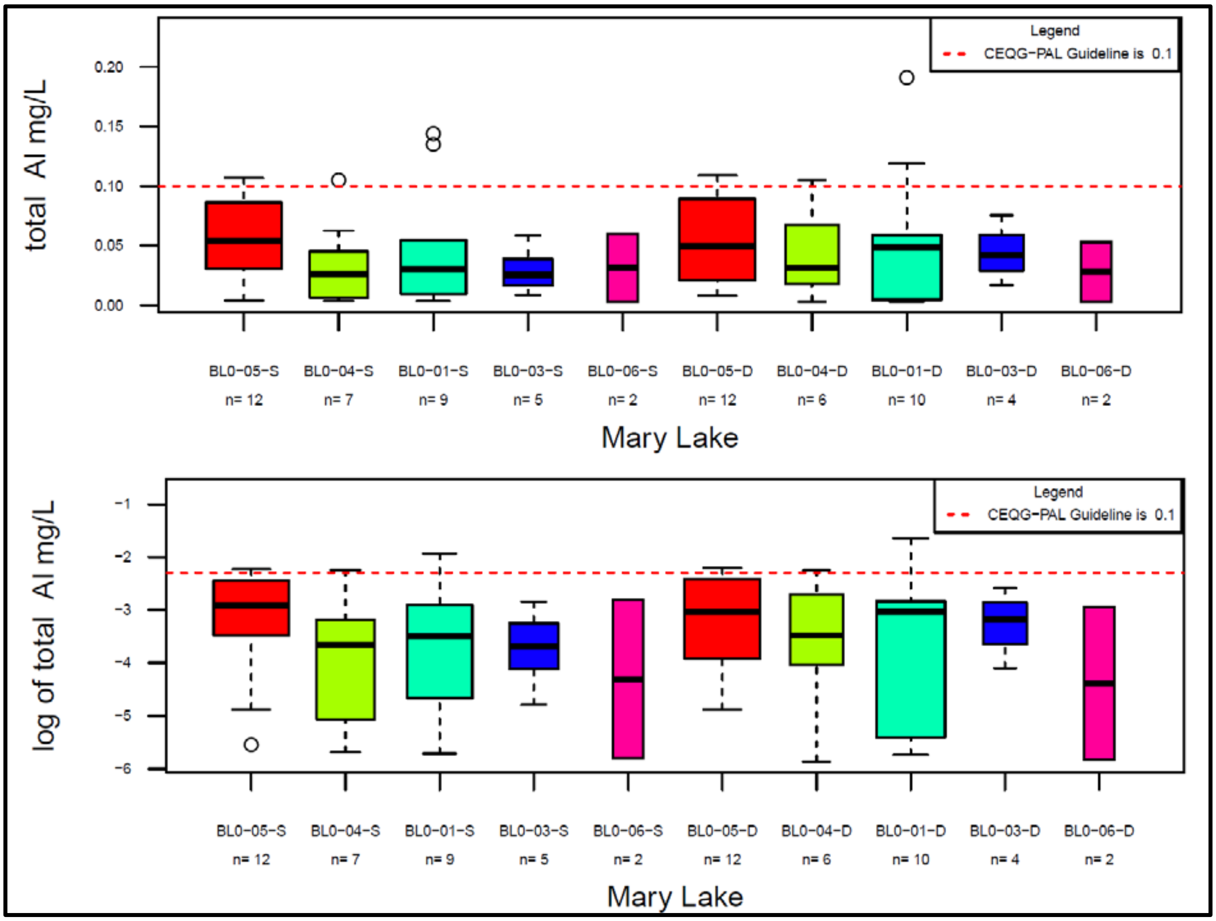


NOTES:

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

Figure B.57 Mary Lake – Variability of Chloride in Water

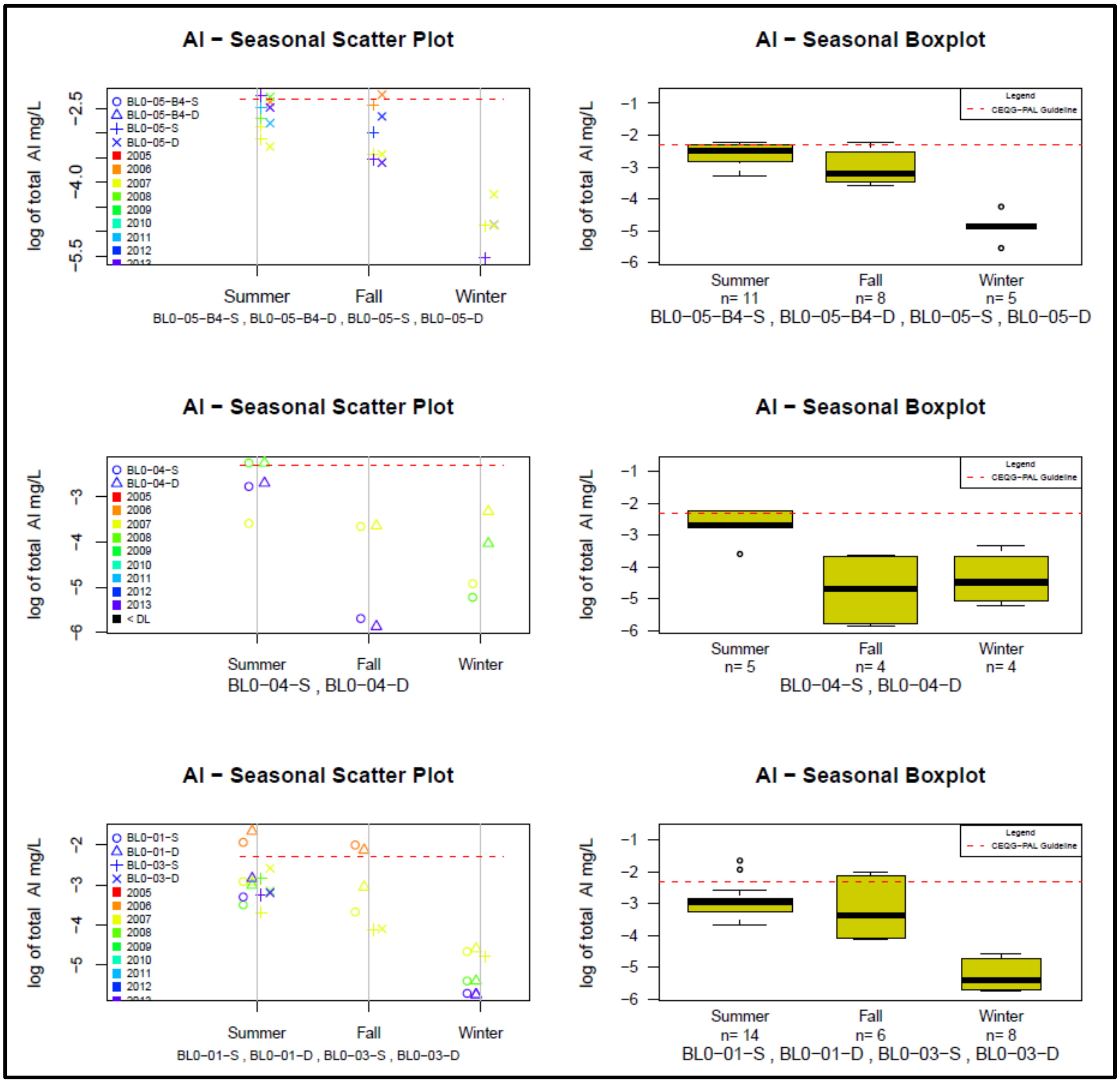
Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be aggregated (Figure B.59). Distinct temporal trends over the eight-year sampling history are not noted.



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.58 Mary Lake – Total Aluminum Concentrations in Water



NOTES:

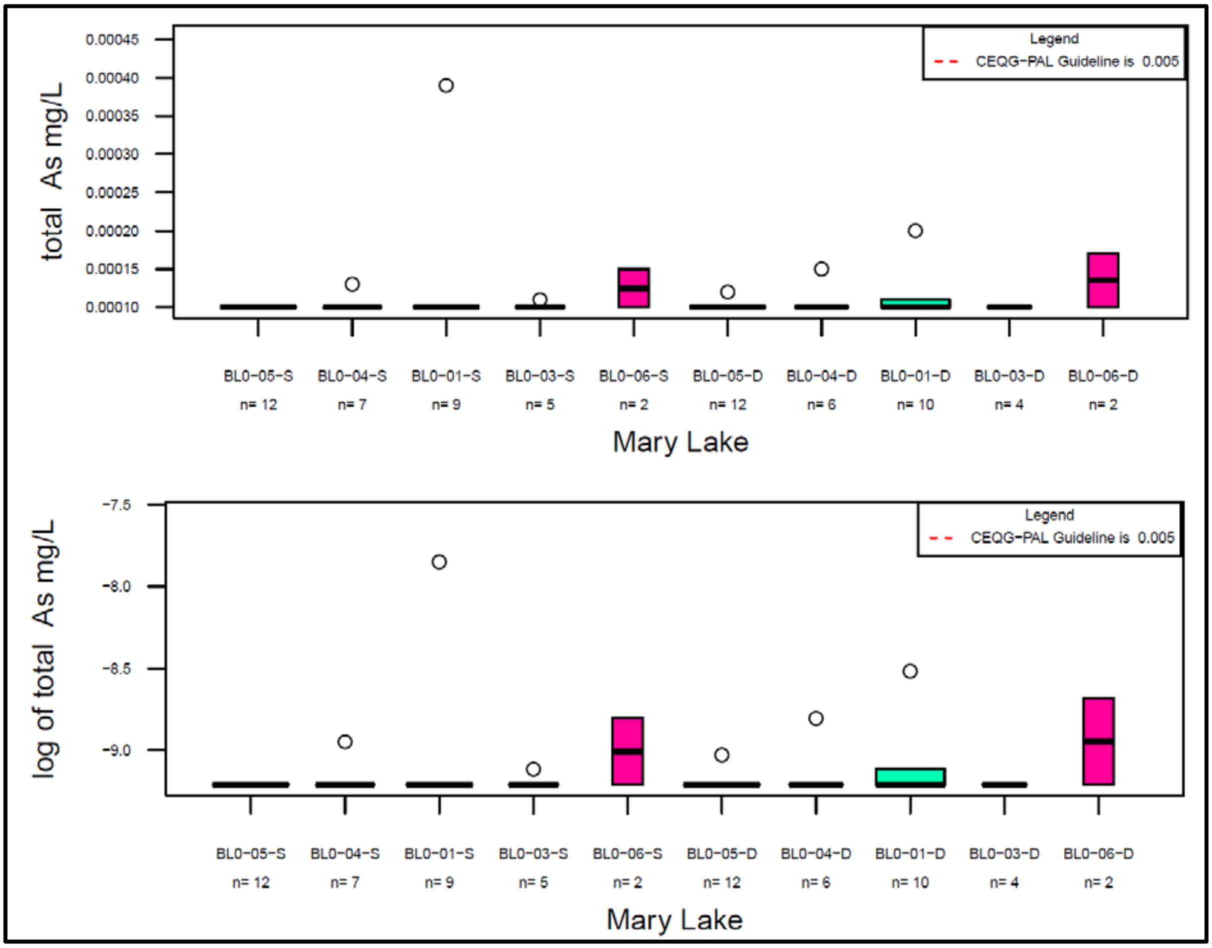
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

Figure 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.

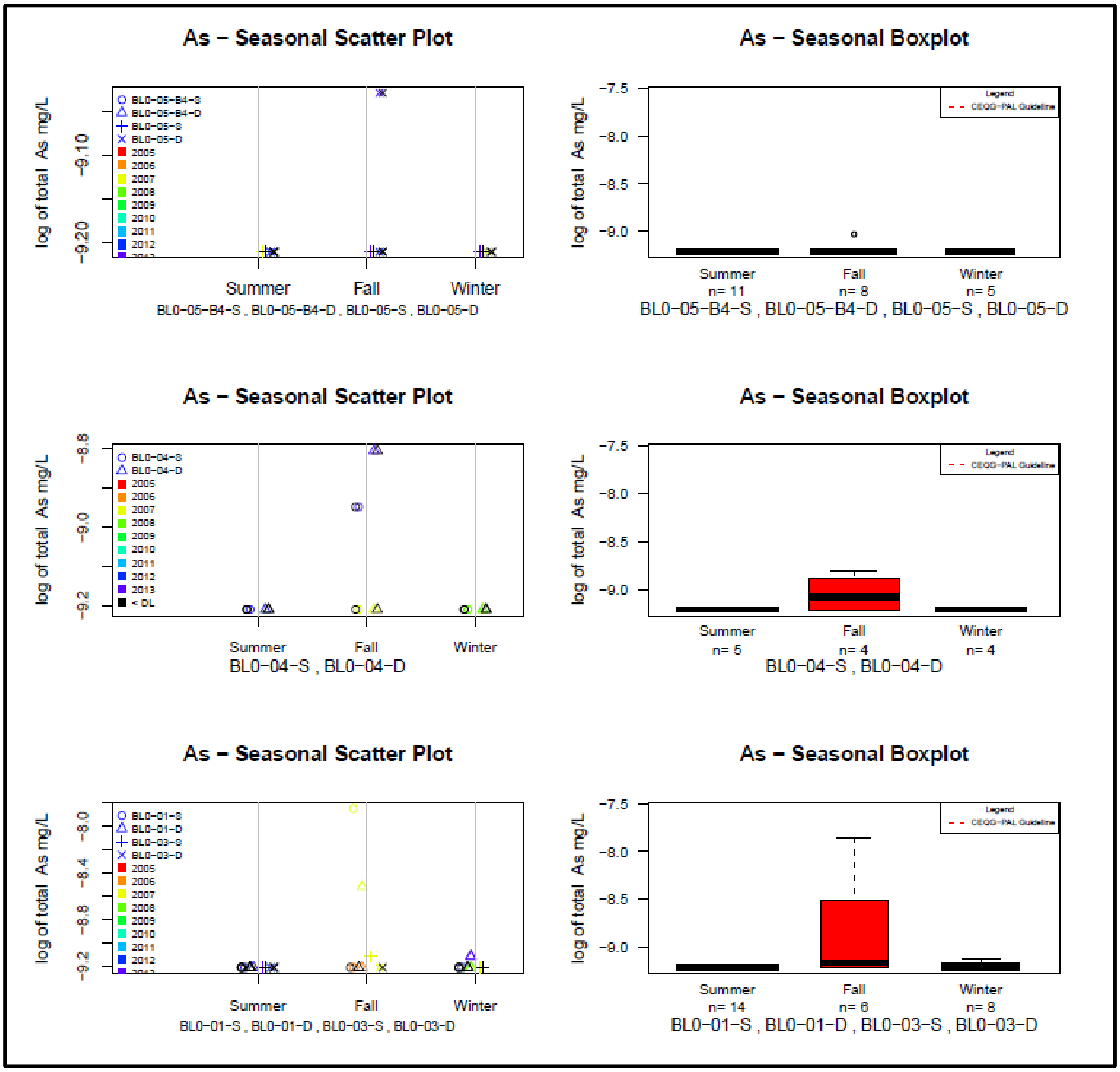


NOTES:

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.

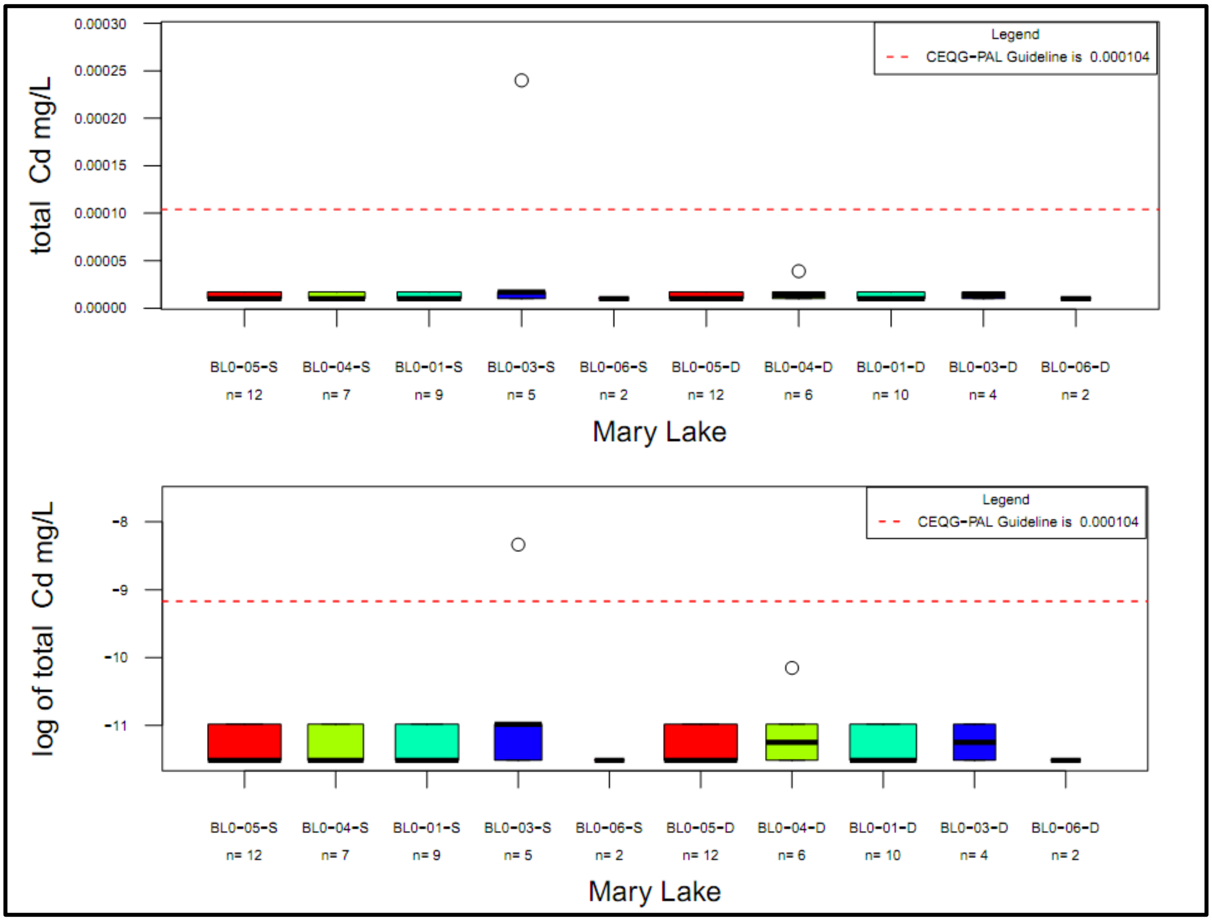
Figure B.61 Mary Lake – Variability of Total Arsenic in Water

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.

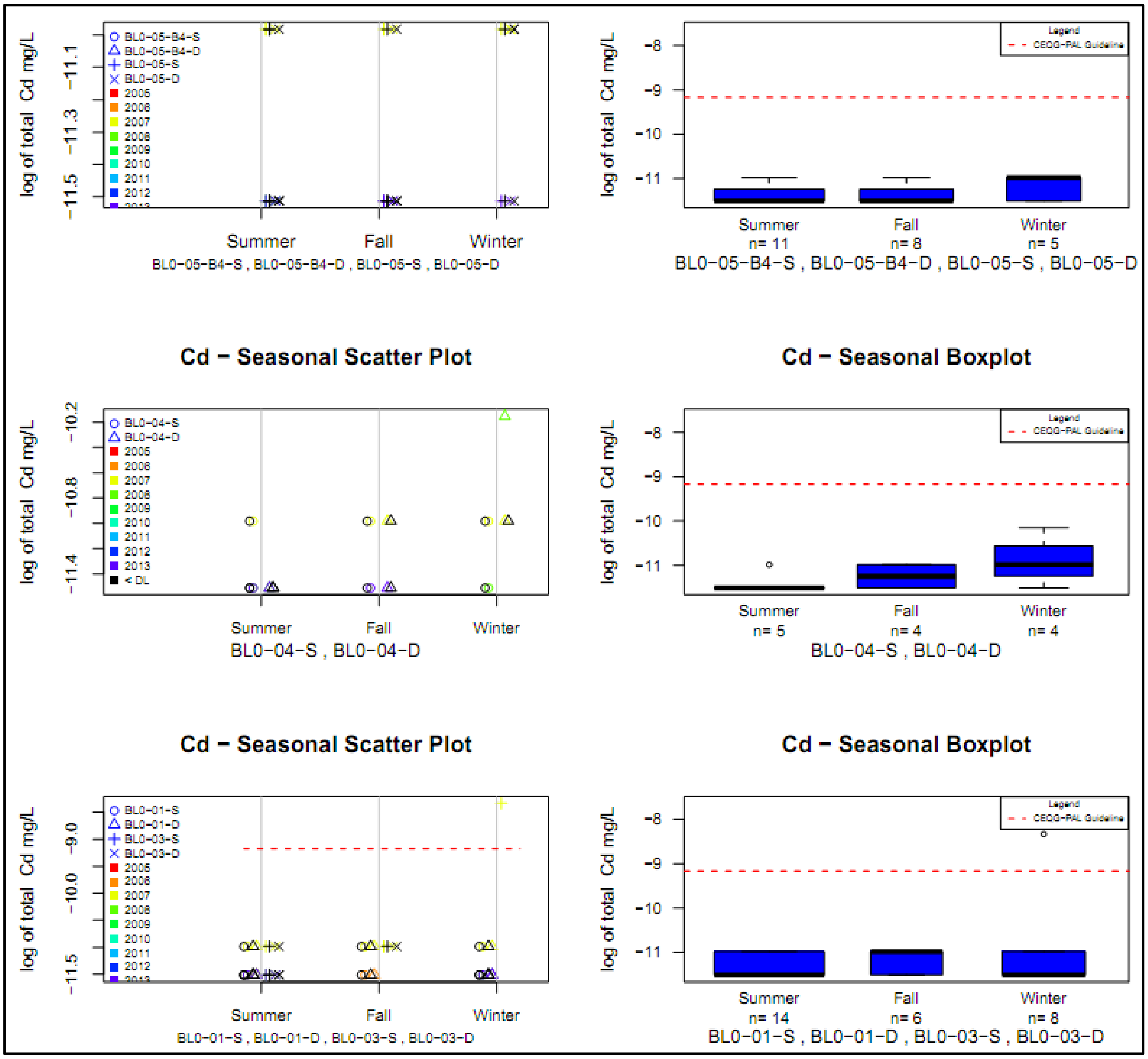
Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be utilized together to determine baseline trends (Figure B.63). Seasonal scatterplots indicate cadmium concentrations are slightly elevated in the winter, when compared to other seasons.



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



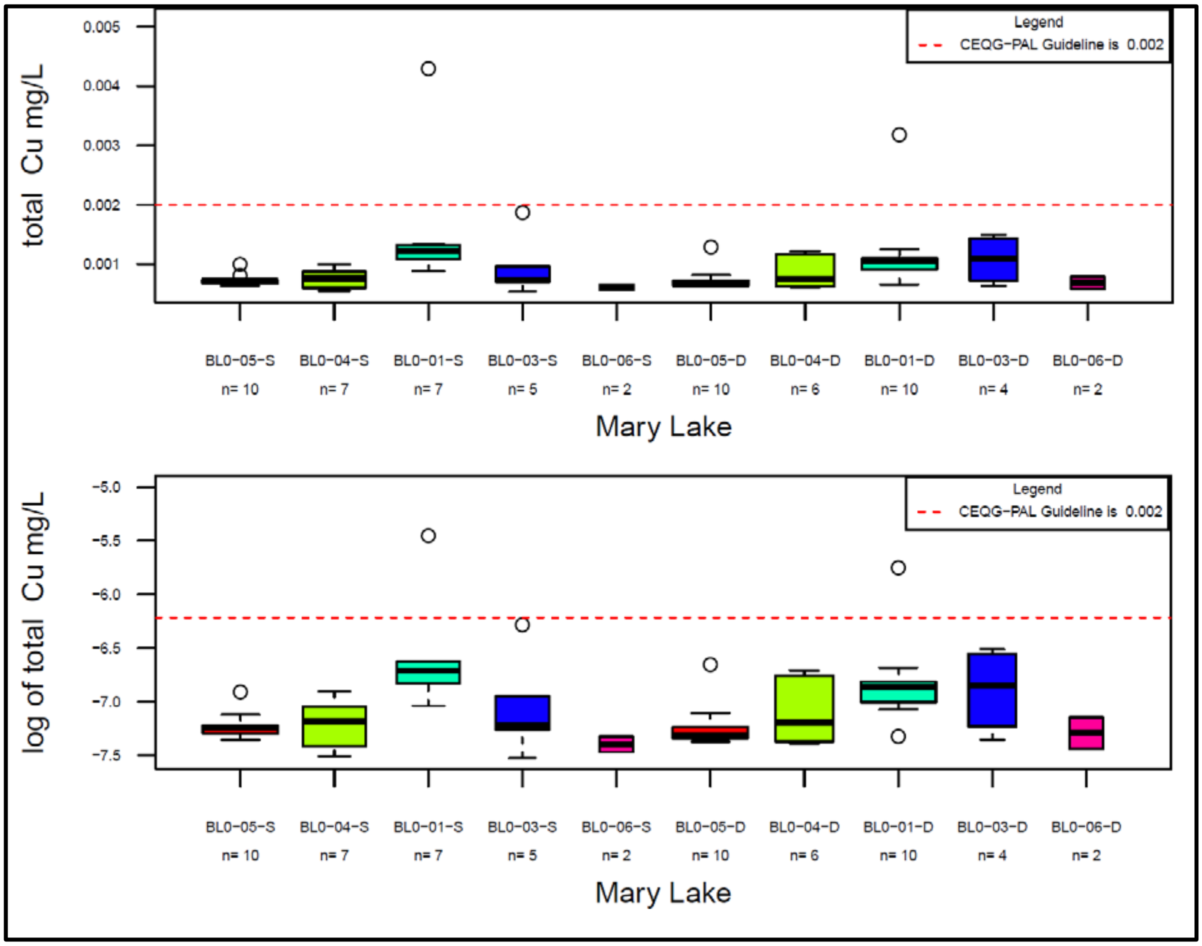
NOTES:

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.

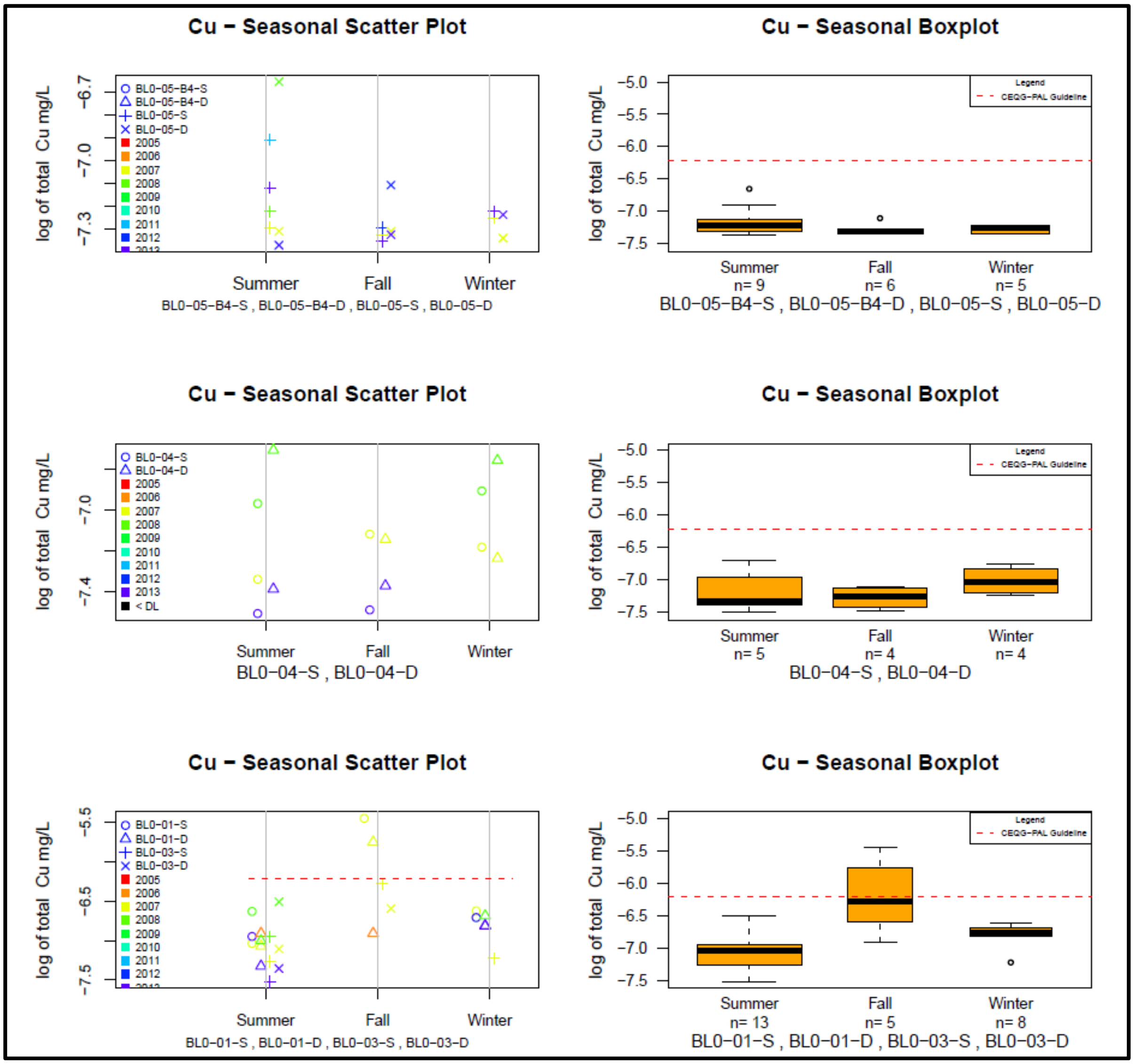


NOTES:

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:

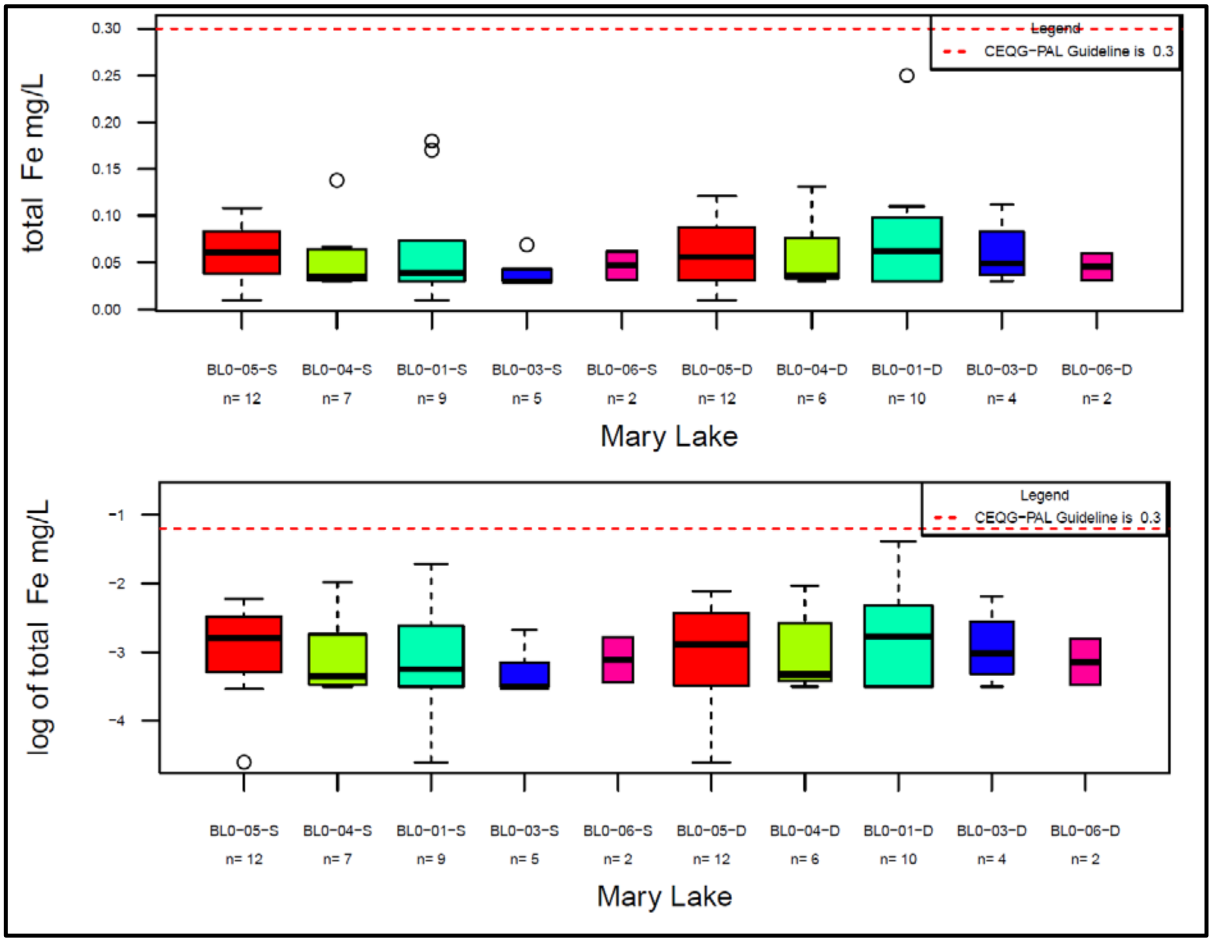
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

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.

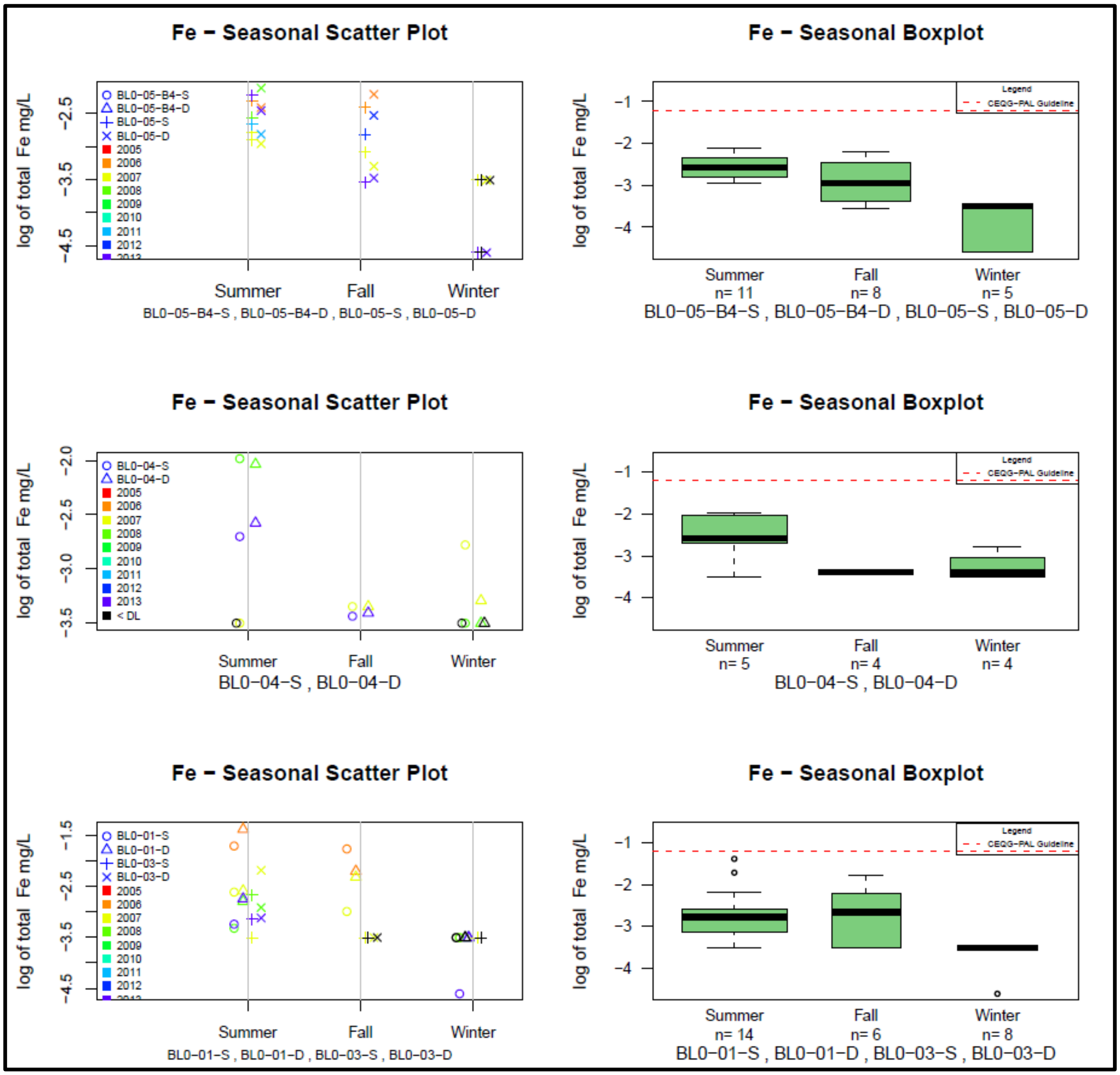
Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be utilized together to gain an understanding of baseline conditions (Figure B.67*)*. Seasonal boxplots indicate summer concentrations are typically elevated, when compared to winter concentrations. Concentration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

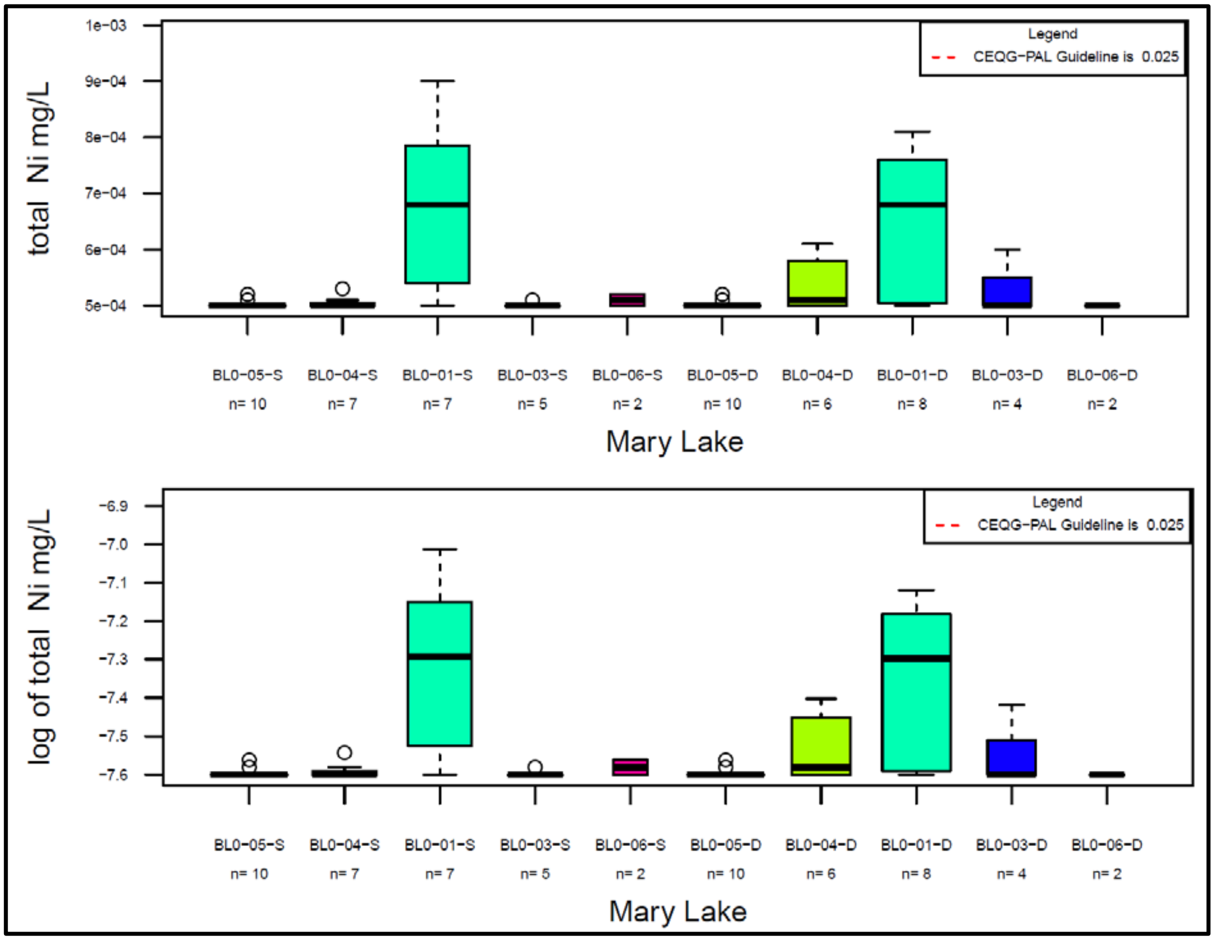
Figure B.67 Mary Lake – Variability of Total Iron in Water

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.

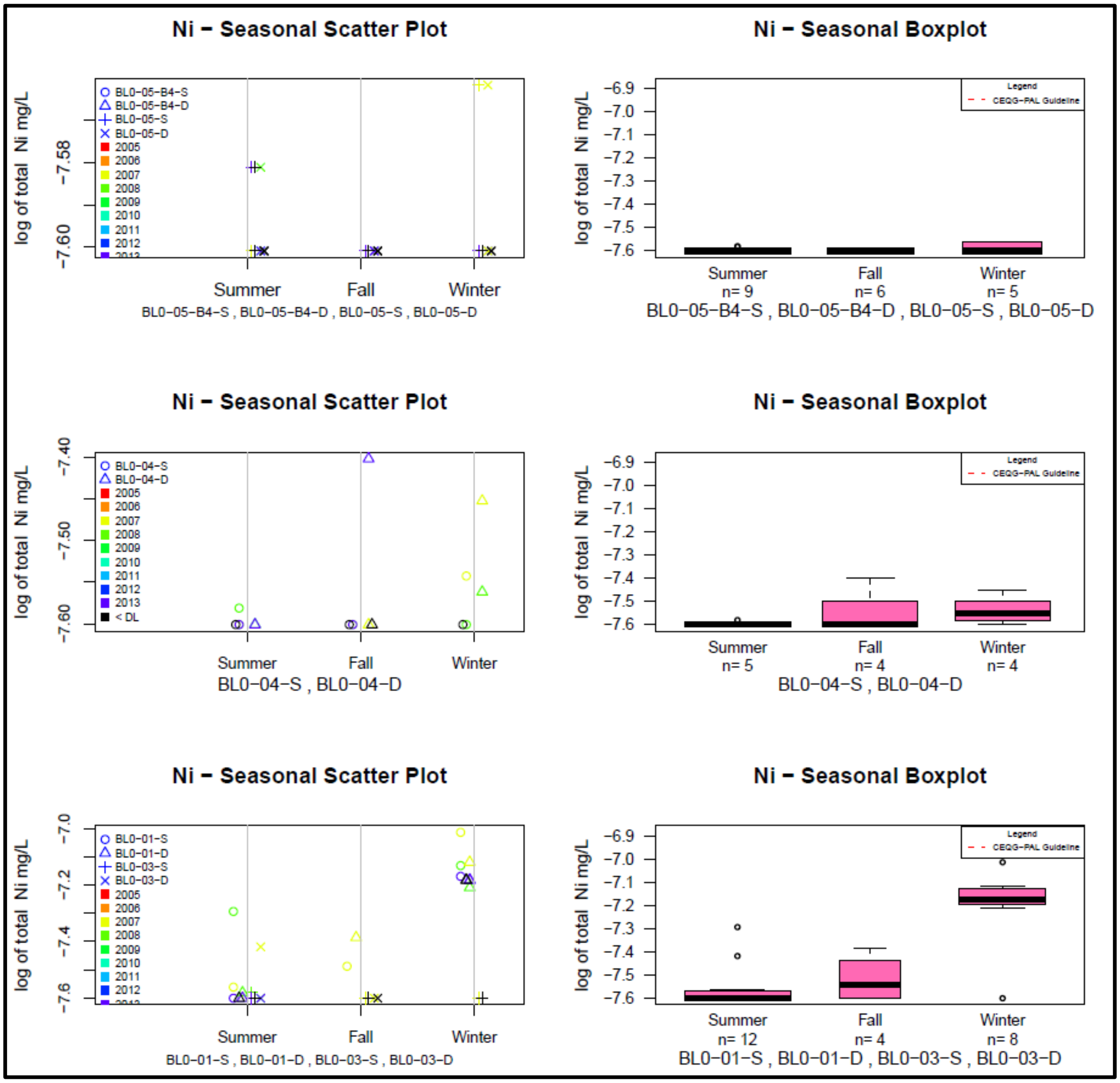
Seasonal scatterplots indicate shallow and deep sampling locations have similar data, and may be utilized en mass to determine overall baseline trends (Figure B.69). Seasonal boxplots indicate summer concentrations are typically depressed when compared to winter concentrations.



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:

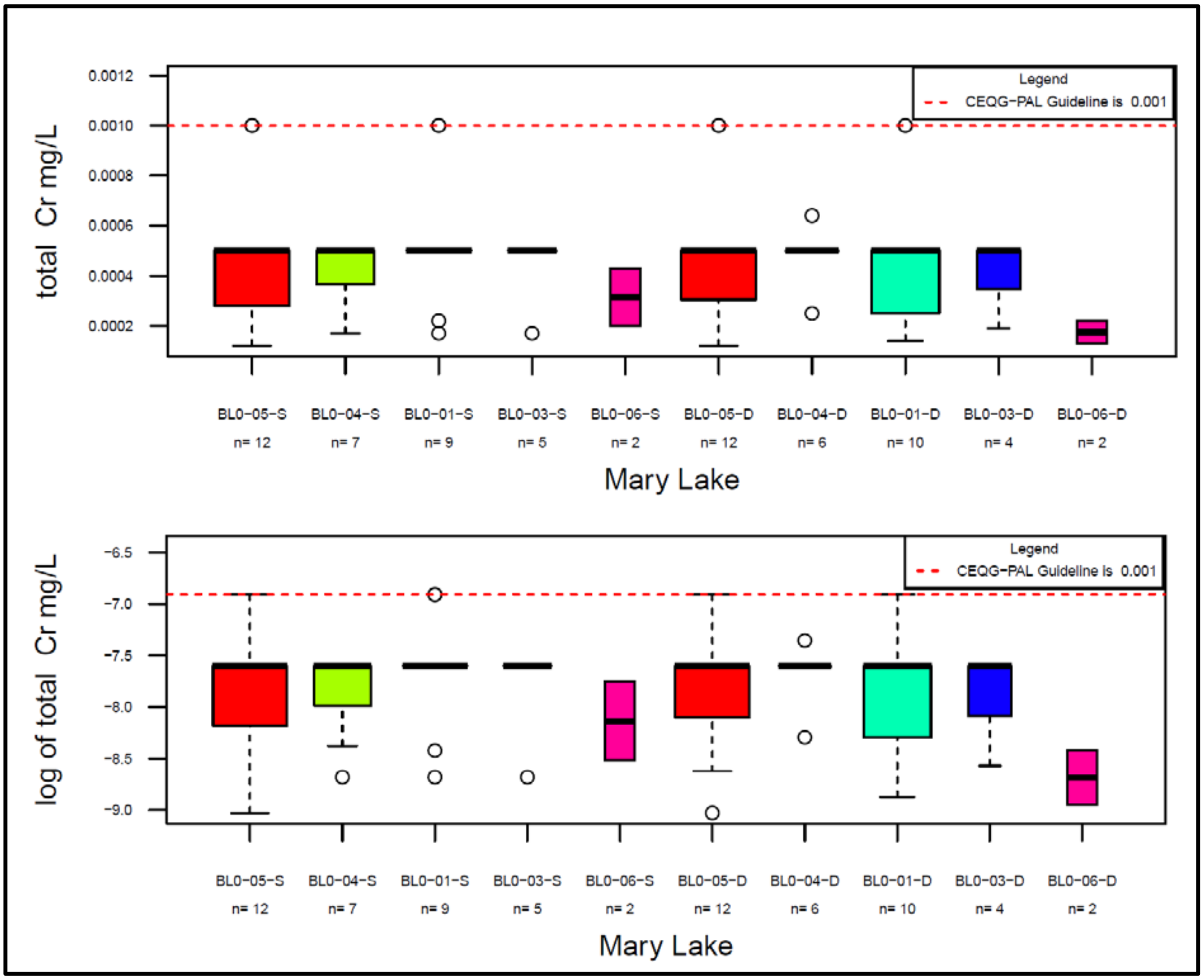
1. CONCENTRATIONS MEASURED AT OR BELOW DETECTION LIMIT ARE PRESENTED AT DETECTION LIMIT.
2. THE CWQG-PAL GUIDELINE LIMIT IS BASED ON THE TOTAL MEDIAN HARDNESS.

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.

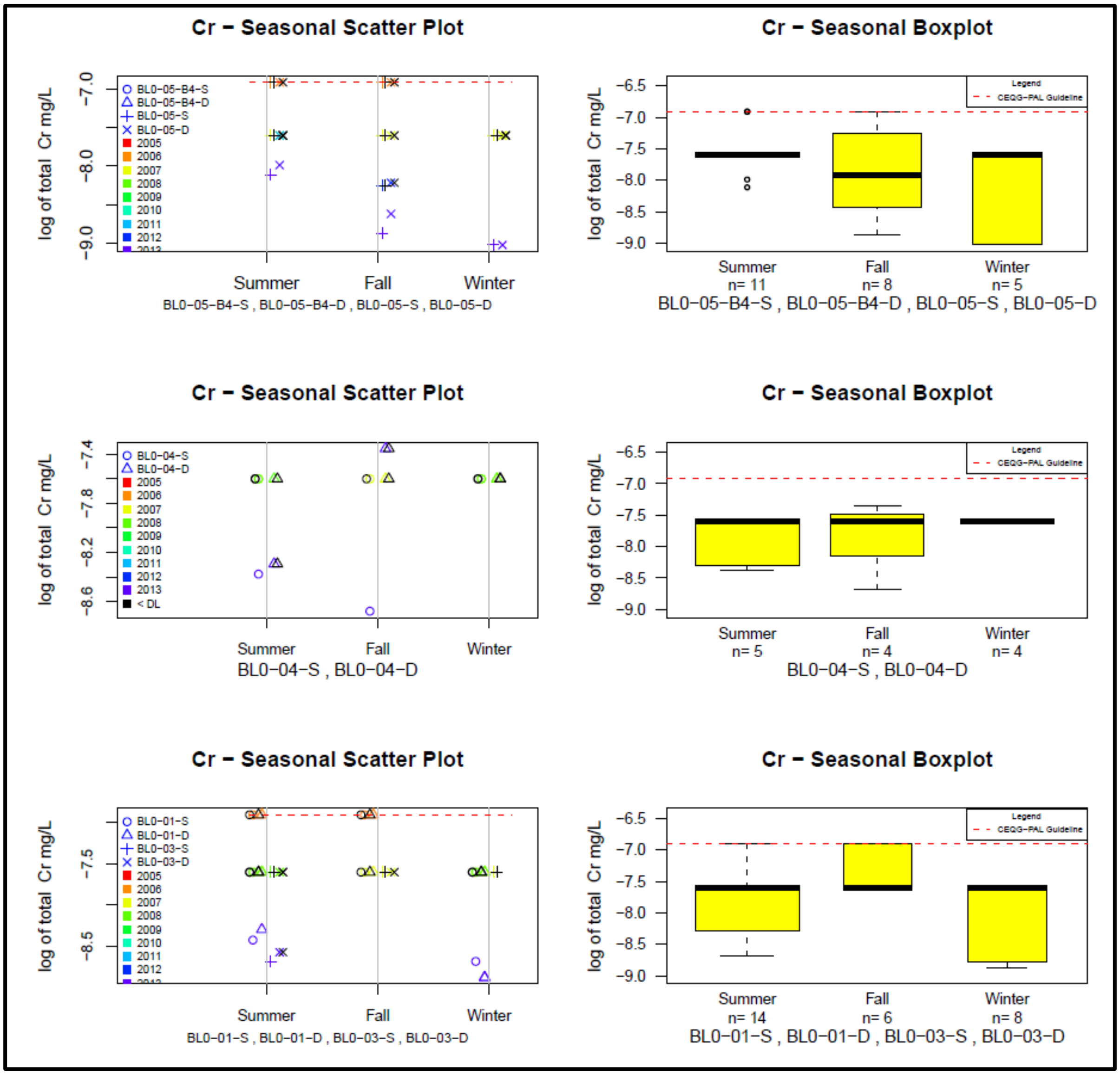
Seasonal scatterplots indicate show that detection limits are defined by applicable years (Figure B.71). Seasonal boxplots do not show any conserved trend throughout sites.



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

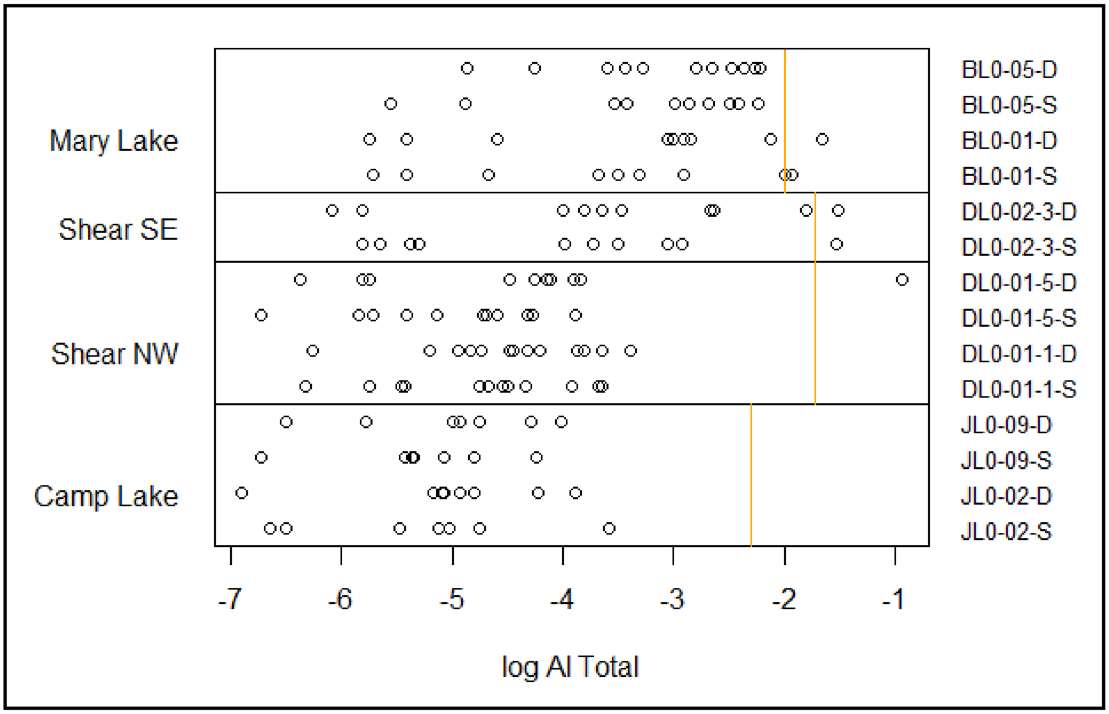
Parameter	Site	Waterbody	Power (given sample size of 10, alpha of 0.1)	Power (given sample size of 50)
Aluminum	DL0-02-3-S	Sheardown Lake SE	50%	78%
	BL0-01-S	Mary Lake	38%	58%
	BL0-05-S	Mary Lake	30%	58%
Copper	BL0-01-S	Mary Lake	30%	38%
Iron	BL0-01-S	Mary Lake	50%	75%

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

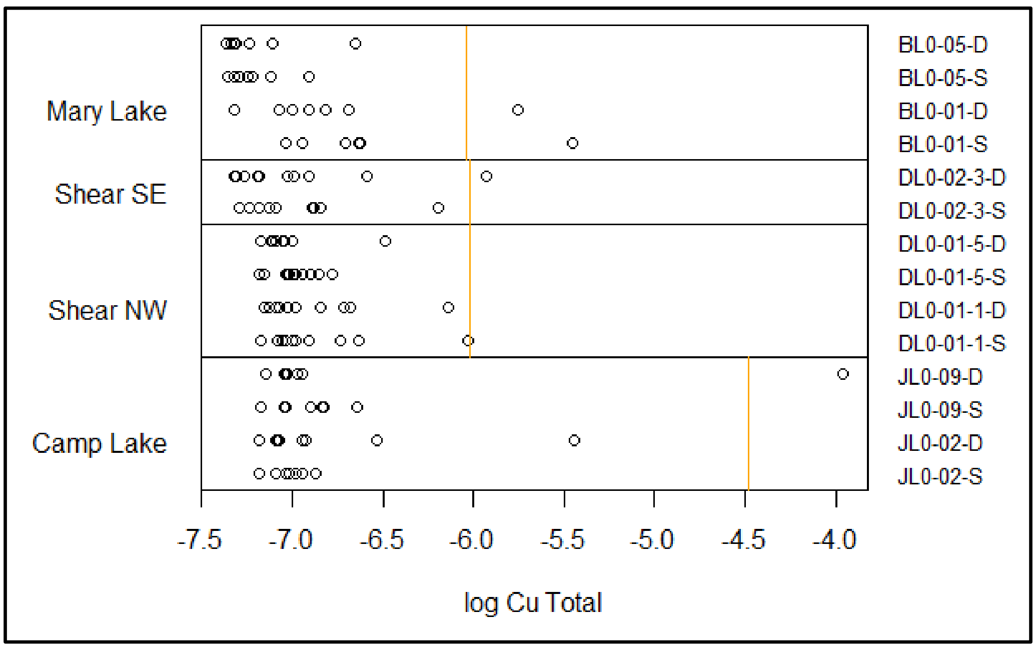
Station	Total Sample Size	Sample Size Detected	Median (mg/L)	Standard Deviation (mg/L)	Log Mean (mg/L)	Log Standard Deviation (mg/L)	ROS Log Mean (mg/L)	Benchmark Value (mg/L)	Log Benchmark Value (mg/L)	N Required	N Required (half benchmark)[1]
Camp Lake											
JL0-02-S	8	8	0.0063	0.01	-5.23	1.00	-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.

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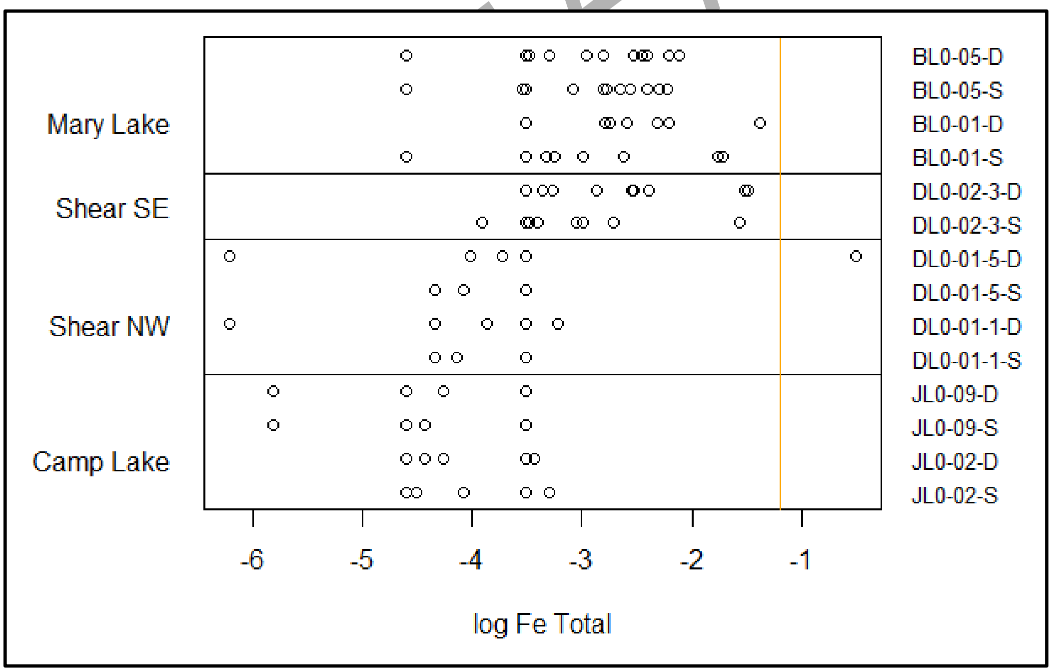
B.3.2.3 Iron

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.

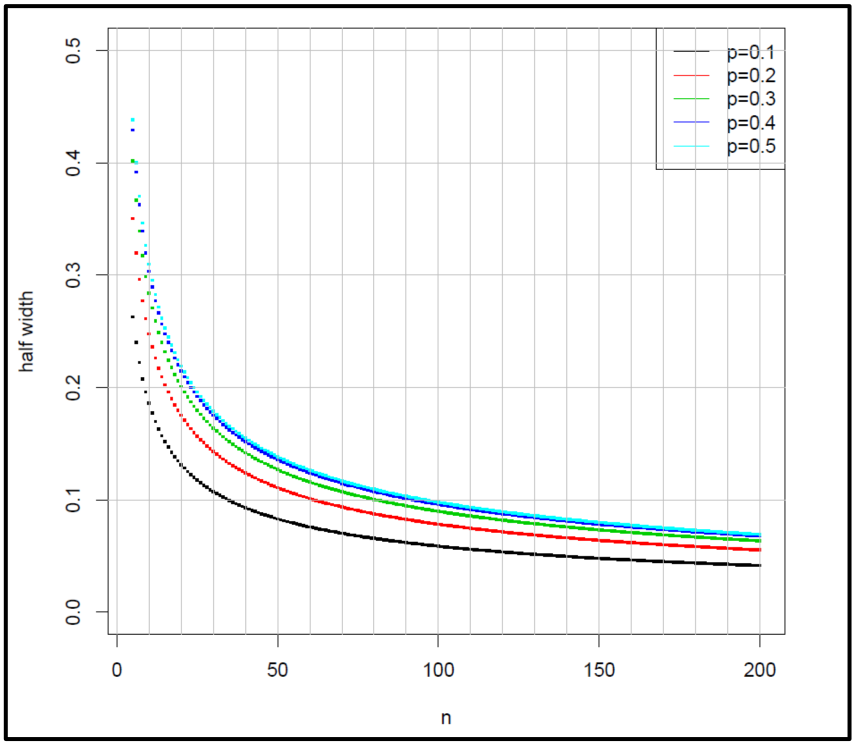
In order to assess statistical power to detect a change in the proportion of values below (or above) MDL from baseline to post-mining, we present a table of the sample sizes required. We see that a sample size of 12 is sufficient to show a change from 30% to 80%; a sample size of 8 is sufficient to show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

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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