

APPENDIX II

EFFLUENT AND WATER CHEMISTRY REPORT



GOLDER

**EFFLUENT AND WATER CHEMISTRY REPORT
IN SUPPORT OF THE 2019 AEMP ANNUAL REPORT
FOR THE DIAVIK DIAMOND MINE,
NORTHWEST TERRITORIES**

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April 2020
19115664/8000

Doc No. RPT-1915 Ver. 0
PO No. 3103966486



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Executive Summary

In 2019, Diavik Diamond Mines (2012) Inc. completed the field component of its Aquatic Effects Monitoring Program (AEMP) in Lac de Gras, Northwest Territories, as required by Water Licence W2015L2-0001, according to the *AEMP Design Plan Version 4.1* approved by the Wek'èezhì Land and Water Board. This report presents the analyses of effluent and water chemistry data collected during the 2019 AEMP field sampling, and from relevant stations in the Surveillance Network Program. The objective of the water quality monitoring component of the AEMP was to assess effects of the Diavik Diamond Mine (Mine) on water quality in Lac de Gras. Initial data analyses were completed to identify substances of interest (SOIs), which are a subset of variables with potential Mine-related effects.

Concentrations of regulated effluent variables were below applicable Water Licence effluent quality criteria in the 2019 monitoring period, and effluent toxicity testing indicated that the effluent was not toxic to aquatic life. Nearly all concentrations measured in samples collected at the mixing zone boundary were within the relevant AEMP water quality Effects Benchmarks for the protection of aquatic life and drinking water. No additional variables were added to the SOI list in 2019 based on the effluent and mixing zone screening results.

During the ice-cover season, elevated conductivity was measured in the bottom two-thirds of the water column in the near-field (NF) area, indicating the depth range where the effluent plume was located. Dissolved oxygen (DO) concentrations and pH values were usually greatest just below the ice and declined slightly with increasing depth. Water temperature increased gradually with depth at most stations and turbidity was typically uniform throughout the water column. During the open-water season, *in situ* water quality measurements for conductivity, DO, water temperature, pH, and turbidity profiles were typically uniform throughout the water column.

Three total manganese samples collected during the ice-cover season exceeded the AEMP Drinking Water Effects Benchmark. Laboratory pH values were below the Effects Benchmark in many samples; however, these occurrences were likely natural and unrelated to the Mine discharge. Concentrations of all variables in all other samples collected during the 2019 AEMP were below the relevant Effects Benchmarks for the protection of aquatic life and drinking water.

Water quality variables were assessed for a Mine-related effect in Lac de Gras according to Action Levels in the Response Framework. There are nine Action Levels defined in the Response Framework for water chemistry. Sixteen variables demonstrated an effect equivalent to Action Level 1 and included total dissolved solids (TDS), turbidity (lab), calcium, chloride, magnesium, sodium, sulphate, ammonia, nitrate, aluminum, barium, manganese, molybdenum, silicon, strontium, and uranium. With NF area median concentrations greater than two times the median concentrations in the reference dataset, these variables were identified as SOIs. No additional variables were added to the SOI list in 2019 based on the effluent screening results.

Of the 16 SOIs that triggered Action Level 1, nine also triggered Action Level 2 and included TDS, chloride, sodium, sulphate, ammonia, nitrate, molybdenum, strontium, and uranium. These variables had 5th percentile concentrations in the NF area that were greater than two times the median concentration in the reference dataset and were greater than the normal range for Lac de Gras.

None of the SOIs triggered Action Level 3.

Spatial trends of decreasing concentrations with distance from the Mine effluent discharge were evident for all 16 SOIs that triggered Action Levels 1 or 2 in 2019 based on a graphical and statistical evaluation of the data. An exception was turbidity, which had a significant decreasing trend along only one of three mid-field (MF) transects (i.e., MF1) during the open-water season. In addition, most of the SOIs had NF mean concentrations significantly greater than the 2019 far-field (FF) area mean concentrations. Overall, the results of these analyses provided confirmation that the increases observed in the NF area for these variables were related to the Mine effluent discharge.

Eleven SOIs (i.e., TDS, turbidity, calcium, chloride, sodium, sulphate, ammonia, nitrate, molybdenum, strontium, and uranium) also exceeded two times the median of the reference dataset at one or more of the four MF area stations located within the estimated zone of influence (ZOI) from dust deposition. Although some variables (i.e., turbidity, sodium, ammonia, strontium, and uranium) had slightly greater concentrations at one or two MF area stations within the ZOI compared to the NF median, nearly all MF station medians were less than the greatest NF station median, and spatial trends within the ZOI were consistent with effects originating from the Mine effluent. Overall, analysis of the water quality results in 2019 provided no clear evidence to suggest that Mine-related dust is affecting the water quality of Lac de Gras.

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- Attachment A 2019 AEMP Sampling Schedule
- Attachment B Quality Assurance and Quality Control Methods and Results
- Attachment C Initial Effluent and Water Quality Data Screening
- Attachment D 2019 Water Quality Raw Data – AEMP and SNP (SNP 1645-18/18B and SNP 1645-19)
- Attachment E 2019 Toxicity Testing Raw Data

Acronyms and Abbreviations

AEMP	Aquatic Effects Monitoring Program
AIC	Akaike's information criterion
AICc	Akaike's information criterion, corrected for small sample size
AL	Action Level
ALS	ALS Laboratories
ANOVA	Analysis of Variance
BC	British Columbia
BV Labs	Bureau Veritas Laboratories, formerly Maxxam Analytics
CaCO ₃	calcium carbonate
CFU	colony forming unit
CWQGs	Canadian Water Quality Guidelines
DDMI	Diavik Diamond Mines (2012) Inc.
DL	detection limit
DO	dissolved oxygen
DQO	data quality objective
EA	Environmental Assessment
EQC	effluent quality criteria
FF	far-field
Golder	Golder Associates Ltd.
HSD	honestly significant difference
IC	ice-cover
KW	Kruskal-Wallis
LDG	Lac de Gras
LDS	Lac du Sauvage
LLCF	Long Lake Containment Facility
Maxxam	Maxxam Analytics Inc.
MF	mid-field
Mine	Diavik Diamond Mine
NF	near-field
NIWTP	North Inlet Water Treatment Plant
OW	open-water
<i>P</i>	probability
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
SD	standard deviation
SNP	Surveillance Network Program
SOI	substance of interest
SOP	Standard Operating Procedure

TDS	total dissolved solids
WLWB	Wek'èezhìi Land and Water Board
ZOI	zone of influence

Symbols and Units of Measure

%	percent
°C	degrees Celsius
>	greater than
<	less than
≥	greater than or equal to
µg/L	micrograms per litre
µg-N/L	micrograms nitrogen per litre
µg-P/L	micrograms phosphorus per litre
µS/cm	microSiemens per centimetre
km	kilometre
km ²	square kilometre
m	metre
mg/L	milligrams per litre
mL	millilitre
NTU	nephelometric turbidity unit

1 INTRODUCTION

1.1 Background

In 2019, Diavik Diamond Mines (2012) Inc. (DDMI) completed the field component of its Aquatic Effects Monitoring Program (AEMP) for the Diavik Diamond Mine (Mine), as required by Water Licence W2015L2-0001 (WLWB 2015). This report presents the analysis of effluent and water chemistry data collected during the 2019 sampling year, which was carried out by Golder Associates Ltd. (Golder) according to the *AEMP Design Plan Version 4.1* (Golder 2017a).

AEMP Design Plan Version 4.1 (Golder 2017a) is the currently approved version of the AEMP design; however, a number of changes outlined in the proposed *AEMP Design Plan Version 5.1* (Golder 2019a) and in WLWB Directives (i.e., 28 August 2017, 24 January 2018, 25 March 2019, and 21 October 2019 Decision Packages) have been incorporated into the 2019 AEMP Annual Report, where relevant.

While the Mine effluent discharge is the main source of constituents to Lac de Gras and the most likely mechanism for effects in the receiving environment, the potential influence of other Mine sources (e.g., Mine-related dust deposition) on water quality in Lac de Gras are also considered herein. Water chemistry data for the Mine effluent and mixing zone boundary in Lac de Gras were obtained from the Surveillance Network Program (SNP) for the Mine, while water quality data in Lac de Gras were collected as part of AEMP field programs, which were carried out by DDMI staff according to the *AEMP Design Plan Version 4.1* (Golder 2017a) and the associated *Quality Assurance Project Plan Version 3.1* (QAPP; Golder 2017b).

1.2 Objectives

The overall objective of the water quality monitoring component of the AEMP is to assess the effects of the Mine on water quality in Lac de Gras. Water chemistry data were analyzed to determine whether there were differences in water quality between areas exposed to Mine-related inputs and reference conditions for Lac de Gras (as defined in the *AEMP Reference Conditions Report Version 1.4* [Golder 2019b]) and to evaluate spatial trends in water quality in Lac de Gras.

1.3 Scope and Approach

The 2019 AEMP water quality survey in Lac de Gras was carried out according to the requirements specified in the *AEMP Design Plan Version 4.1* for a comprehensive monitoring year (Golder 2017a). The objective of the annual report for a comprehensive year is to assess effects on water quality in Lac de Gras by evaluating whether an Action Level has been triggered. A second objective is to provide a spatial analysis of effects, which consisted of evaluating trends in water quality variables in relation to the diffusers in Lac de Gras and by comparing concentrations in the near-field (NF) and far-field (FF) areas in Lac de Gras. A summary of variables concentrations in the Mine effluent and at the mixing zone boundary in Lac de Gras is also provided, including seasonal variation. Temporal analyses and an assessment of trends over time are provided in Aquatic Effects Re-evaluation Reports rather than in annual reports.

Water quality variables were assessed for a Mine-related effect according to Action Levels described in the *AEMP Design Plan Version 4.1* (Golder 2017a). The magnitude, extent, and importance of effects are defined in the Action Level criteria. Field measurements (i.e., depth profile data) are discussed qualitatively herein, and nutrients (i.e., phosphorus and nitrogen) are evaluated in the Eutrophication Indicators Report (Appendix XIII).

The results of the water quality Action Level screening were used in combination with an assessment of effluent and mixing zone chemistry and potential effects from dust deposition from the Mine to identify a subset of variables with potential Mine-related effects, referred to as substances of interest (SOIs). The intent of defining SOIs was to identify a meaningful set of variables for further analyses, while limiting analyses for variables that were less likely to be affected by the Mine.

Water quality variables within Lac de Gras were assessed for the presence of spatial trends with distance from the Mine-effluent diffusers, and in relation to stations located within the estimated zone of influence (ZOI) from dust deposition. Statistical analysis in the form of linear regressions along the mid-field (MF) transects were completed for SOIs that triggered Action Levels. The SOIs were also compared statistically between the NF area and the FF areas. The FF areas in Lac de Gras have now become exposed to a low concentration of Mine effluent and represent the least exposed areas of the lake (Golder 2019c).

In-water construction work was not completed and dewatering flows were not discharged directly to Lac de Gras during the 2019 reporting period. Therefore, an assessment of effects from these potential Mine-sources was not required in 2019.

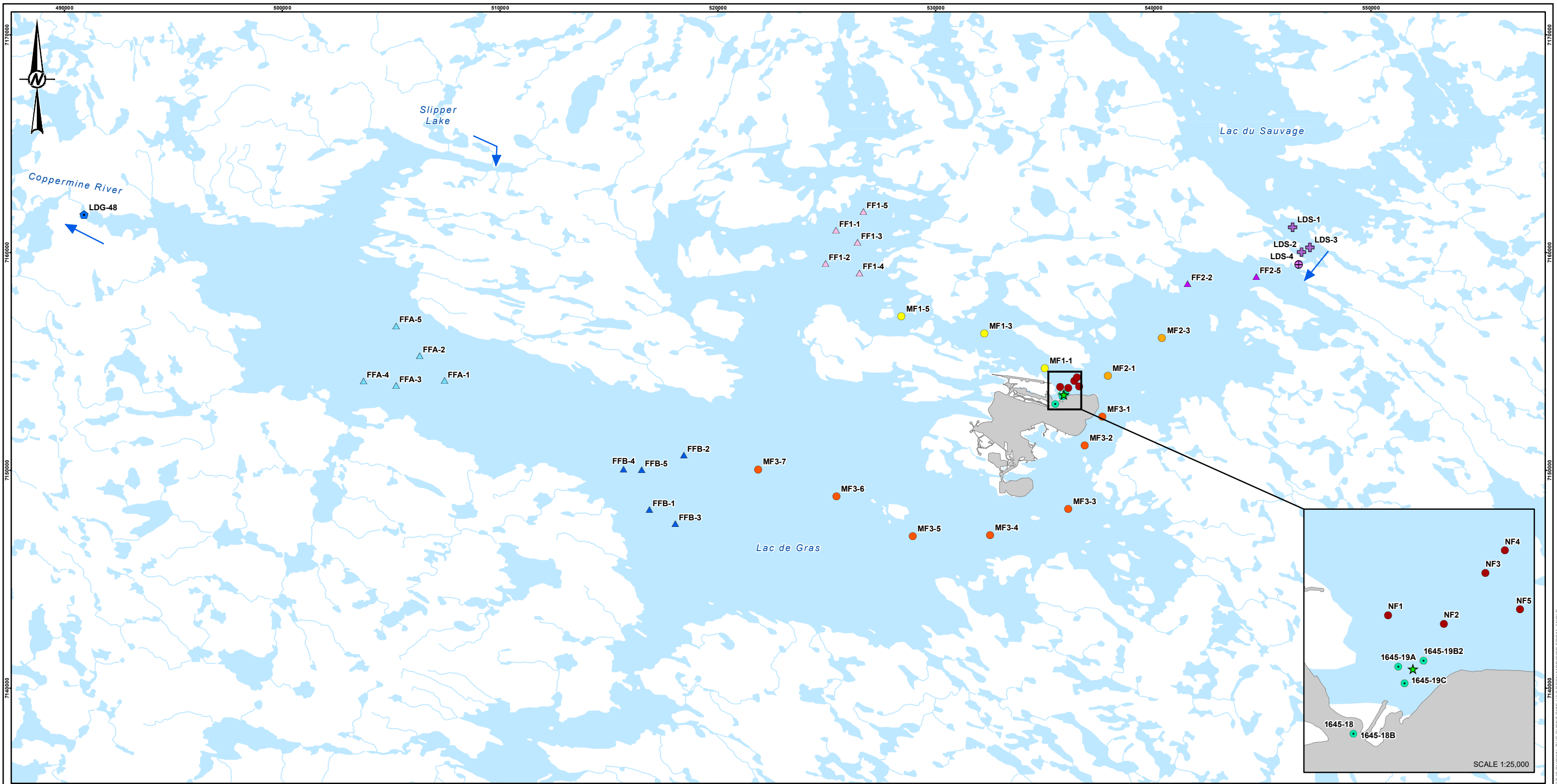
2 METHODS

2.1 Field Sampling

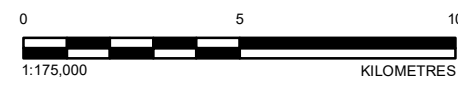
The 2019 water quality field sampling program included *in situ* water quality measurements and collection of water samples for chemical analysis. The *in situ* water column profile measurements were taken at AEMP stations using a multi-parameter water quality meter (YSI) following the methods described in DDMI's Standard Operating Procedure (SOP) ENVI-684-0317 "SOP YSI ProDSS". Collection of water samples followed the protocols described in ENVI-923-0119 "AEMP SOP Combined Open-water and Ice-cover Sampling". Water samples were handled according to ENVI-902-0119 "SOP Quality Assurance Quality Control" and ENVI-900-0119 "SOP Chain of Custody".

Effluent and water quality data collected in support of the Mine's SNP were incorporated herein. Data were summarized for the period of effluent discharge from 1 November 2018 to 31 October 2019. Treated effluent from the NIWTP was sampled from both diffusers; SNP 1645-18 is the original diffuser station in Lac de Gras, and SNP 1645-18B is the second diffuser station, which became operational in September 2009 (Figure 2-1). Both diffusers discharged continuously to Lac de Gras throughout the 2019 monitoring period. Sampling was completed approximately every six days at each discharge point. The 20 December 2018 results from 1645-18 and 1645-18B are not available as samples were lost by the laboratory while in transit (DDMI 2019).

Water quality sampling at the mixing zone boundary was completed at three stations (i.e., SNP 1645-19A, SNP 1645-19B2, SNP 1645-19C), which are located along a semi-circle, approximately 60 m from the effluent diffusers (Figure 2-1). These stations represent the edge of the mixing zone, which covers an area of approximately 0.01 km². Sampling at the mixing zone boundary occurred monthly at the water surface (2 m depth) and at 5 m depth intervals (5, 10, 15, and 20 m depth) at each station for the duration of the 2019 monitoring period. Sampling did not occur during the months of November 2018 and June 2019 when conditions were unsafe due to ice-on and ice-off.



- LEGEND**
- ★ DIFFUSERS
 - SURVEILLANCE NETWORK PROGRAM
 - ▲ FAR-FIELD 1
 - ▲ FAR-FIELD 2
 - ▲ FAR-FIELD A
 - ▲ FAR-FIELD B
 - ◆ LAC DE GRAS OUTLET
 - ⊕ LAC DU SAUVAGE
 - ⊕ LAC DU SAUVAGE OUTLET
 - MID-FIELD 1
 - MID-FIELD 2
 - MID-FIELD 3
 - NEAR-FIELD
 - ➔ FLOW DIRECTION
 - WATERCOURSE
 - DIAVIK FOOTPRINT
 - WATERBODY



REFERENCE(S)
 HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
 PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT	RioTinto	
CONSULTANT	YYYY-MM-DD	2020-04-28
	DESIGNED	LJ
	PREPARED	LMS
	REVIEWED	LJ
	APPROVED	ZK

PROJECT	DIAVIK DIAMOND MINES INC.		
TITLE	LOCATIONS OF AEMP WATER QUALITY SAMPLING STATIONS, 2019		
PROJECT NO.	PHASE	REV.	FIGURE
19115664	8000	0	2-1

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Water quality sampling at AEMP stations in 2019 was carried out according to the sampling design for a comprehensive year AEMP, which includes sampling in the NF and MF areas as well as the FF areas of the lake (Golder 2017a).

In total, water quality samples were collected at 39 stations in 2019 (Figure 2-1). Sampling occurred at a cluster of five replicate stations in the NF area (i.e., NF1 to NF5), multiple stations located along transects in the MF areas (i.e., MF1, MF2-FF2, and MF3) and three FF areas (i.e., FF1, FFA, and FFB). Three stations were located within the MF1 area (i.e., MF1-1, MF1-3, MF1-5), four stations in the MF2-FF2 area (i.e., MF2-1, MF2-3, FF2-2, FF2-5), and seven stations within the larger MF3 area (i.e., MF3-1 to MF3-7). Five stations were sampled in each of the three FF areas. The NF, MF, and FF stations were approximately 20 m deep. Additional stations were sampled at the Lac de Gras outflow to the Coppermine River (LDG-48), in Lac du Sauvage (LDS-1, LDS-2, LDS-3), and the Lac du Sauvage outflow to Lac de Gras (LDS-4). Coordinates of the AEMP stations, and their approximate distance from the Mine effluent diffusers along the most direct flow path are provided in Table 2-1.

The 2019 AEMP water quality sampling was carried out over two monitoring seasons: ice-cover and open-water. Ice-cover season (i.e., late winter) sampling was completed from 22 April to 10 May 2019. Open-water sampling was completed from 15 August to 5 September 2019. The same locations were sampled in each season, with the exception of LDS-4, which was sampled in the open-water season only. A detailed sampling schedule for the 2019 AEMP is provided in Attachment A, Table A-1.

Stations in the NF and MF areas were sampled at three depths (i.e., top, middle, and bottom) during each season, as these stations were likely to have vertical gradients in water quality due to the Mine discharge. Near-surface water samples (top) were collected at a depth of 2 m below the water surface, and bottom samples were collected at a depth of 2 m above the lake bottom. Mid-depth samples were collected from the mid-point of the total water column depth. Stations in the FF areas (i.e., FF1, FFA, and FFB) and stations LDG-48, LDS-1, LDS-2, LDS-3, and LDS-4 were sampled at mid-depth only.

2.2 Laboratory Analysis

Water samples were shipped to Bureau Veritas Laboratories (BV Labs; formerly Maxxam Analytics) in Burnaby, British Columbia (BC), or Calgary, Alberta (AB), Canada for analysis of general parameters, major ions, nutrients and total metals¹. In 2019, analysis of water samples for ammonia was conducted by both BV Labs in Burnaby or Calgary, and ALS Laboratories (ALS) in Vancouver, BC, Canada. A list of the variables analyzed by BV Labs in 2019 is provided in Table 2-2.

Laboratory detection limits (DLs) represent the lowest concentration of a substance that can be reliably measured by the analytical laboratory. The target DLs for the AEMP are defined in the *AEMP Design Plan Version 4.1* (Golder 2017a) and are summarized in Table 2-2. Deviations from the target DLs and a discussion of potential effects on data quality are discussed in Attachment B.

¹ The term metal is used throughout this report and includes non-metals (i.e., selenium) and metalloids (i.e., arsenic).

Table 2-1 Locations of the 2019 AEMP Water Quality Monitoring Stations

Area	Station	UTM Coordinates		Distance from Diffusers ^(a) (m)
		Easting	Northing	
NF	NF1	535740	7153854	394
	NF2	536095	7153784	501
	NF3	536369	7154092	936
	NF4	536512	7154240	1,131
	NF5	536600	7153864	968
MF1	MF1-1	535008	7154699	1,452
	MF1-3	532236	7156276	4,650
	MF1-5	528432	7157066	8,535
MF2	MF2-1	538033	7154371	2,363
	MF2-3	540365	7156045	5,386
FF2	FF2-2	541588	7158561	8,276
	FF2-5	544724	7158879	11,444
MF3	MF3-1	537645	7152432	2,730
	MF3-2	536816	7151126	4,215
	MF3-3	536094	7148215	7,245
	MF3-4	532545	7147011	11,023
	MF3-5	528956	7146972	14,578
	MF3-6	525427	7148765	18,532
	MF3-7	521859	7150039	22,330
FF1	FF1-1	525430	7161043	13,571
	FF1-2	524932	7159476	12,915
	FF1-3	526407	7160492	12,788
	FF1-4	526493	7159058	11,399
	FF1-5	526683	7161824	12,823
FFB	FFB-1	516831	7148207	26,355
	FFB-2	518473	7150712	24,991
	FFB-3	518048	7147557	25,245
	FFB-4	515687	7150036	27,591
	FFB-5	516533	7150032	26,761
FFA	FFA-1	506453	7154021	36,769
	FFA-2	506315	7155271	38,312
	FFA-3	505207	7153887	38,734
	FFA-4	503703	7154081	40,211
	FFA-5	505216	7156657	39,956
Outlet of Lac de Gras	LDG-48	490900	7161750	55,556
Lac du Sauvage	LDS-1	546398	7161179	(b)
	LDS-2	546807	7160027	(b)
	LDS-3	547191	7160256	(b)
Outlet of Lac du Sauvage	LDS-4	546702	7159479	(b)

a) Approximate distance from the Mine effluent diffusers along the most direct path of effluent flow.

b) Distance not shown as the station is located upstream of Lac de Gras.

UTM = Universal Transverse Mercator, NAD83, Zone 12V; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Table 2-2 Detection Limits for Water Quality Analysis, 2019

Variable	Unit	Detection Limit ^(a)
Conventional Parameters		
Total alkalinity as CaCO ₃	mg/L	0.5
Specific conductivity – lab	µS/cm	1
Total hardness as CaCO ₃	mg/L	0.5
pH – lab	pH units	-
Total dissolved solids, calculated	mg/L	-
Total dissolved solids, measured	mg/L	1
Total suspended solids	mg/L	1
Total organic carbon	mg/L	0.2
Turbidity – lab	NTU	0.1
Major Ions		
Bicarbonate	mg/L	0.5
Calcium (dissolved)	mg/L	0.01
Carbonate	mg/L	0.5
Chloride	mg/L	0.5
Fluoride	mg/L	0.01
Hydroxide	mg/L	0.5
Magnesium (dissolved)	mg/L	0.005
Potassium (dissolved)	mg/L	0.01
Sodium (dissolved)	mg/L	0.01
Sulphate	mg/L	0.5/0.05 ^(b)
Nutrients		
Ammonia	µg-N/L	5
Nitrate	µg-N/L	2
Nitrite	µg-N/L	1
Nitrate + nitrite	µg-N/L	2
Total Kjeldahl nitrogen	µg-N/L	20
Total dissolved nitrogen	µg-N/L	20
Total nitrogen	µg-N/L	20
Soluble reactive phosphorus	µg-P/L	1
Total dissolved phosphorus	µg-P/L	2
Total phosphorus	µg-P/L	2
Total Metals		
Aluminum	µg/L	0.2
Antimony	µg/L	0.02
Arsenic	µg/L	0.02
Barium	µg/L	0.02
Beryllium	µg/L	0.01
Bismuth	µg/L	0.005
Boron	µg/L	5
Cadmium	µg/L	0.005
Calcium	mg/L	0.01
Chromium	µg/L	0.05
Cobalt	µg/L	0.005
Copper	µg/L	0.05
Iron	µg/L	1
Lead	µg/L	0.005
Lithium	µg/L	0.5
Magnesium	mg/L	0.005
Manganese	µg/L	0.05
Mercury	µg/L	0.002
Molybdenum	µg/L	0.05
Nickel	µg/L	0.02
Potassium	mg/L	0.01
Selenium	µg/L	0.04
Silicon	µg/L	50
Silver	µg/L	0.005
Sodium	mg/L	0.01
Strontium	µg/L	0.05
Sulphur	mg/L	0.5/0.1 ^(b)
Thallium	µg/L	0.002
Tin	µg/L	0.01
Titanium	µg/L	0.5
Uranium	µg/L	0.002
Vanadium	µg/L	0.05
Zinc	µg/L	0.1
Zirconium	µg/L	0.05

a) Detection limits for a subset of samples (n = 184; 1.2%) were raised in 2019; details and a discussion of potential effects on data quality are provided in Attachment B.

b) Samples for sodium and sulphur were analyzed using either inductively coupled plasma-mass spectrometry (ICP-MS) or inductively coupled plasma atomic emission spectroscopy (ICP-OES). Samples with reported concentrations that were less than the DL for the ICP-MS method were analyzed using ICP-OES at a lower DL, to improve the sensitivity of the reported results. A discussion of potential effects on data quality is provided in Attachment B.

µS/cm = microsiemens per centimetre; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; µg-P/L = micrograms phosphorus per litre; CaCO₃ = calcium carbonate.

2.3 Data Analysis

2.3.1 Overview and Substances of Interest

Initial data analyses were completed to identify SOIs (i.e., a subset of variables with the potential to show Mine-related effects). The criteria used to select SOIs are defined in the *AEMP Design Plan Version 4.1* (Golder 2017a) and are summarized as follows:

- *Criterion 1:* effluent chemistry data collected at SNP 1645-18 and SNP 1645-18B were compared to EQC defined in the Water Licence (i.e., Sections 2.3.4.2 and 3.2.4). Variables with concentrations in individual grab samples greater than EQC for the Maximum Average Concentration (Table 2-4) were included as SOIs.
- *Criterion 2:* variables with concentrations at the mixing zone boundary (i.e., SNP 1645-19A, SNP 1645-19B2, SNP 1645-19C) that exceeded AEMP Effects Benchmarks (Table 2-5; Sections 2.3.4.3 and 3.2.5) were included in the SOI list, provided there was not a large percentage of values below the DL (greater than 90%).
- *Criterion 3:* water quality variables were assessed according to Action Levels in the Response Framework (Sections 2.3.6.1 and 3.4). Variables that triggered Action Level 1 in the NF area were added to the SOI list. Action Level 1 involves identifying if the median of the NF area is greater than two times the median of the reference dataset, together with strong evidence of a link to the Mine.
- *Criterion 4:* variables that triggered an effect equivalent to Action Level 1 at individual MF area stations that fall within the ZOI from dust deposition in Lac de Gras (i.e., within approximately 1.5 km of the Mine boundary: MF1-1, MF2-1, MF3-1 and MF3-2) were added to the SOI list (Sections 2.3.6.4 and 3.7).

Water quality variables analyzed in 2019 (Table 2-2) were initially evaluated for inclusion as SOIs against the above noted four criteria, with the exception of the following analytes or variables:

- dissolved oxygen (DO), temperature, pH, and specific conductivity (i.e., variables associated with *in situ* water column profile measurements) which are assessed in Section 3.3; DO and pH were compared to EQC and/or Effects Benchmarks, as appropriate
- carbonate and hydroxide, which are not detected at the pH range encountered in Lac de Gras
- bicarbonate, which is redundant with total alkalinity and not a parameter of toxicological concern
- hardness, which is integrated into the calculation of Effects Benchmarks for certain parameters (e.g., copper, lead, nickel), but is not a parameter of toxicological concern itself
- nutrients that are generally not toxic to aquatic organisms (i.e., phosphorus and some forms of nitrogen), which are evaluated in the Eutrophication Indicators Report (Appendix XIII)
- nitrate + nitrite, which was evaluated separately as nitrate and nitrite
- dissolved metals; metals were evaluated in terms of the total concentrations, which have AEMP Effects Benchmarks (Section 2.3.4.3) and defined reference conditions for Lac de Gras (as described in the *AEMP Reference Conditions Report Version 1.4* [Golder 2019b])

Data for nitrogen parameters that may be toxic to aquatic organisms at elevated concentrations were summarized herein (i.e., ammonia, nitrate, and nitrite) and in the Eutrophication Indicators Report (Appendix XIII), because they also have the potential to result in nutrient enrichment.

Variables that triggered Action Level 1 were retained as SOIs (Section 3.5.1). In 2019, total and dissolved calcium and sodium, and total magnesium in the NF area triggered Action Level 1. To avoid redundancy, and match methods from previous annual reports, graphing and statistical analyses were conducted on the dissolved fractions only. Similarly, while both total dissolved solids (TDS; calculated) and TDS (measured) triggered Action Level 1, to avoid redundancy, the analysis was focused on TDS (calculated).

A list of analyses completed on SOIs that met one or more of the criteria listed above, along with a reference to the location where the methods and results for each analysis can be found in the report, are summarized in Table 2-3.

Table 2-3 Data Analyses Completed on Substances of Interest (SOIs)

Analysis	SOIs	Location in Report
An examination of loads in Mine effluent and effluent chemistry (from SNP 1645-18 and 1645-18B)	SOIs that met Criteria 1 to 3	Sections 2.3.4 and 3.2
An examination of water chemistry at the edge of the mixing zone (from SNP 1645-19a, 1645-19b2, 1645-19c)	SOIs that met Criteria 1 to 3	Sections 2.3.4 and 3.2
An assessment of the magnitude and extent of effects, as defined by the Action Level criteria in the Response Framework for water quality	All SOIs	Sections 2.3.6.1 and 3.5
An evaluation of spatial trends in SOI concentrations with distance from the diffusers, including linear regression analysis of data along the MF transects	SOIs that met Criteria 1 to 3	Sections 2.3.6.2.1 and 3.6
A statistical comparison between the NF and FF areas	SOI that met Criteria 1 to 3	Sections 2.3.6.2.2 and 3.7
An examination of potential effects from dust deposition	SOIs that met Criterion 4	Sections 2.3.6.4 and 3.9
An evaluation of the potential cumulative effects in Lac de Gras from the Ekati and Diavik mines.	SOI that met Criteria 1 to 3	Sections 2.3.6.5 and 3.10

SNP = Surveillance Network Program; SOI = substance of interest.

2.3.2 Data Screening

Initial screening of the SNP and AEMP datasets was completed prior to data analyses to identify unusually large or small values, and decide whether to exclude anomalous data from further analysis. An explanation of the objectives and approach taken to complete the initial screening is provided in the *Quality Assurance Project Plan Version 3.1* (Golder 2017b), or QAPP, and in Attachment C.

Results of the initial screening for anomalous values in the SNP and AEMP datasets are presented in Attachment C, Tables C-1 to C-3. The SNP data screening identified 16 anomalous values in the effluent dataset and five anomalous values in the mixing zone dataset, representing 0.2% and 0.04% (respectively) of the data within each dataset. In total, 27 anomalous values were identified within the AEMP water quality

dataset, representing 0.2% of the data. In cases where unusual values were identified in the SNP and AEMP datasets, scatter-plots were generated to allow a visual review of the excluded data (Attachment C, Figures C-1 to C-10).

2.3.3 Censored Data

For the purposes of the AEMP, censored data are concentrations reported below the analytical DL (referred to as non-detect values). Due to the location of Lac de Gras on the Canadian Shield, concentrations of many water quality variables are low and are frequently measured at or below the DL. A commonly used, simple approach to deal with censored data is the substitution of a surrogate value (e.g., the DL or some fraction of the DL) for non-detect data, which is considered acceptable in cases when a relatively small proportion of the data (less than 15%) are below the DL (US EPA 2000).

Prior to data analyses, non-detect values were substituted with half the DL (i.e., 0.5 times the DL). This approach for handling censored data (US EPA 2000) is consistent with the approved methods applied in the calculation of the normal range in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019b). Data measured at less than the DL are presented on plots at half the DL. The non-parametric (i.e., percentile based) methods used to assess Action Levels for water quality in this report (Section 2.3.6.1) minimized the influence of using a substitution method for handling censored data. Handling of censored data in statistical analysis of water quality datasets is also discussed in Section 2.3.6.2.

2.3.4 Effluent and Mixing Zone Assessment

The effluent discharge from the NIWTP to Lac de Gras was assessed in terms of quantity and quality. The period of effluent discharge summarized in this report was 1 November 2018 to 31 October 2019. Concentrations of SOIs at the mixing zone boundary are also presented.

2.3.4.1 Trends in Effluent and at the Mixing Zone Boundary

Trends in effluent quantity were evaluated graphically by plotting total monthly discharge volumes (cubic metres per month) and loading rates (kilograms per month) of SOIs that met selection criteria 1 to 3 defined in Section 2.3.1, as bar charts. Mean daily loads for each SOI were calculated by multiplying the discharge rate by the concentration for each effluent diffuser station (SNP 1645-18, SNP 1645-18B). Linear interpolation was used to estimate the concentrations between sampling events. The total monthly load was estimated as the sum of daily loads from the two diffusers. One SOI, turbidity (Section 3.1), was excluded from this assessment because load is not a relevant measure for turbidity. The 20 December 2018 results from 1645-18 and 1645-18B are not available because samples were lost by the laboratory while in transit (DDMI 2019).

Graphs showing the concentrations in the effluent of SOIs that met criteria 1 to 3 were generated for the 2019 discharge period. Results for individual grab samples were plotted separately for each station. Water sampling at the mixing zone boundary is completed monthly at 5 m depth intervals at three stations (i.e., SNP 1645-19A, SNP 1645-19B2 and SNP 1645-19C). Therefore, up to 15 samples were collected each month. Results were summarized as boxplots showing 10th, 25th, 50th (median), 75th, and 90th percentile concentrations.

2.3.4.2 Comparison to Effluent Quality Criteria

The quality of the effluent discharged to Lac de Gras via the North Inlet was assessed by comparing water chemistry results at SNP 1645-18 and SNP 1645-18B with the EQC defined in the Water Licence (WLWB 2015) and in Table 2-4. In addition to the criteria listed in Table 2-4, all discharges from the NIWTP to Lac de Gras must have a pH between 6.0 to 8.4 (WLWB 2015). The comparison of phosphorus to the applicable EQC is discussed in the Eutrophication Indicators Report (Appendix XIII). Maximum average and maximum grab sample concentrations in the effluent from November 2018 to October 2019 were compared to the EQC for the Mine. Variables with concentrations in effluent that exceeded the EQC were included in the SOI list.

Table 2-4 Effluent Quality Criteria for Discharge to Lac de Gras

Variable	Units	Maximum Average Concentration	Maximum Concentration of Any Grab Sample
Total ammonia	µg-N/L	6,000	12,000
Total aluminum	µg/L	1,500	3,000
Total arsenic	µg/L	50	100
Total copper	µg/L	20	40
Total cadmium	µg/L	1.5	3
Total chromium	µg/L	20	40
Total lead	µg/L	10	20
Total nickel	µg/L	50	100
Total zinc	µg/L	10	20
Nitrite	µg-N/L	1,000	2,000
Total suspended solids	mg/L	15.0	25.0
Turbidity	NTU	10	15
Biochemical oxygen demand	mg/L	15.0	25.0
Total petroleum hydrocarbons	mg/L	3.0	5.0
Fecal coliforms	CFU/100 mL	10	20

Source: WLWB (2015)

µg-N/L = micrograms nitrogen per litre; NTU = nephelometric turbidity unit; CFU = colony forming units.

2.3.4.3 Comparison to Effects Benchmarks

Water quality in Lac de Gras at the edge of the mixing zone was compared to the AEMP Effects Benchmarks presented in Table 2-5. Variables with concentrations at the mixing zone boundary that exceeded AEMP Effects Benchmarks were included in the SOI list. Water chemistry results at the edge of the mixing zone were also evaluated as part of the Action Level screening (Section 2.3.6.1).

Effects Benchmarks represent concentrations intended to protect human health or aquatic life. They are based on the Canadian Water Quality Guidelines (CWQGs) for the protection of aquatic life (CCME 1999 + updates), the Canadian Drinking Water Quality Guidelines (Health Canada 1996, 2006), guidelines from other jurisdictions (e.g., provincial and state guidelines), adaptations of general guidelines to site-specific conditions in Lac de Gras (Appendix IV.1 in DDMI 2007), or when appropriate, values from the scientific literature.

The CWQGs are intended to provide protection of freshwater life from anthropogenic stressors such as chemical inputs or physical changes (CCME 1999). These guidelines are based on current, scientifically-defensible toxicological data and are intended to protect all forms of aquatic life, including the most sensitive life stage of the most sensitive species over the long term. The Canadian Drinking Water Quality Guidelines are based on published scientific research related to health effects, aesthetic effects and operational considerations (Health Canada 1996, 2006). Health-based guidelines are established based on comprehensive review of the known health effects associated with each chemical, exposure levels, and availability of water treatment and analytical technologies. Aesthetic effects (e.g., taste, odour) are taken into account when these play a role in determining whether consumers will consider the water drinkable. For variables with both aquatic life and drinking water values, the Effects Benchmark is the lower of the two.

The Effects Benchmarks used for the AEMP are generally consistent with those established during the Environmental Assessment (EA), referred to as ecological thresholds in the EA, but have incorporated a number of revisions to maintain their relevance over time for the Lac de Gras environment. Under the Response Framework for water chemistry, an Effects Benchmark must be established for water quality variables that trigger Action Level 2, if an Effects Benchmark does not already exist. As a result, DDMI has developed Effects Benchmarks for six variables: turbidity, dissolved sodium, total aluminum, total antimony, total silicon and total tin (Golder 2017a).

In 2019, the benchmark for total silver was updated based on the updated CWQG for this variable (Golder 2019a). This update is reflected in Table 2-5 and the *AEMP Design Plan Version 5.1* (Golder 2019a). Three additional variables (lead, manganese, selenium and strontium) have updated Health Canada drinking water guidelines, which are not yet reflected in the design plan (i.e., either Versions 4.1 or 5.1) but are presented in Table 2-5. These updated guidelines were considered in the screening.

Table 2-5 Effects Benchmarks for Water Quality Variables

Variable	Unit	Effects Benchmarks ^(a)	
		Protection of Aquatic Life	Drinking Water
Conventional Parameters			
Dissolved oxygen	mg/L	Cold water:	
		early life stages = 9.5	
		other life stages = 6.5	
pH	pH Units	6.5 to 9.0	6.5 to 8.5
Total dissolved solids	mg/L	500 ^(b)	500
Total alkalinity	mg/L	n/a ^(c)	-
Total suspended solids	mg/L	+5 (24 h to 30 days) ^(d)	-
		+25 (24 h period) ^(d)	
Turbidity	NTU	2.2 (long term, IC) ^(e)	-
		2.3 (long term, OW) ^(e)	
Major Ions			
Chloride	mg/L	120	250
Fluoride	mg/L	0.12	1.5
Sodium (dissolved)	mg/L	52 ^(e)	200
Sulphate	mg/L	100 ^(f)	500
Nutrients			
Ammonia	µg-N/L	4,730 ^(g)	-
Nitrate	µg-N/L	3,000	10,000
Nitrite	µg-N/L	60	1,000
Total Metals			
Aluminum (total)	µg/L	87 ^(e)	100/200 ^(h)
Aluminum (dissolved)	µg/L	Variable with pH ^(g,i)	-
Antimony	µg/L	33 ^(e)	6
Arsenic	µg/L	5	10
Barium	µg/L	1,000 ^(f)	1,000
Boron	µg/L	1,500	5,000
Cadmium	µg/L	0.1 ^(g)	5
Chromium	µg/L	1 (Cr VI) ^(j)	50
Copper	µg/L	2	1,000
Iron	µg/L	300	300
Lead	µg/L	1	10 [5] ^(l)
Manganese	µg/L	-	50 [20] ^(l)
Mercury	µg/L	0.026 (inorganic); 0.004 (methyl)	1
Molybdenum	µg/L	73	-
Nickel	µg/L	25	-
Selenium	µg/L	1	10 [50] ^(l)
Silicon	µg/L	2,100 ^(e)	-
Silver	µg/L	0.25	-
Strontium	µg/L	30,000 ^(k)	[7,000] ^(l)
Thallium	µg/L	0.8	-
Tin	µg/L	73 ^(e)	-
Uranium	µg/L	15	20
Zinc	µg/L	30	5,000

Source: Golder (2019a)

a) Unless noted, benchmarks are derived from current CWQGs and Canadian Drinking Water Quality Guidelines; the Effects Benchmark is selected as the lesser of the two values.

b) Adopted from Alaska DEC (2012) and as dictated by the WLWB (2013).

c) Alkalinity should not be less than 25% of natural background level. There is no maximum guideline (US EPA 1998); because this benchmark involves a decrease in alkalinity and the Mine effluent is slightly alkaline, this benchmark is not applicable.

d) Average increase of 5 mg/L (over a period of 24 hours to 30 days) or maximum increase of 25 mg/L in a 24 h-period.

e) See Appendix B of the *AEMP Design Plan Version 4.1* (Golder 2017a) for description.

f) BC MOE (2013).

g) See Appendix IV.1 in DDMI (2007) and BC MOE (2001) for description.

h) 100 µg/L for conventional treatment and 200 µg/L for other treatment types.

i) Benchmark value (mg/L) = $e[1.6-3.327(\text{median pH})+0.402(\text{median pH})^2]$ when median pH is less than 6.5 and is 50 µg/L when median pH is greater than or equal to 6.5 (BC MOE 2017).

j) Total chromium concentrations will be compared to the benchmark for chromium VI.

k) Based on results from HydroQual (2009) and Pacholski (2009).

l) Updated Health Canada drinking water guideline, which are not reflected in AEMP Design Plan Version 4.1 or 5.1.

- = benchmark not available; IC = ice-cover; OW = open-water; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; n/a = not applicable

2.3.4.4 Effluent Toxicity

Part H, Item 30 of the Water Licence (WLWB 2015) requires toxicity testing of effluent discharged to Lac de Gras (WLWB 2015). The following toxicity testing is completed on a quarterly basis:

- acute lethality to Rainbow Trout, *Oncorhynchus mykiss*, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/13
- acute lethality to the crustacean, *Daphnia magna*, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/14
- chronic toxicity to the amphipod, *Hyalella azteca*, per a water-only protocol approved by the Wek'èezhii Land and Water Board (WLWB)
- chronic toxicity to early life stages of salmonid fish, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/28
- chronic toxicity to the crustacean, *Ceriodaphnia dubia*, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/21
- chronic toxicity to the freshwater alga, *Pseudokirchneriella subcapitata*, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/25

Quarterly *Hyalella azteca* testing was removed from the Mine's Water Licence but is required if elevated levels of ammonia are observed in the treated effluent (see the Revision History Table in Annex 1 of the Water Licence [WLWB 2015]).

Effluent samples were submitted to BV Labs and Nautilus Environmental in Burnaby, BC, Canada, for toxicity testing. The effluent toxicity data collected during the 2019 reporting period were used to evaluate whether Mine effluent was causing toxic responses in biota in Lac de Gras.

The results of lethal and sublethal toxicity testing carried out on effluent samples from SNP 1645-18 and SNP 1645-18B were summarized herein for the 2019 reporting period. Results for lethal tests are presented as a "pass" or "fail" to be consistent with laboratory procedures and standards. A lethal test was considered a fail if a result of greater than or equal to 50% mortality in 100% effluent was obtained. Although not a requirement under the Water Licence, a sublethal test was considered a fail if the test results demonstrated sublethal effects greater than or equal to 50%, relative to the control.

2.3.5 Effluent Dispersion

Calculated total dissolved solids (referred to herein as TDS unless specified as measured TDS) is used as a tracer of the Mine effluent in Lac de Gras; TDS was identified as a suitable tracer of the Mine effluent in Lac de Gras based on the considerations discussed in Section 4.3.4.6 and Appendix A in Golder 2016a. Concentrations of TDS at AEMP stations during the ice-cover sampling program in 2019 were plotted against distance from the diffusers to illustrate the spatial pattern of effluent exposure in Lac de Gras. Concentrations in the FF area were compared to the normal range for Lac de Gras, as defined in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019b). Areas with concentrations above the normal range were considered to be exposed to effluent from the Mine.

2.3.6 AEMP Water Quality Assessment

2.3.6.1 Action Level Evaluation

Water quality variables were assessed for a Mine-related effect as described in the *AEMP Design Plan Version 4.1* (Golder 2017a) Response Framework. The Action Levels for water quality were developed to meet the goals of the draft *Guidelines for Adaptive Management – A Response Framework for Aquatic Effects Monitoring* (WLWB 2010; Racher et al. 2011). The main goal of the Response Framework is to ensure that significant adverse effects never occur. This is accomplished by requiring proponents to take actions at pre-defined Action Levels, which are triggered well before significant adverse effects could occur (Table 2-6). A significant adverse effect, as it pertains to water quality, was defined in the EA as a concentration of a variable that exceeds an established guideline for the protection of aquatic life and drinking water quality by more than 20% (Government of Canada 1999). This effect must have a high probability of being permanent or long-term in nature and must occur throughout Lac de Gras.

Water quality is assessed annually relative to the Action Levels for water chemistry (Table 2-6). Magnitude of effects to water chemistry variables was determined by comparing variable concentrations between NF, MF, and FF sampling areas, reference conditions, and benchmark values. Reference conditions for Lac de Gras are those that fall within the range of natural variability, referred to as the normal range. The normal ranges used in the Action Level screening for water quality are described in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019b) and are summarized in Table 2-7. The water quality benchmark values used in the Action Level assessment (referred to herein as Effects Benchmarks), are discussed in Section 2.3.4.3 and are presented in Table 2-5. The magnitude of effect was classified according to the appropriate Action Level (Table 2-6).

Action Levels were assessed separately for the ice-cover and open-water seasons. The ice-cover season was defined as November to June, and the open-water season was defined as July to October. The results for all depths and stations sampled, both at the mixing zone boundary and at AEMP stations, were included in the calculation of the 2019 exposure values considered at each Action Level (Table 2-6).

Box and whisker plots were generated for SOIs that triggered an Action Level, to illustrate spatial variation in water quality in Lac de Gras and to show the 2019 results relative to the Action Levels. The box was bound by the 25th and 75th quantiles, with a thick line showing the median value. The whiskers depicted the 10th and 90th quantiles, and points were used to show the 5th and 95th quantiles. Non-detect values were plotted at half the DL, to be consistent with data handling procedures used in the evaluation of Action Levels and estimation of the normal range (Golder 2019b).

Table 2-6 Action Levels for Water Chemistry, Excluding Indicators of Eutrophication

Action Level	Magnitude of Effect ^(a)	Extent of Effect	Action/Note
1	Median of NF greater than 2 times the median of reference dataset ^(b) (open-water or ice-cover) and strong evidence of link to Mine	NF	Early warning.
2	5th percentile of NF values greater than 2 times the median of reference areas AND normal range ^(b)	NF	Establish Effects Benchmark if one does not exist.
3	75th percentile of MZ values greater than normal range plus 25% of Effects Benchmark ^(c)	MZ	Confirm site-specific relevance of Effects Benchmark. Establish Effects Threshold. Define the Significance Threshold if it does not exist. The WLWB to consider developing an EQC if one does not exist
4	75th percentile of MZ values greater than normal range plus 50% of Effects Threshold ^(c)	MZ	Investigate mitigation options.
5	95th percentile of MZ values greater than Effects Threshold	MZ	The WLWB to re-assess EQC. Implement mitigation required to meet new EQC if applicable.
6	95th percentile of NF values greater than Effects Threshold + 20%	NF	The WLWB to re-assess EQC. Implement mitigation required to meet new EQC if applicable.
7	95th percentile of MF values greater than Effects Threshold + 20%	MF	The WLWB to re-assess EQC. Implement mitigation required to meet new EQC if applicable.
8	95th percentile of FFB values greater than Effects Threshold + 20%	FFB	The WLWB to re-assess EQC. Implement mitigation required to meet new EQC if applicable.
9	95th percentile of FFA values greater than Effects Threshold + 20%	FFA	Significance Threshold. ^(d)

a) Calculations were based on pooled data from all depths.

b) Normal ranges and reference datasets were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019b); the normal range for open-water was based on the 15 August to 15 September period. In cases where the reference area median value reported in the reference conditions report was equal to the DL, half the DL was used to calculate the 2 x reference area median criterion, to be consistent with data handling methods used for the AEMP.

c) Indicates 25% or 50% of the difference between the Effects Benchmark/Threshold and the top of the normal range.

d) Although the Significance Threshold is not an Action Level, it is presented as the highest Action Level to show escalation of effects towards the Significance Threshold.

NF = near-field; MZ = mixing zone; MF = mid-field; FF = far-field; WLWB = Wek'èezhìi Land and Water Board; EQC = Effluent Quality Criteria.

Table 2-7 Normal Ranges for Water Chemistry Variables

Variable	Unit	Normal Range			
		Ice-cover		Open-water	
		Lower Limit	Upper Limit	Lower Limit	Upper Limit
Conventional Parameters					
Total alkalinity	mg/L	3.2	6.0	3.1	4.7
Total hardness	mg/L	5.0	7.0	4.0	6.0
Total dissolved solids, calculated	mg/L	2.9	6.5	3.8	5.8
Total dissolved solids, measured	mg/L	0	24.0	0	20.0
Total suspended solids	mg/L	0	1.0	0	1.0
Total organic carbon	mg/L	2.0	3.1	1.9	3.0
Turbidity – lab	NTU	0	0.18	0.13	0.29
Major Ions					
Calcium (dissolved)	mg/L	0.9	1.3	0.8	1.1
Chloride	mg/L	0	1.0	0	1.0
Fluoride	mg/L	0.02	0.03	0.019	0.03
Magnesium (dissolved)	mg/L	0.6	0.8	0.6	0.8
Potassium (dissolved)	mg/L	0.5	0.8	0.4	0.7
Sodium (dissolved)	mg/L	0	1.0	0	1.0
Sulphate	mg/L	1.9	2.5	1.7	2.1
Nutrients					
Ammonia	µg-N/L	14.3	23.0	0	5.0
Nitrate	µg-N/L	0	15.2	0	2.0
Nitrite	µg-N/L	0	2	0	2
Total Metals					
Aluminum	µg/L	2.3	3.9	3.4	6.2
Antimony	µg/L	0	0.02	0	0.02
Arsenic	µg/L	0.15	0.22	0.16	0.19
Barium	µg/L	1.74	2.18	1.61	1.94
Beryllium	µg/L	0	0.01	0	0.01
Bismuth	µg/L	0	0.005	0	0.005
Boron	µg/L	0	5	0	5
Cadmium	µg/L	0	0.005	0	0.005
Calcium	mg/L	0.94	1.15	0.87	1.00
Chromium	µg/L	0	0.06	0	0.06
Cobalt	µg/L	0.01	0.02	0.01	0.04
Copper	µg/L	0	0.8	0	0.6
Iron	µg/L	0	5.0	0	7.6
Lead	µg/L	0	0.007	0	0.006
Lithium	µg/L	1.2	1.5	1.2	1.3
Magnesium	mg/L	0.59	0.79	0.58	0.66
Manganese	µg/L	0.60	1.95	1.54	4.67
Mercury	µg/L	0	0.01	0	0.01
Molybdenum	µg/L	0.06	0.09	0.07	0.13
Nickel	µg/L	0.83	1.10	0.72	1.12
Potassium	mg/L	0.53	0.67	0.50	0.57
Selenium	µg/L	0	0.04	0	0.04
Silicon	µg/L	0	50	0	50
Silver	µg/L	0	0.005	0	0.005
Sodium	mg/L	0.56	0.75	0.55	0.68
Strontium	µg/L	6.70	8.78	6.51	8.01
Sulphur	mg/L	0.84	1.07	0.83	1.32
Thallium	µg/L	0	0.002	0	0.002
Tin	µg/L	0	0.01	0	0.01
Titanium	µg/L	0	0.5	0	0.5
Uranium	µg/L	0.027	0.030	0.024	0.029
Vanadium	µg/L	0	0.1	0	0.1
Zinc	µg/L	0.37	1.53	0.29	2.04
Zirconium	µg/L	0	0.05	0	0.05

Source: AEMP Reference Conditions Report Version 1.4 (Golder 2019b)
NTU = nephelometric turbidity unit; µg-N/L micrograms nitrogen per litre.

2.3.6.2 Statistical Analysis

Spatial patterns in SOI concentrations in Lac de Gras were analyzed statistically using a combination of linear regression analysis (Section 2.3.6.2.1) and Analysis of Variance (ANOVA; or a related approach; Section 2.3.6.2.2). Regression analysis was used to evaluate trends in SOI concentrations along the three gradients in Lac de Gras (Section 2.1) and in relation to the Mine effluent diffusers, whereas ANOVA was used to compare SOI concentrations between the NF and FF areas of Lac de Gras. Recent updates to the *AEMP Design Plan Version 5.1* (Golder 2019a) have emphasized the linear gradient aspect of the AEMP sampling design, because the FF areas of Lac de Gras have become exposed to a low level of Mine effluent. Consequently a valid control-impact comparison of constituent concentrations in the NF area relative to the FF areas is no longer possible. However, the NF vs FF comparisons have been retained in the 2019 AEMP to meet the data analysis requirements set out in Version 4.1 of the AEMP design, and are considered as a supporting analysis to the spatial gradient analysis (Section 2.3.6.2.1).

2.3.6.2.1 Gradient Analysis

The spatial gradients in water quality SOIs along the MF1, MF2-FF2, and MF3 transects were analyzed using linear regression, as per the *AEMP Design Plan Version 4.1* (Golder 2017a). The NF area data were included in the linear regression for each of the three MF transects. Hereafter, the NF-MF1-FF1 transect is referred to as the MF1 transect, the NF-MF2-FF2 transect is referred to as the MF2 transect, and the NF-MF3-FFB-FFA transect is referred to as MF3 transect. The stations included in each of the MF transects are described in Section 2.1. The maximum values of top, middle and bottom depth samples for the three MF transects were used in the regression analysis. Regression analyses were considered significant at α (or P -value) = 0.1.

Due to the spatial span of the MF3 transect, variables often had non-linear patterns with distance from the diffusers. Therefore, the analysis method allowed for piecewise regression (also referred to as segmented, or broken stick regression). Two approaches were used:

- Model 1: a linear multiplicative model, with main effects of distance from diffusers, gradient (MF1, MF2, and MF3 transects), and their interaction
- Piecewise modeling to account for changes in spatial gradients, where individual transects were analyzed separately from one another:
 - Model 2: a linear multiplicative model, with main effects of distance from diffusers, gradient (only MF1 and MF2 transects), and their interaction
 - Model 3: a linear piecewise (broken stick) model with distance (MF3 transect only)

For each variable in each season, Model 1 was used to test for presence of a significant ($P < 0.05$) breakpoint (i.e., where the slopes of the linear regressions changed) using the Davies test (Davies 1987, 2002). If a significant breakpoint was identified, Models 2 and 3 were used for that variable in that season. If no significant breakpoint was identified, Model 1 was used for that variable in that season.

Following the initial fit of the model, the residuals (of either Model 1 or Model 2, as applicable) were examined for normality. Model 3 was not considered for transformations, since the addition of breakpoint was expected to resolve non-linear patterns. Box-cox transformations were applied to the datasets for each

variable (Box and Cox 1964). The Box-Cox transformations are a family of transformations that include the commonly used log and square root transformations. The Box-Cox transformation process tests a series of power values, usually between -2 and +2, and records the log-likelihood of the relationship between the response and the predictor variables under each transformation. The transformation that maximizes the log-likelihood is the one that will best normalize the data. Therefore, the data are transformed using a power value identified by the transformation process. For a power value (λ) of zero, the data are natural log transformed. The transformation rules can be described using the following definitions:

$$\text{Transformed value} = \frac{\text{value}^{\lambda} - 1}{\lambda} \quad \text{if } \lambda \neq 0$$

$$\text{Transformed value} = \ln(\text{value}) \quad \text{if } \lambda = 0$$

The selected transformation was applied to all data (i.e., a transformation selected based on Model 2 was also applied to MF3 data).

Following data transformation (if required), the selected models were fitted to the data. Statistical outliers were identified using studentized residuals with absolute values of 3.5 or greater, or due to consideration of leverage (where a single point could strongly influence the overall fit of the model). All values removed from analysis were retained for plots of model predictions, where they were presented using a different symbol from the rest of the data.

Following removal of outliers, breakpoint significance and data transformation was re-examined. Residuals from the refitted models were examined for normality, heteroscedasticity, and evidence of nonlinear patterns. If non-linearity was evident from residual examination, the analysis was terminated and data were presented qualitatively. If no lack of normality was evident, three models were constructed to assess the effect of heteroscedasticity for each response variable in each season:

- heteroscedasticity by gradient (applied only to Models 1 and 2)
- heteroscedasticity by predicted value (accounting for the classic trumpet shape of heteroscedastic data)
- heteroscedasticity by distance from the diffuser

These three models were compared to the original model that did not account for heteroscedasticity, using Akaike's information criterion (AIC), corrected for small sample size (AICc). The model with the lowest AIC score among a set of candidate models was interpreted to have the strongest support, given the set of examined models and the collected data (Burnham and Anderson 2002), and thus was selected for interpretation. When using AIC not corrected for small sample size, models with AIC scores within two units of each other are considered to have similar levels of support (Arnold 2010). Since the small sample size correction was used in the analysis, the cut-off value was adjusted to reflect the higher penalization of model parameters (the adjustment depended on the number of data points and model parameters).

The constructed models were used to produce the following outputs:

- estimates and significance of slopes (i.e., distance effects) for each gradient; in the case of MF3 data analyzed using piecewise regression, the significance of the first slope, extending from the NF to the breakpoint, was calculated

- the r^2 value of each model, to examine explained variability
- fitted prediction lines and 95% confidence intervals (back-transformed to original scale of the variable)

Analyses were performed using the statistical environment R v. 3.6.1 (R Core Team 2019) and package “segmented” (Muggeo 2008).

Based on United States Environmental Protection Agency guidance, a screening value of greater than 15% censoring was used to flag datasets that may not be amenable to the linear regression analysis (US EPA 2000). The decision of whether to analyze the data using linear regression was based on review of the number of values less than the DL (<DL) according to variable and season. Because of large numbers of values below the DL, linear regression analysis was not performed for:

- turbidity: ice-cover (32% <DL)
- nitrate: open-water (38% <DL)
- silicon: ice cover (56% <DL) and open-water (100% <DL)

Scatter-plots of concentrations according to distance from the effluent discharge have been included for variables which had large numbers of values that were less than the DL.

2.3.6.2.2 Near-Field Versus Far-Field Area Comparisons

The objective of the statistical comparisons for water quality variables was to compare the NF area to the three FF areas (i.e., FF1, FFB, and FFA). Statistical testing was conducted using a combination of ANOVA, the Kruskal-Wallis (KW) test, and the one-sample t-test. The choice of test depended on the amount of censoring (i.e., values below the DL) within a dataset and the outcome of assumptions testing for ANOVA (see details below). Statistical methods used for each type of test are provided in the subsections below. Statistical analyses were performed using the statistical environment R v. 3.6.1 (R Core Team 2019).

Water samples were collected at three depths in the NF area (top, middle, and bottom) and at a single depth in the FF areas (middle), in two seasons (ice-cover and open-water). To provide the most conservative interpretation of effects, statistical analyses were run on the depth with the greatest concentrations in the NF area, evaluated separately for each season (Table 2-8).

Observations below analytical DLs were considered censored. Censored data can potentially bias summary statistics calculated using parametric statistics because of violation of underlying assumptions. Based on US EPA guidance, a screening value of greater than 15% censoring was used to flag data sets that may require an alternative data analysis method be used. The decision of how to analyze the datasets, however, was determined on a parameter-by parameter basis. The intent of this process was to select the appropriate test for each variable and season based on the amount of censoring within each dataset. The results of the screening are presented in Table 2-9 and are summarized as follows:

- Twenty-five datasets (i.e., combination of season and variable) contained only detectable results. In these cases, an ANOVA was used to test for differences in SOI concentrations between the NF and FF areas (see “Analysis of Variance” section below). The KW test (see “Kruskal-Wallis Test” section below),

was used in cases where the assumptions of ANOVA were not met (see “Testing Assumption for Analysis of Variance” section below).

- Seven datasets contained censored values (i.e., ice-cover and open-water turbidity, nitrate and silicon; open-water ammonia). These seven datasets were analyzed as follows:
 - Three datasets (i.e., ice-cover silicon, and open-water ammonia and nitrate) contained detectable results for greater than or equal to 60% of observations in the NF area (i.e., at 3 of 5 stations), whereas greater than 50% of observations in the FF areas were censored. In these three cases, a one-sample t-test was used to compare the mean value in the NF area to the DL (see “One-Sample t-Test” section below).
 - Three datasets (i.e., ice-cover and open-water turbidity and ice-cover nitrate) contained detectable results for greater than or equal to 80% of observations in the NF area (i.e., at 4 of 5 stations), whereas less than 50% of observations in the FF areas were censored. In these cases, an ANOVA was used to test for differences in concentrations between the NF and FF areas (see “Analysis of Variance” section below). The same assumptions testing was performed as for the datasets containing only detectable results (see “Testing Assumptions for Analysis of Variance” section below).
 - The remaining dataset (i.e., open-water silicon) contained 100% non-detectable results. Consequently, silicon was excluded from the statistical analysis.

Table 2-8 NF Area Data Used for Statistical Analysis by SOI and Season, 2019

Variable	Season	NF Area Depth ^(a)
Conventional Parameters		
Turbidity - lab	Ice-cover	T
	Open-water	M
Total Dissolved Solids, calculated	Ice-cover	M
	Open-water	T
Major Ions		
Calcium (dissolved)	Ice-cover	M
	Open-water	T
Chloride	Ice-cover	M
	Open-water	T
Magnesium (dissolved)	Ice-cover	M
	Open-water	B
Sodium (dissolved)	Ice-cover	M
	Open-water	T
Sulphate	Ice-cover	M
	Open-water	T
Nutrients		
Ammonia ^(b)	Ice-cover	M
	Open-water	M
Nitrate	Ice-cover	M
	Open-water	T
Total Metals		
Total Aluminum	Ice-cover	M
	Open-water	T
Total Barium	Ice-cover	M
	Open-water	T
Total Manganese	Ice-cover	B
	Open-water	M
Total Molybdenum	Ice-cover	M
	Open-water	T
Total Silicon	Ice-cover	M
	Open-water	B
Total Strontium	Ice-cover	M
	Open-water	T
Total Uranium	Ice-cover	M
	Open-water	M

a) The highest mean concentration was used to determine the depth used in the statistical analyses. When all mean concentrations for each depth were the same, the bottom data were used as the default.

b) Based on the results of the ammonia investigation, the ALS ammonia dataset was used in the ice-cover season and the BV ammonia dataset was used in the open-water season (Section 2.4.1, Attachment B).

T= top depth; M = middle depth; B = bottom depth; NF = near-field.

Table 2-9 Percent Censoring and Statistical Tests Used by SOI and Season, 2019

Variable	Season	All Data	NF Area	FF1 Area	FFB Area	FFA Area	Overall FF Area	Statistical Test
Conventional Parameters								
Turbidity - lab	Ice-cover	30	20	0	0	100	33	ANOVA
	Open-water	15	0	40	0	20	20	ANOVA
Total Dissolved Solids, calculated	Ice-cover	0	0	0	0	0	0	ANOVA
	Open-water	0	0	0	0	0	0	ANOVA
Major Ions								
Calcium (dissolved)	Ice-cover	0	0	0	0	0	0	ANOVA
	Open-water	0	0	0	0	0	0	ANOVA
Chloride	Ice-cover	0	0	0	0	0	0	ANOVA
	Open-water	0	0	0	0	0	0	ANOVA
Magnesium (dissolved)	Ice-cover	0	0	0	0	0	0	ANOVA
	Open-water	0	0	0	0	0	0	ANOVA
Sodium (dissolved)	Ice-cover	0	0	0	0	0	0	ANOVA
	Open-water	0	0	0	0	0	0	ANOVA
Sulphate	Ice-cover	0	0	0	0	0	0	ANOVA
	Open-water	0	0	0	0	0	0	ANOVA
Nutrients								
Ammonia ^(a)	Ice-cover	0	0	0	0	0	0	ANOVA
	Open-water	40	0	75	60	40	58	One-sample t-test
Nitrate	Ice-cover	25	0	0	100	0	33	ANOVA
	Open-water	65	0	80	80	100	87	One-sample t-test
Total Metals								
Total Aluminum	Ice-cover	0	0	0	0	0	0	ANOVA
	Open-water	0	0	0	0	0	0	ANOVA
Total Barium	Ice-cover	0	0	0	0	0	0	KW
	Open-water	0	0	0	0	0	0	ANOVA
Total Manganese	Ice-cover	0	0	0	0	0	0	ANOVA
	Open-water	0	0	0	0	0	0	ANOVA
Total Molybdenum	Ice-cover	0	0	0	0	0	0	ANOVA
	Open-water	0	0	0	0	0	0	ANOVA
Total Silicon	Ice-cover	70	0	80	100	100	93	One-sample t-test
	Open-water	100	100	100	100	100	100	Not Tested
Total Strontium	Ice-cover	0	0	0	0	0	0	ANOVA
	Open-water	0	0	0	0	0	0	ANOVA
Total Uranium	Ice-cover	0	0	0	0	0	0	ANOVA
	Open-water	0	0	0	0	0	0	ANOVA

a) Based on the results of the ammonia investigation, the ALS ammonia dataset was used in the ice-cover season and the BV ammonia dataset was used in the open-water season (Section 2.4.1, Attachment B).

ANOVA = analysis of variance; KW = Kruskal-Wallis test.

Testing Assumptions for Analysis of Variance

Parametric tests such as ANOVA assume that the data fit a normal distribution, because the residuals (i.e., error terms of the variates) are assumed to fit a normal distribution. If a measurement variable is not normally distributed, there is an increased chance of a false positive result, or Type I error.

The goodness-of-fit of the data to the normal distribution were tested with the Kolmogorov-Smirnov test (Sokal and Rohlf 2012). Many datasets that are significantly non-normal will still be appropriate for an ANOVA; therefore, issues with non-normality were only addressed at a P -value less than 0.01. Another assumption of ANOVA is that group variances are equal (i.e., homogeneity of variances). When variances differ markedly, various data transformations will typically remedy the problem. As with normality, small to moderate deviations from the assumption of equal variances do not compromise the overall test of significance by ANOVA. Homogeneity of variances was tested using the Bartlett and Levene's tests. If the data were clearly non-normal and/or had large differences in-group variances, and if transformations did not remedy the problem, the data were analyzed using the non-parametric Kruskal-Wallis test.

Analysis of Variance

The mean values of the four areas (i.e., NF, FF1, FF2, and FFA) were compared in an overall ANOVA. Within the overall ANOVA, an *a priori* comparison (i.e., planned contrast) was conducted to test for differences of means among specific areas (e.g., NF vs. FF areas). The P -value used for these tests was 0.1.

In some cases, differences were observed among FF areas in Lac de Gras. To assess this variability, comparisons were also made among the three FF areas. Such comparisons are considered unplanned or *a posteriori* comparisons. The procedure used for these comparisons was Tukey's honestly significant difference (HSD) method. This test adopts a conservative approach by employing experiment-wise error rates for the Type I error (Day and Quinn 1989). Therefore, the P -value used for these tests was 0.1, the same P -value used for the planned contrasts.

Kruskal-Wallis Test

The Kruskal-Wallis test was used to test for differences among sampling areas for variables that did not meet parametric test assumptions, or were not analyzed using a one-sample t-test (see the "One-Sample t-Test" section below). A similar approach was taken as described for ANOVA. Upon finding a significant overall difference, planned contrasts were conducted to test for differences between the NF area and the pooled FF areas (Gibbons 1976). To assess variability among FF areas, the three FF areas were compared to one another (i.e., FF1 vs. FF2 vs. FFA). The multiple-comparison procedure employed followed Dunn (1964) and is the non-parametric analogue to the unplanned tests using Tukey's HSD method described under ANOVA.

Kruskal-Wallis tests were considered significant at $P < 0.1$. The multiple-comparison procedure controls the experiment wise error rates for the Type I error and, therefore, holds the probability of correctly concluding no difference at $1 - \alpha$. However, under this scenario, the task of correctly detecting differences that are significant is more difficult (Daniel 1990). To maintain a sufficiently small Type II error (β) with the multiple comparisons, a larger α was used. The contrasts were tested at $P = 0.1$, and the multiple comparisons were conducted at $P = 0.15$.

One-Sample t-Test

A one-sample t-test was used in instances where (1) greater than or equal to 60% of observations in the NF area were detectable and (2) greater than 50% of observations in the FF area were below the DL. In this situation, the median SOI concentration in the FF areas is less than the DL and, if the data follow the normal distribution, the mean would also be less than the DL. Therefore, testing that the NF area mean is greater than the DL would provide statistical evidence that the NF and FF areas are different in terms of SOI concentration. One-tailed critical values were used for the tests, because the alternative hypothesis was that the NF area mean was greater than the DL. One-sample t-tests were considered significant at $P < 0.1$.

2.3.6.3 Comparison to Effects Benchmarks

The field and analytical data obtained from the AEMP water quality sampling programs were compared to Effects Benchmarks presented in the *AEMP Design Plan Version 4.1* (Golder 2017a) and in Table 2-5. These water quality benchmark values were also used in the Action Level screening at Action Level 3 (Section 2.3.6.1).

2.3.6.4 Effects from Dust Deposition

The AEMP water quality data analysis included an evaluation of effects on water quality at stations potentially affected by Mine-related dust emissions. The ZOI from dust deposition in Lac de Gras is estimated to be approximately 4 km from the geographic center of the Mine, or approximately 1.5 km from the Mine boundary, extending radially from the source (Golder 2019). These distances were estimated based on gradient analysis of dust deposition relative to distance from the Mine site and encompass the area of the lake where potential effects would be expected to be measurable (Golder 2019c). Beyond this estimated zone, dust deposition is similar to background levels. The AEMP sampling stations that fall within the expected ZOI from dust deposition include the five stations in the NF area, and stations MF1-1, MF2-1, MF3-1 and MF3-2.

The combined effects from discharge of Mine effluent and potentially dust deposition on water quality in the NF area were assessed according to the water quality Action Level 1 criteria (Section 2.3.6.1). A similar analysis was used to evaluate potential effects from dust emissions at affected stations in the MF area. Water quality variables at the aforementioned four MF stations with median concentrations (i.e., of top, middle, and bottom samples) that exceeded 2× the median of reference area data (i.e., the same criterion used in the assessment of Action Level 1 in the NF area) were considered potentially affected by dust emissions, in addition to potential effluent effects. This comparison was only considered for the open-water season data, because access by dust particles to under-ice lake water is prevented during winter. If a variable triggered an effect equivalent to Action Level 1 at the MF stations identified above, but not the NF area (i.e., where the concentration of effluent is greatest), it was considered that the effects at these stations may have resulted from dust deposition, or a combination of dust deposition and effluent discharge.

2.3.6.5 Cumulative Effects in Lac de Gras

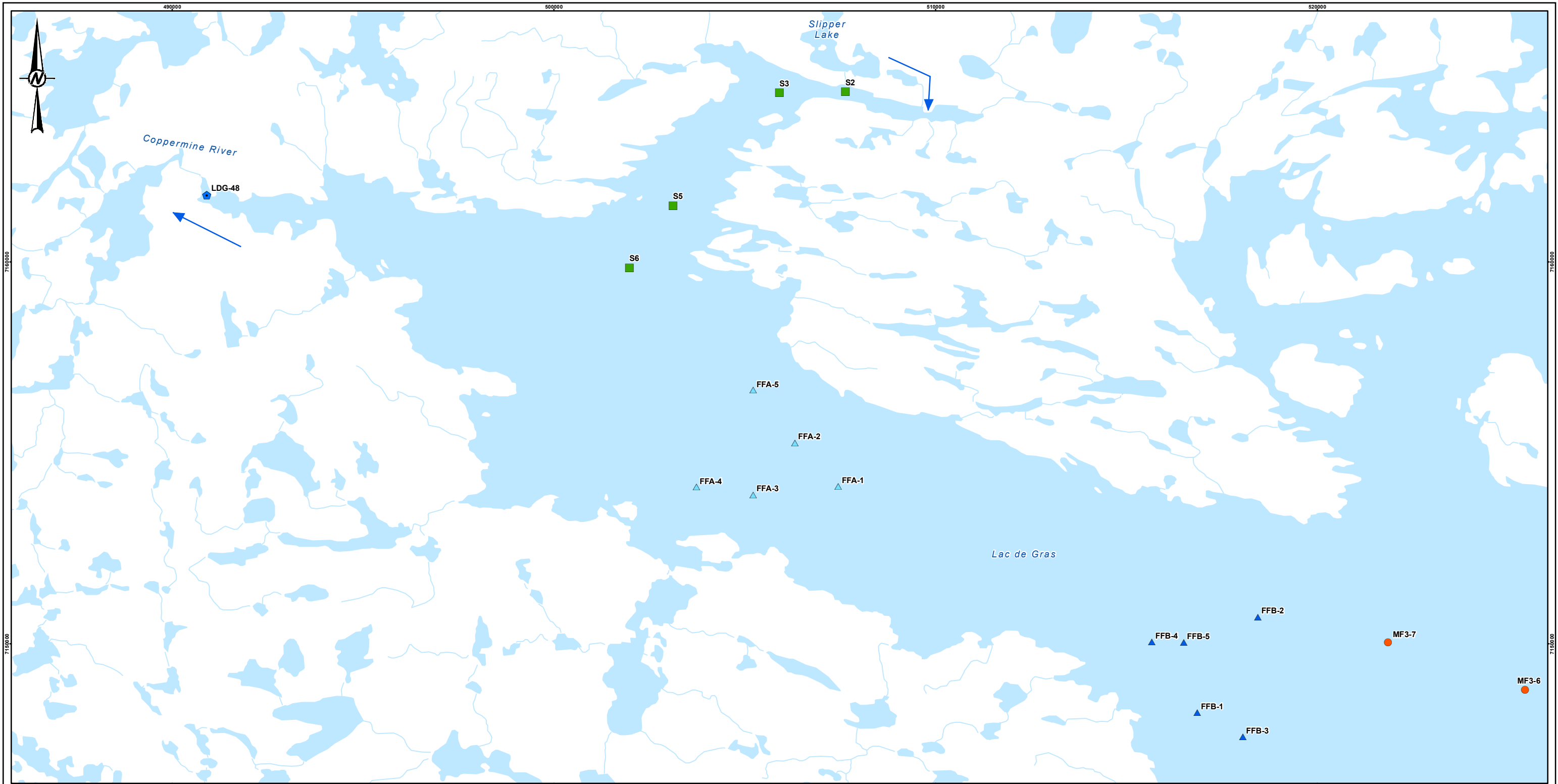
A spatial gradient approach was used to evaluate potential cumulative effects in Lac de Gras from the Ekati and Diavik Mines per *AEMP Design Plan Version 4.1* (Golder 2017a). Effects were assessed for water quality SOIs along the gradient of exposure at stations in the MF3, FFB, and FFA areas and at Station LDG-48.

Effluent from Ekati mine is discharged to the Long Lake Containment Facility (LLCF) and flows through several small lakes, eventually to Slipper Bay, which is located at the northwest end of Lac de Gras (Figure 2-2). The effluent discharge from Ekati could, therefore, influence water quality in the northwest portion of Lac de Gras. Given that the primary direction of water flow in Lac de Gras is from east to west, the concentration of a substance released via the Diavik effluent would be expected to decrease with distance from the effluent diffusers, with the smallest concentrations occurring at the far northwest end of Lac de Gras, at the mouth of the Coppermine River (LDG-48). The presence of a spatial trend with distance from the Diavik diffusers that is reversed in the western part of the lake (based on data from the FFA, FFB and MF3 areas) would suggest that effluent from the Ekati mine is potentially influencing the variable in question. This interaction would constitute a cumulative effect, since it is known that the DDMI effluent is influencing water quality in Lac de Gras beyond the FFA area.

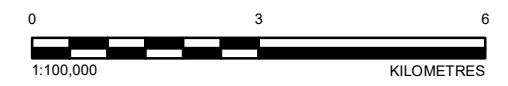
The Diavik AEMP results were qualitatively compared to Ekati AEMP data collected at the Slipper Bay monitoring stations in Lac de Gras (i.e., S2, S3, S5 and S6) to further evaluate the potential contribution of Ekati to cumulative effects in Lac de Gras (Figure 2-2). As the 2019 Ekati data were not publicly available at the time of preparation of this report, the 2018 Ekati data were used in the comparisons to Diavik data collected in 2019. There is some potential that differences in effluent release (i.e., timing, loading rates) between years and mines, and placement of sampling stations could interfere with the ability to draw conclusions based on these comparisons. These factors were considered in the interpretation of results.

Graphs were prepared to visually evaluate potential cumulative effects in Lac de Gras from the Ekati and Diavik Mines. From east to west in Lac de Gras, areas and stations included in the plots were MF3, FFB (mid-lake), FFA (closest to the Ekati mine discharge via Slipper Lake) and LDG-48 (outlet to the Coppermine River). These stations were plotted against distance from the Diavik Mine effluent diffusers. Ekati stations (i.e., S2, S3, S5 and S6; Figure 2-2) were plotted separately from the Diavik Mine distance axis as these stations are associated with the Ekati Mine effluent source, and do not lie along the Diavik Mine effluent concentration gradient. For reference purposes, the approximate location of the S6 station, which is the Ekati station located furthest into the body of Lac de Gras, was indicated with an arrow denoting its location along the Diavik Mine distance axis, and relative to the Diavik AEMP stations. Magnitude of effects were evaluated by comparing the results to the normal range for Lac de Gras, as defined in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019b).

Results for all available depths were plotted. Sampling depths for the Diavik AEMP are described in Section 2.1. The Ekati samples were collected in duplicate during both ice-cover and open-water seasons. During ice-cover, samples were collected at mid-depth and bottom (~2 m above the sediment water interface). During open-water samples were collected at mid-depth and at a shallow depth (1 m below water surface).



- LEGEND**
- EKATI STATION LOCATION
 - ▶ FLOW DIRECTION
 - ▲ FAR-FIELD A
 - ▲ FAR-FIELD B
 - ◆ LAC DE GRAS OUTLET
 - MID-FIELD 3
 - WATERCOURSE
 - WATERBODY



REFERENCE(S)
 HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
 PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT	RioTinto	
CONSULTANT	YYYY-MM-DD	2020-04-28
	DESIGNED	LJ
	PREPARED	LMS
	REVIEWED	LJ
	APPROVED	ZK

PROJECT	DIAVIK DIAMOND MINES INC.		
TITLE	LOCATIONS OF DIAVIK MINE AEMP SAMPLING STATIONS RELATIVE TO EKATI MINE AEMP SAMPLING STATIONS		
PROJECT NO.	PHASE	REV.	FIGURE
19115664	8000	0	2-2

PATH: I:\CLIENTS\DIAMOND\19115664\Map\GIS\Products\Final\MEMO_2019\Fig-2_2019_AEMP_SamplingStations_Ekati_Diavik_Riv0.mxd PRINTED ON: 2020-04-28 AT 8:35:41 AM
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2.4 Quality Assurance/Quality Control

The *Quality Assurance Project Plan Version 3.1* (Golder 2017b) outlines the quality assurance (QA) and quality control (QC) procedures employed to support the collection of scientifically defensible and relevant data addressing the objectives of the AEMP. A description of QA/QC practices applied to the water quality component of the 2019 AEMP and an evaluation of the QC data are provided in Attachment B. A summary of the main QC issues identified during the 2019 AEMP sampling is provided herein. With the exception of the specific circumstances summarized below and in Attachment B, data collected during the 2019 AEMP were considered to be of acceptable quality.

2.4.1 Ammonia Investigation

In 2019, DDMI sent lake water quality samples to both BV Labs and ALS for analysis of ammonia. The reader is also directed to Appendix 4B of the *2014 to 2016 Aquatic Effects Re-evaluation Report Version 1.1* (Golder 2019c) and Appendix B of the 2017 and 2018 AEMP annual effluent and water chemistry reports (Golder 2018b and 2019d) for a review of the history of the ammonia contamination issue and a description of recent investigations and follow-up studies.

In both the ice-cover and open-water seasons the ammonia sample bottles provided by BV Labs were identified as having been preloaded with contaminated preservative. For the ice-cover season, BV Labs recommended that the ALS ice-cover data be reported. Since the ALS data did not appear to have a similar contamination issue, this recommendation was accepted and the ammonia data generated by ALS was used in the data analysis. In the open-water season, BV Labs conducted the ammonia analysis on sample water obtained from the unpreserved general chemistry bottle; however, there was no alternate container for seven samples (three of which were QC samples) and the original contaminated data were reported in error (Attachment B, Table B-3). These seven samples were removed from the dataset. An inter-laboratory comparison study of the open-water data conducted by BV Labs determined that the BV Labs ammonia data analyzed from the unpreserved general chemistry bottles were useable and had fewer data quality issues than the ALS data. Therefore, the ammonia data generated by BV Labs were used for the open-water season.

Further details on efforts to improve ammonia data quality in 2019 are provided in Attachment B, including results of the 2019 open-water inter-laboratory comparison study. Although there were data quality issues for ammonia in 2019, the concentrations were well below toxicological risk-based benchmarks for the protection of aquatic life (i.e. AEMP Effects Benchmarks). The DL used for ammonia (0.005 mg/L) is at the absolute limit of instrument sensitivity, and concentrations measured close to the DL are subject to high uncertainty as a result. This uncertainty is a key factor contributing to the data quality issues for ammonia. DDMI will continue to work with the analytical laboratory to determine a path forward for ammonia analysis for future monitoring.

3 RESULTS

3.1 Substances of Interest

Sixteen variables met the criteria for inclusion as SOIs in 2019 (Table 3-1) as per the selection procedure described in Section 2.3.1:

- *Criterion 1:* None of the effluent chemistry variables with EQC were added to the SOI list because concentrations in individual grab samples were less than EQC for the maximum average concentration (Section 3.2.4) in all samples analyzed during the 2019 reporting period.
- *Criterion 2:* None of the mixing zone water chemistry variables with Effects Benchmarks were added to the SOI list because concentrations in all samples analyzed during the 2019 reporting period were below the relevant Effects Benchmarks (Section 3.2.5).
- *Criterion 3:* Sixteen variables were added to the list of SOIs because they triggered Action Level 1 (Section 3.5.1): TDS, turbidity, calcium, chloride, magnesium, sodium, sulphate, ammonia, nitrate, aluminum, barium, manganese, molybdenum, silicon, strontium, and uranium.
- *Criterion 4:* No additional variables were added as SOIs as a result of applying this criterion. Eleven of SOIs selected under Criterion 3 also triggered an effect equivalent to Action Level 1 at one or more of the four MF area stations located within the estimated ZOI from dust deposition from the Mine site (Section 3.9): TDS, turbidity, calcium, chloride, sodium, sulphate, ammonia, nitrate, molybdenum, strontium, and uranium. The triggers at the MF stations were likely caused by dispersion of Mine effluent within the lake.

Table 3-1 Water Quality Substances of Interest, 2019

Substance of Interest	Substances of Interest Criteria			
	1 Effluent Screening	2 Mixing Zone Screening	3 Action Level 1	4 Potential Dust Effects
Conventional Parameters				
Total dissolved solids, calculated	-	-	X	X
Turbidity – lab	-	-	X	X
Major Ions				
Calcium (dissolved)	-	-	X ^(a)	X ^(b)
Chloride	-	-	X	X
Magnesium (dissolved)	-	-	X ^(a)	-
Sodium (dissolved)	-	-	X ^(a)	X ^(b)
Sulphate	-	-	X	X
Nutrients				
Ammonia	-	-	X	X
Nitrate	-	-	X	X
Total Metals				
Aluminum	-	-	X	-
Barium	-	-	X	-
Manganese	-	-	X	-
Molybdenum	-	-	X	X
Silicon	-	-	X	-
Strontium	-	-	X	X
Uranium	-	-	X	X

a) Both the total and dissolved fractions of calcium and sodium triggered Action Level 1. Only the total fraction of magnesium triggered Action Level 1. To avoid redundancy and match methods from previous annual reports, the analysis was conducted on the dissolved fractions only.

b) Total and dissolved calcium and sodium triggered an effect equivalent to Action Level 1 at one or more of the four mid-field (MF) area stations located within the estimated zone of influence (ZOI) from dust deposition from the Mine site. To avoid redundancy and match methods from previous annual reports, the analysis was conducted on the dissolved fractions only.

X = criterion met; - = criterion not met.

3.2 Trends in Effluent and at the Mixing Zone Boundary

3.2.1 Conventional Variables, Total Dissolved Solids, and Associated Ions

The conventional variables and major ions that met Criteria 1 to 3 of the SOI selection process (Section 2.3.1) included TDS, turbidity, calcium, chloride, magnesium, sodium, and sulphate. Loads of these variables, together with their concentrations in effluent and at the mixing zone, are presented in Figure 3-1 to Figure 3-7.

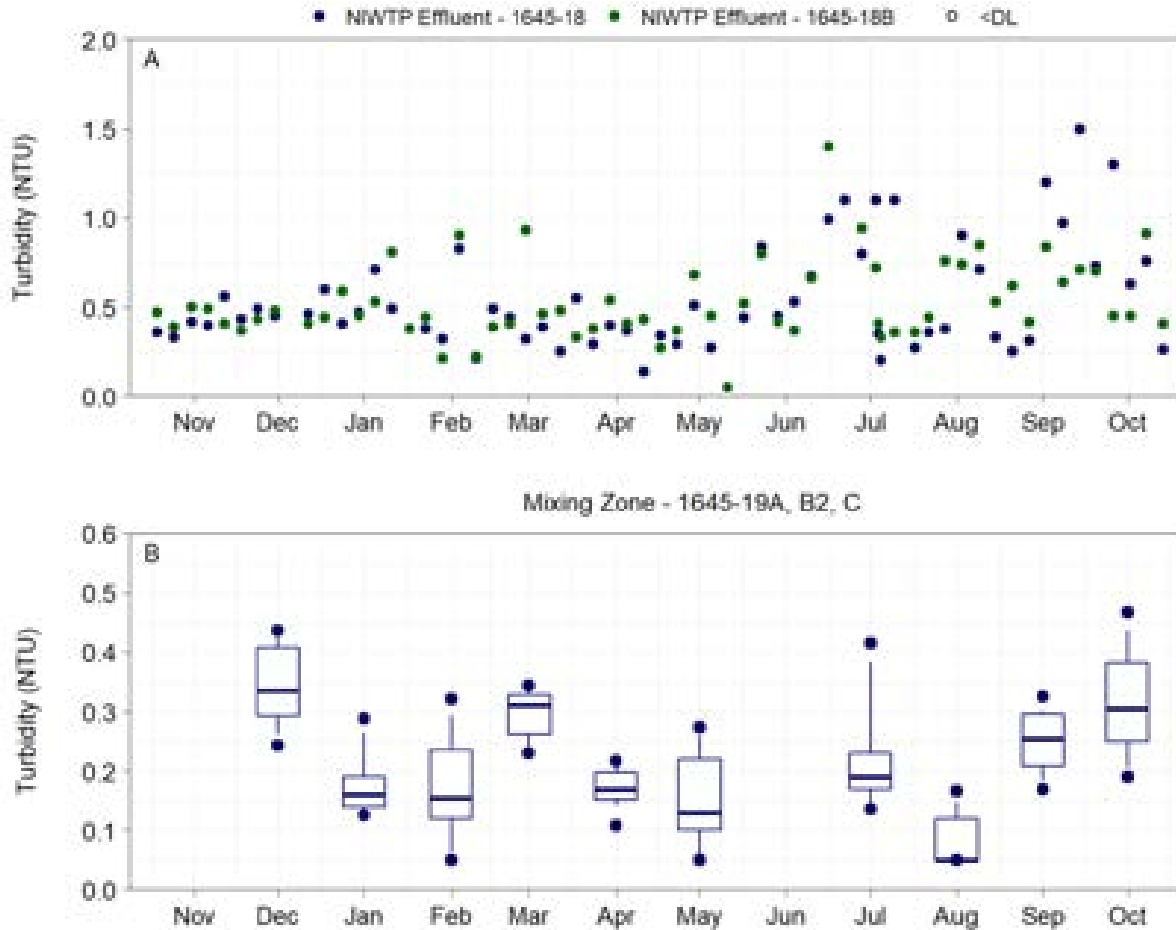
The turbidity of the effluent discharged from the NIWTP was generally more variable during the open-water season compared to in ice-cover (Figure 3-1A). Median turbidity values at the mixing zone boundary varied without a distinct pattern, with the smallest median values occurring in August, and the largest values occurring in December (Figure 3-1B).

The monthly loads of TDS and associated ions (i.e., calcium, chloride, magnesium, sodium and sulphate) from the NIWTP remained within a similar range through April, reflecting the variation in the monthly volume of effluent discharged (Figure 3-2A to Figure 3-7A). The loads of these SOIs increased during the late ice-cover and early open-water seasons, peaking in August, before decreasing through the remainder of the open-water season as flow rates from the NIWTP decreased.

The concentrations of TDS, calcium, magnesium, and sulphate in the effluent decreased from November to January. Calcium concentrations increased gradually over the remainder of the reporting season (Figure 3-3B). The concentrations of TDS, magnesium and sulphate remained within a similar range from January until May or June, and then increased from May or June to August or September, before gradually declining again through the late open-water season (Figure 3-2B, Figure 3-5B, and Figure 3-7B). The concentration of chloride remained within a similar range until May, decreased slightly from May to August, before gradually increasing during the late open-water season (Figure 3-4B). The concentration of sodium remained within a similar range throughout the ice-cover season, before subsequently increasing through the open-water season (Figure 3-6B).

The median concentrations of TDS and associated ions at the mixing zone boundary generally increased through the ice-cover season, with the exception of decreases in the concentrations of calcium, magnesium, and sodium during the month of May. Median concentrations were lower during the open-water season for these SOIs, with the exception of sulphate, which had open-water concentrations similar to ice-cover concentrations (Figure 3-2C to Figure 3-7C). Concentrations of most of these SOIs at the mixing zone boundary were more variable during ice-cover compared to the open-water season.

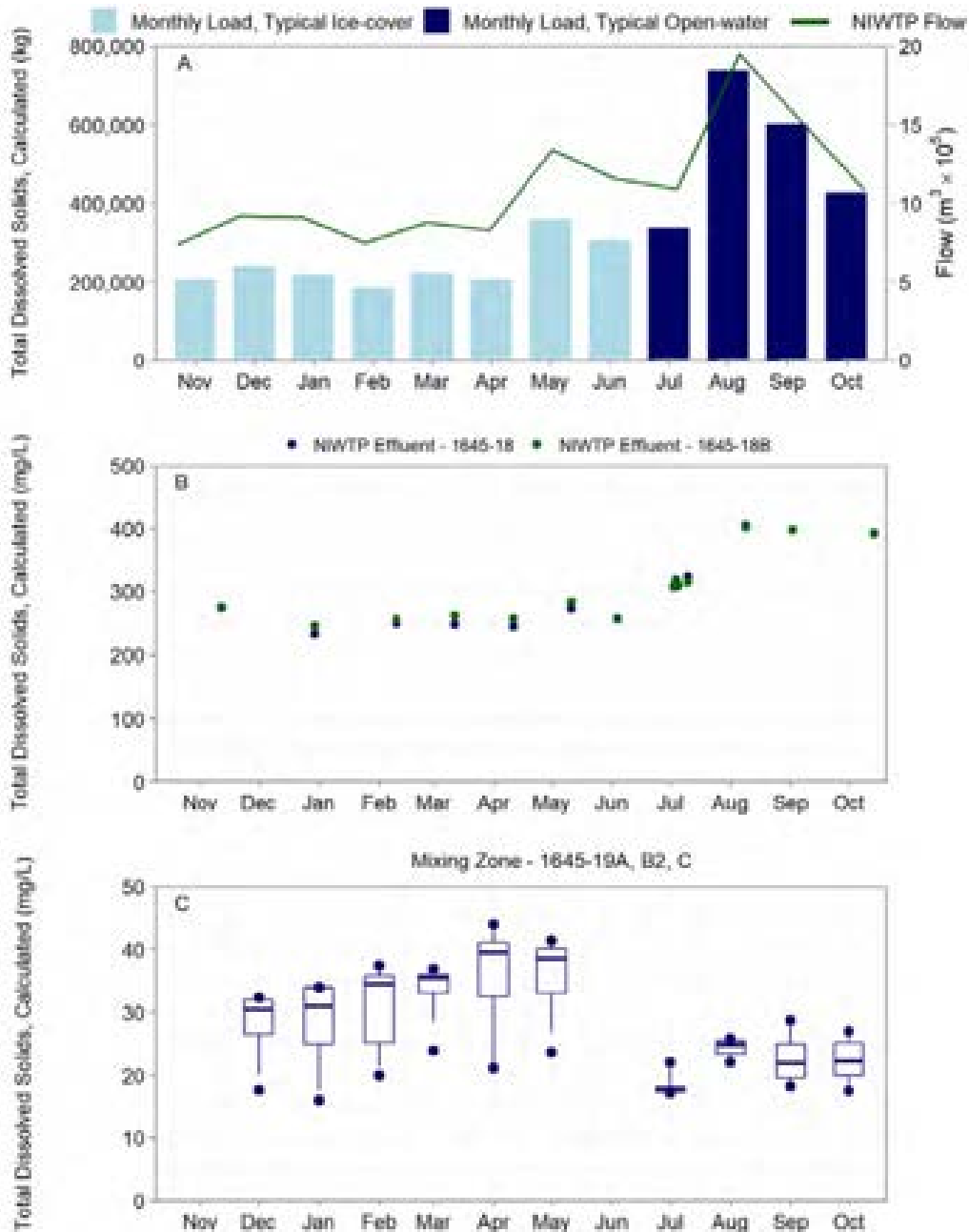
Figure 3-1 Turbidity: A) North Inlet Water Treatment Plant Effluent (SNP 1645-18 and SNP 1645-18B) and at B) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

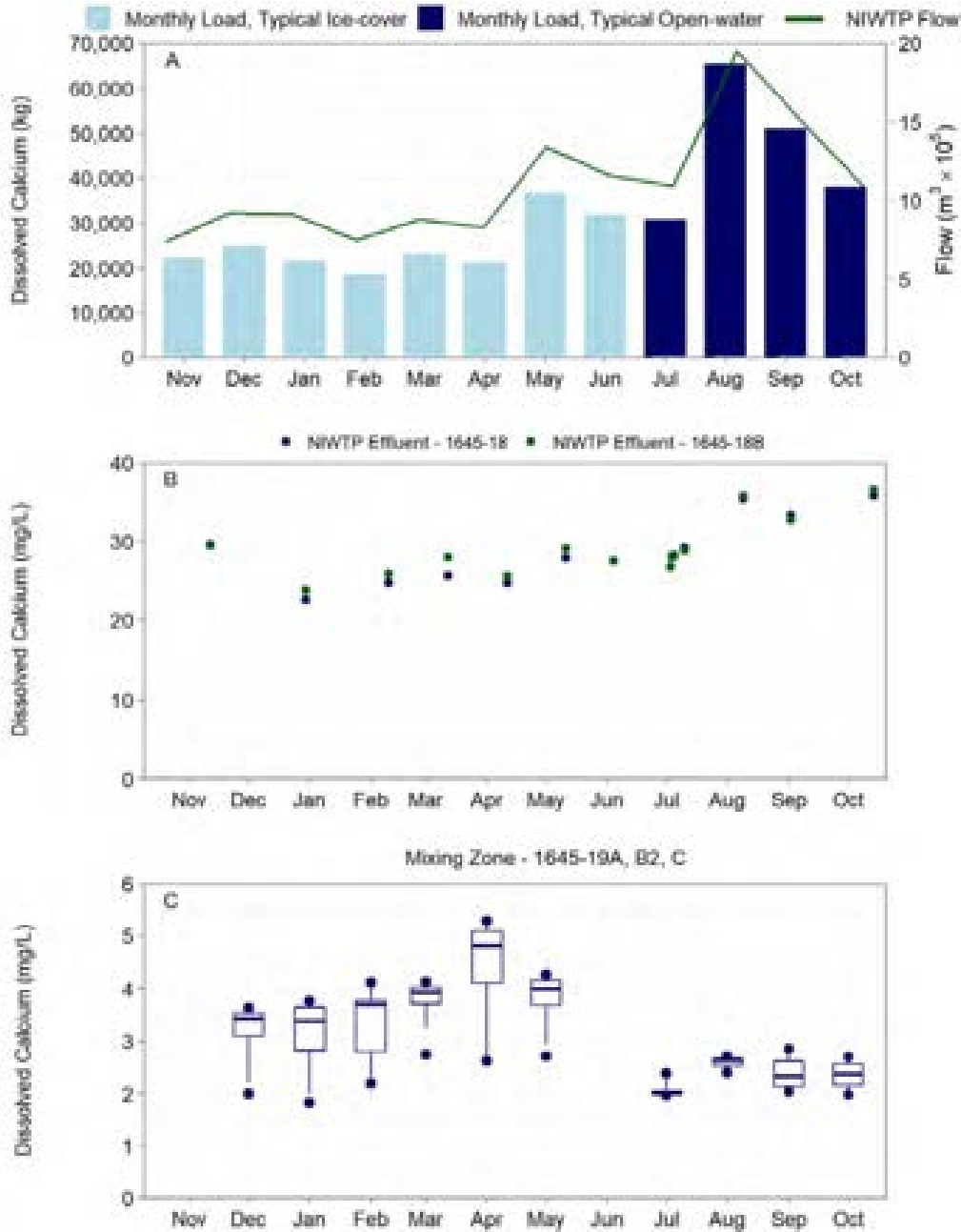
Figure 3-2 Total Dissolved Solids, Calculated: A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

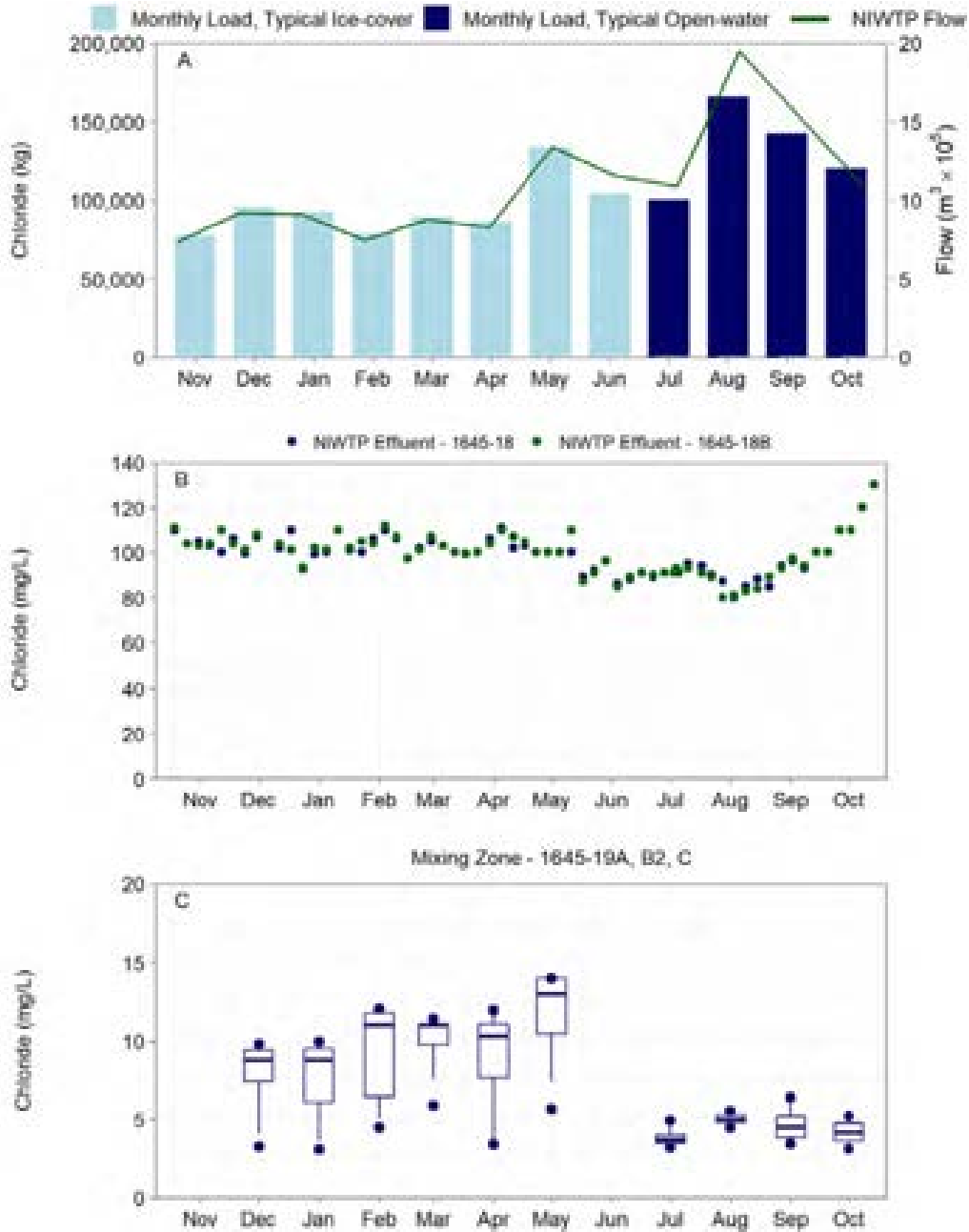
Figure 3-3 Calcium (Dissolved): A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

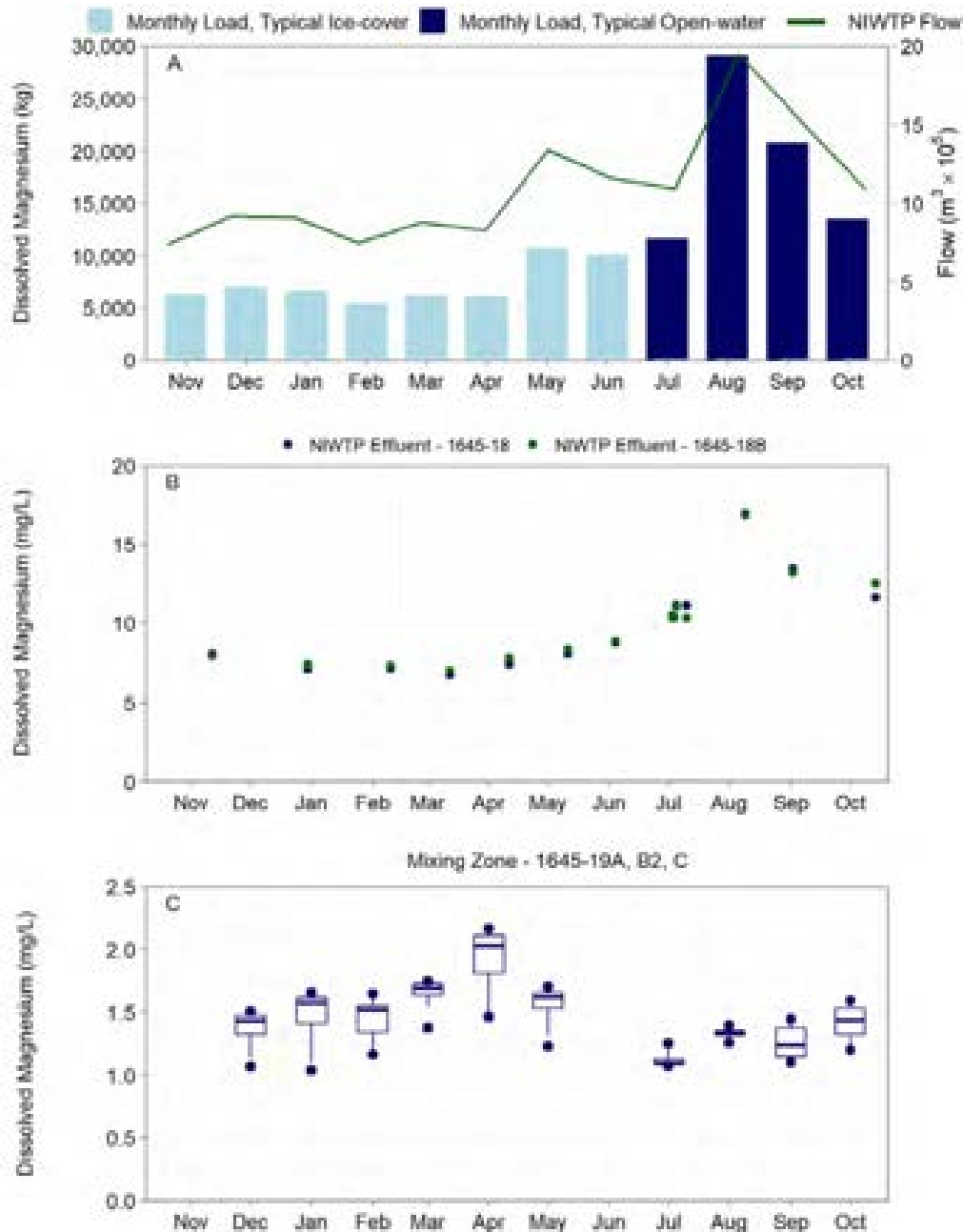
Figure 3-4 Chloride: A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

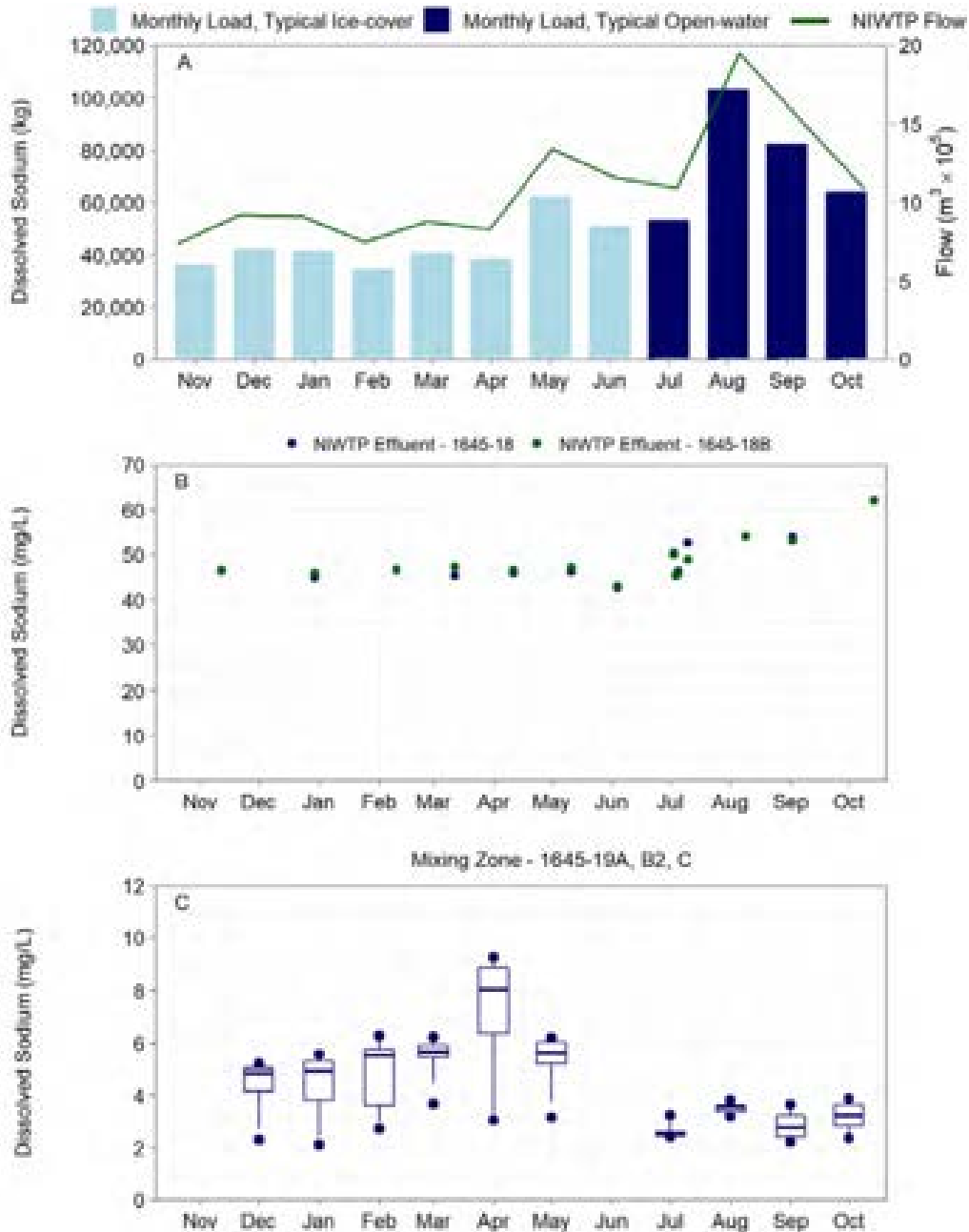
Figure 3-5 Magnesium (Dissolved): A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

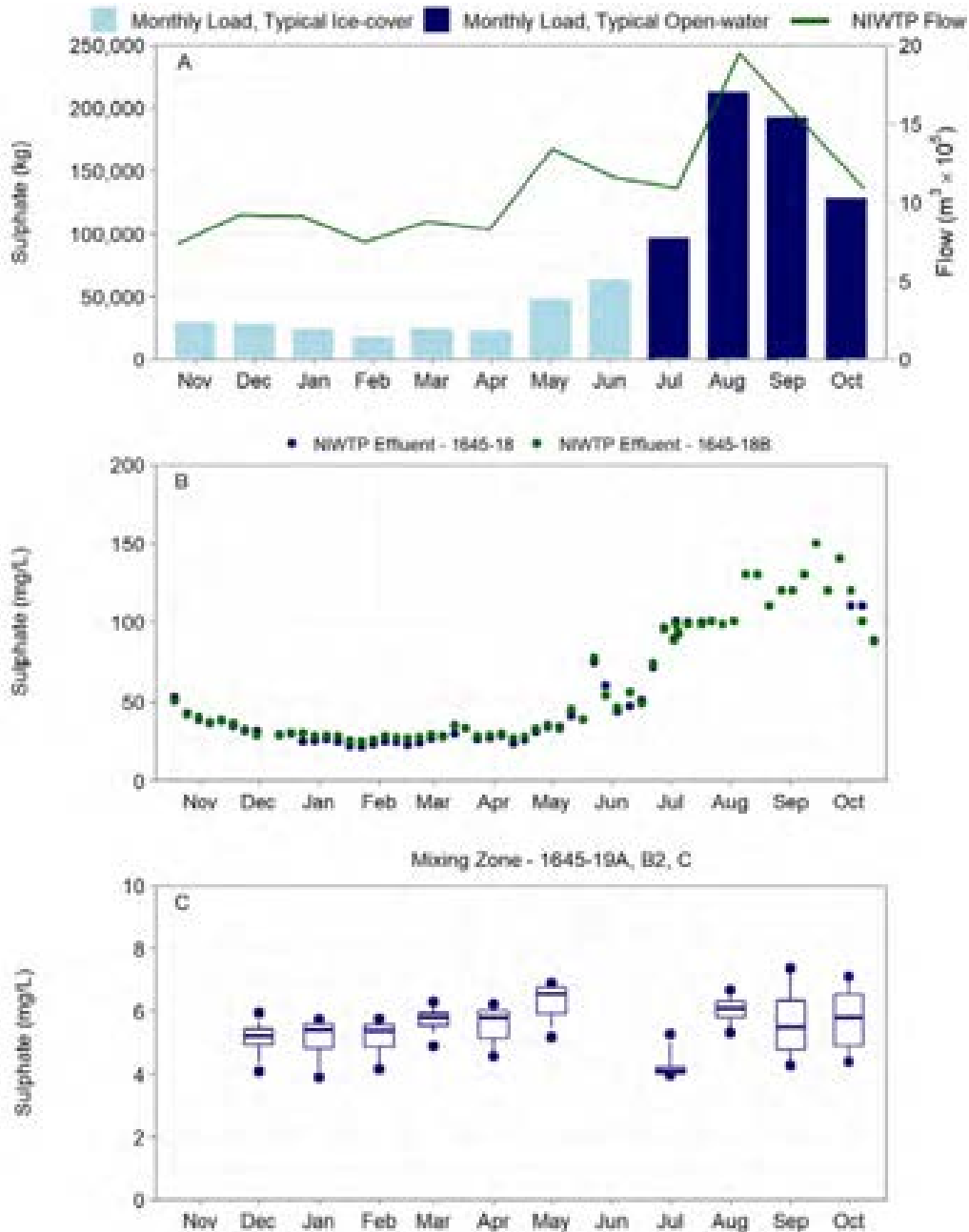
Figure 3-6 Sodium (Dissolved): A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

Figure 3-7 Sulphate: A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

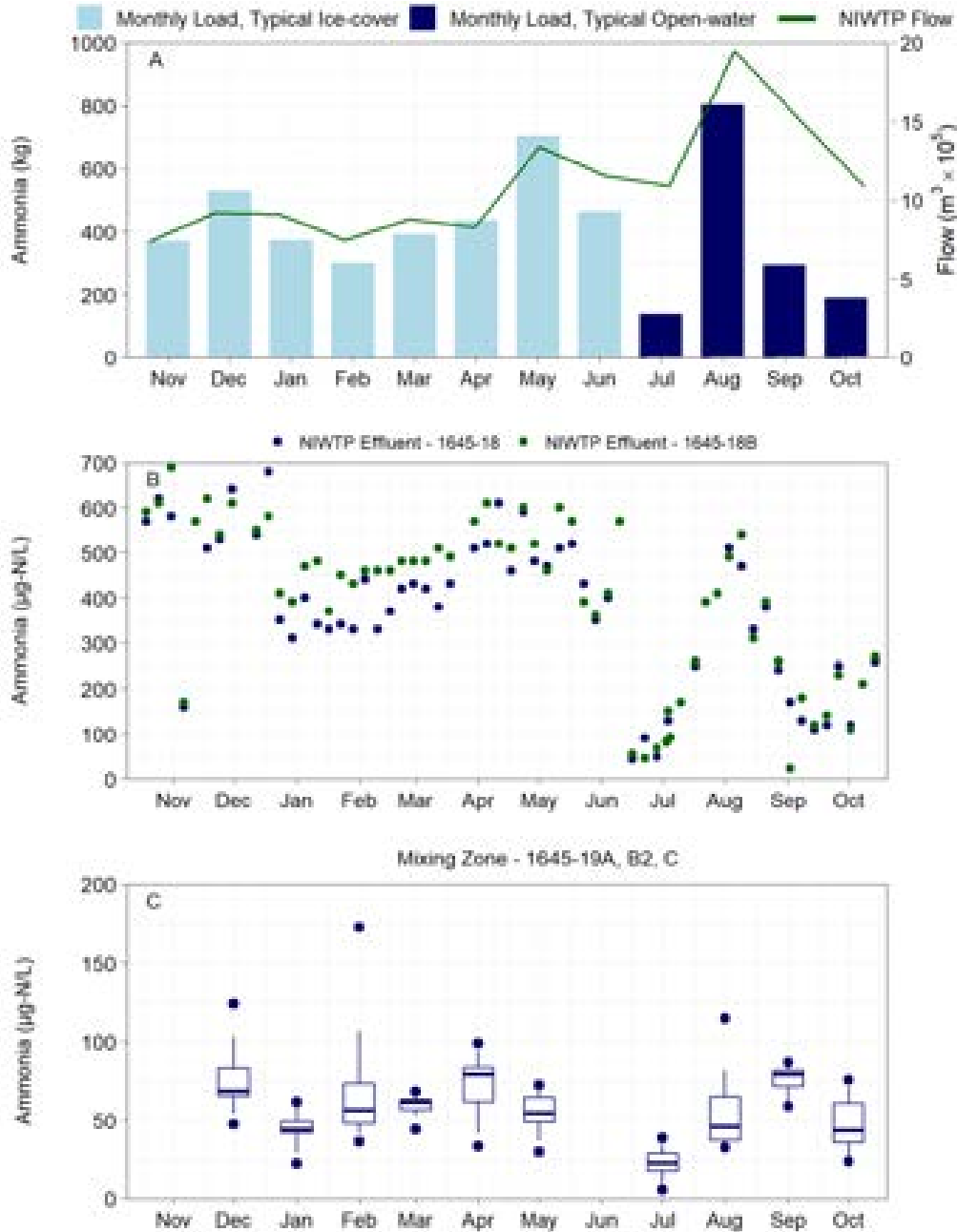
3.2.2 Nitrogen Variables

The nitrogen variables that met Criteria 1 to 3 in the SOI selection process (Section 2.3.1) included ammonia and nitrate. Loads of these variables, together with their concentrations in effluent and at the mixing zone boundary, are presented in Figure 3-8 and Figure 3-9.

The monthly loading rate of ammonia varied within a similar range from November to April, and increased in May (Figure 3-8A/B). Monthly loads of ammonia decreased through the late ice-cover and early open-water seasons, and then peaked in August before declining again in the late open-water season. The seasonal trend in the loading rate of ammonia reflected trends both in the effluent flow rate and in effluent concentration. The load and concentration of nitrate generally declined through the early ice-cover season from November to February, and then increased through late ice-cover and early open-water seasons, peaking in August, before decreasing again in October (Figure 3-9A/B).

The median concentrations of ammonia at the mixing zone boundary varied without a distinct pattern, with smallest median values occurring in July, and the largest values occurring in September (Figure 3-8C). The median concentrations of nitrate at the mixing zone remained within a similar range from December to March, and then increased through the late ice-cover season. Median nitrate concentrations at the mixing zone were generally smaller during the open-water season compared to ice-cover, with the exception of August, which had a median concentration similar to that observed during ice-cover, likely reflecting the increase in both the effluent loading rate and concentration of nitrate in August (Figure 3-9C).

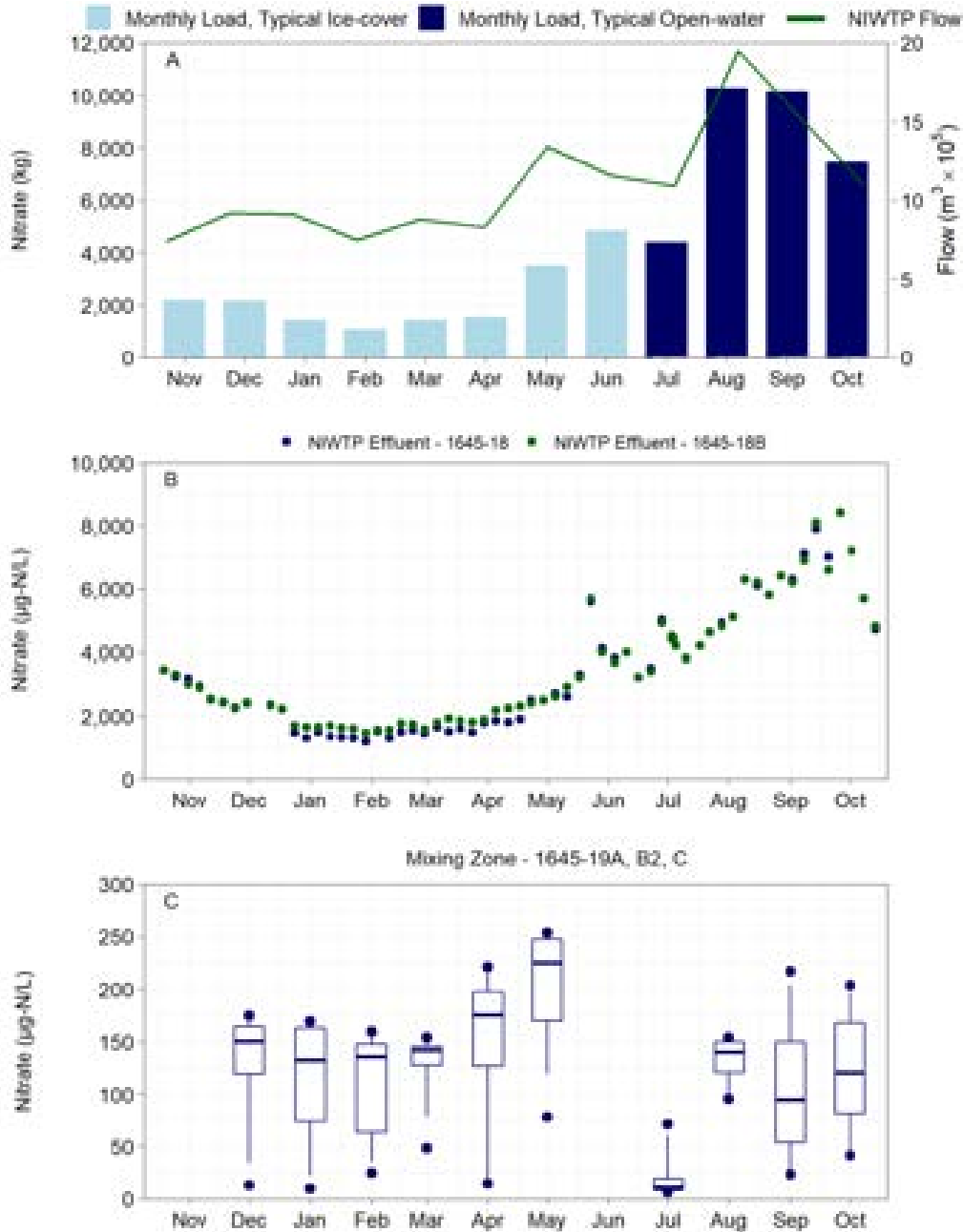
Figure 3-8 Ammonia: A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

Figure 3-9 Nitrate: A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

3.2.3 Total Metals

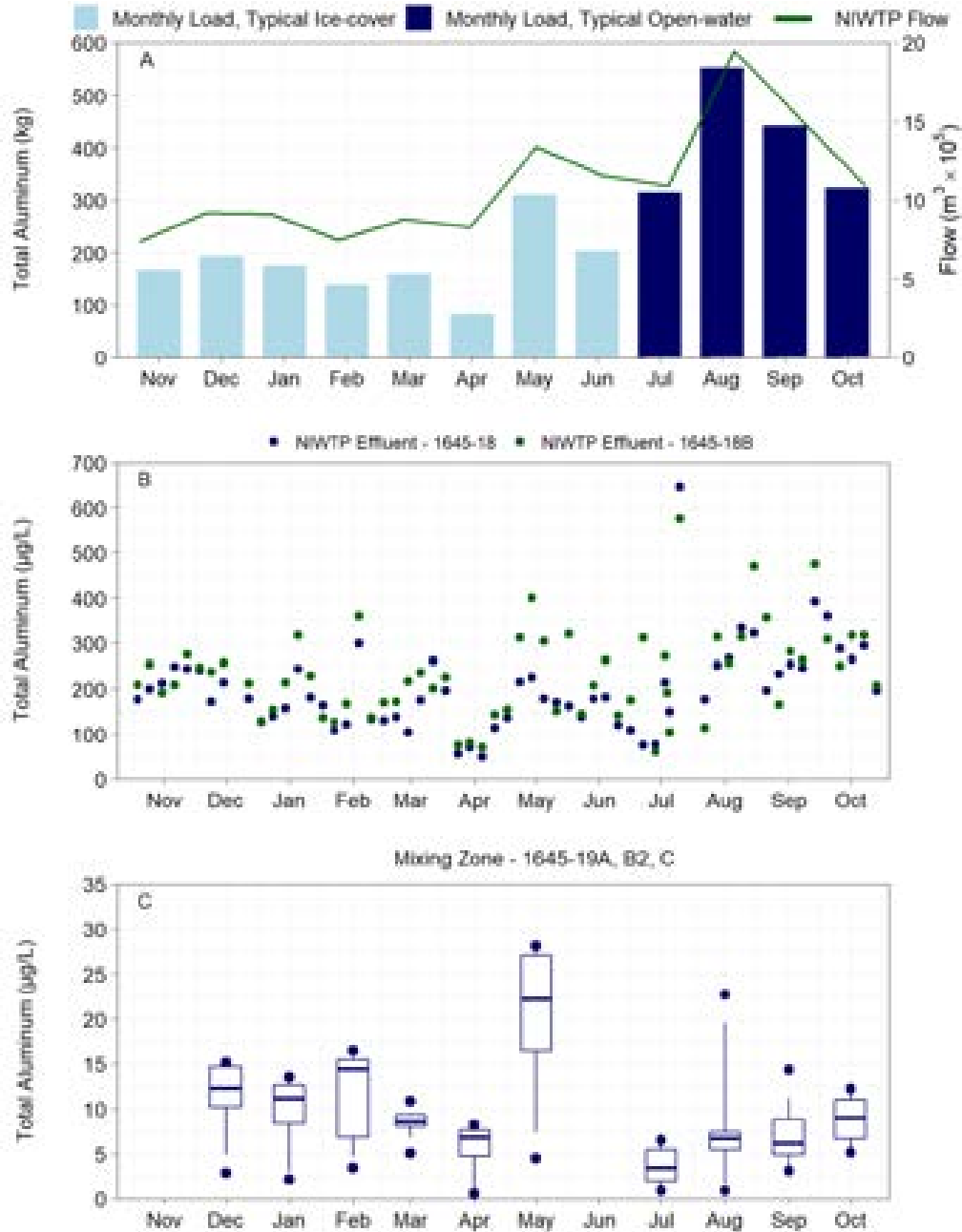
The total metal SOIs that met Criteria 1 to 3 in the SOI selection process (Section 2.3.1) included aluminum, barium, manganese, molybdenum, silicon, strontium, and uranium. Loads of these variables, together with their concentrations in effluent and at the mixing zone boundary, are presented in Figure 3-10 to Figure 3-16. The monthly loading rates of total metal SOIs either reflected trends in the effluent flow rate or chemistry, or were influenced by a combination of the two.

The seasonal pattern in the concentrations of variables in the effluent over the reporting period were variable-specific:

- The concentrations of aluminum, strontium, and uranium generally decreased through the ice-cover season, then increased during the open-water season (Figure 3-10B, Figure 3-15B, and Figure 3-16B). Concentrations of aluminum were more variable during the open-water season compared to in ice-cover (Figure 3-10B).
- The concentration of barium in the effluent decreased from November to January and then generally increased through the remainder of the reporting period (Figure 3-11B).
- The concentration of manganese in effluent generally decreased through the ice-cover season to approximately March, increased through late ice-cover, and then decreased in early open-water, before increasing again during the late open-cover season (Figure 3-12B).
- The concentration of molybdenum in effluent decreased gradually from November to January, remained within a similar range through April, then increased and became more variable during the open-water season (Figure 3-13B).
- The concentration of silicon in effluent increased from November to January, remained within a similar range through May, decreased in late ice-cover, and subsequently remained within a similar range for the remainder of the reporting period (Figure 3-14B).

Concentrations of total metal SOIs in the effluent were greater than the concentrations measured at the mixing zone boundary in 2019, indicating that the Mine effluent is a source of these variables to Lac de Gras. The concentrations of most of these SOIs at the mixing zone boundary were generally greater and more variable during the ice-cover season than during the open-water season (Figure 3-10C to Figure 3-16C).

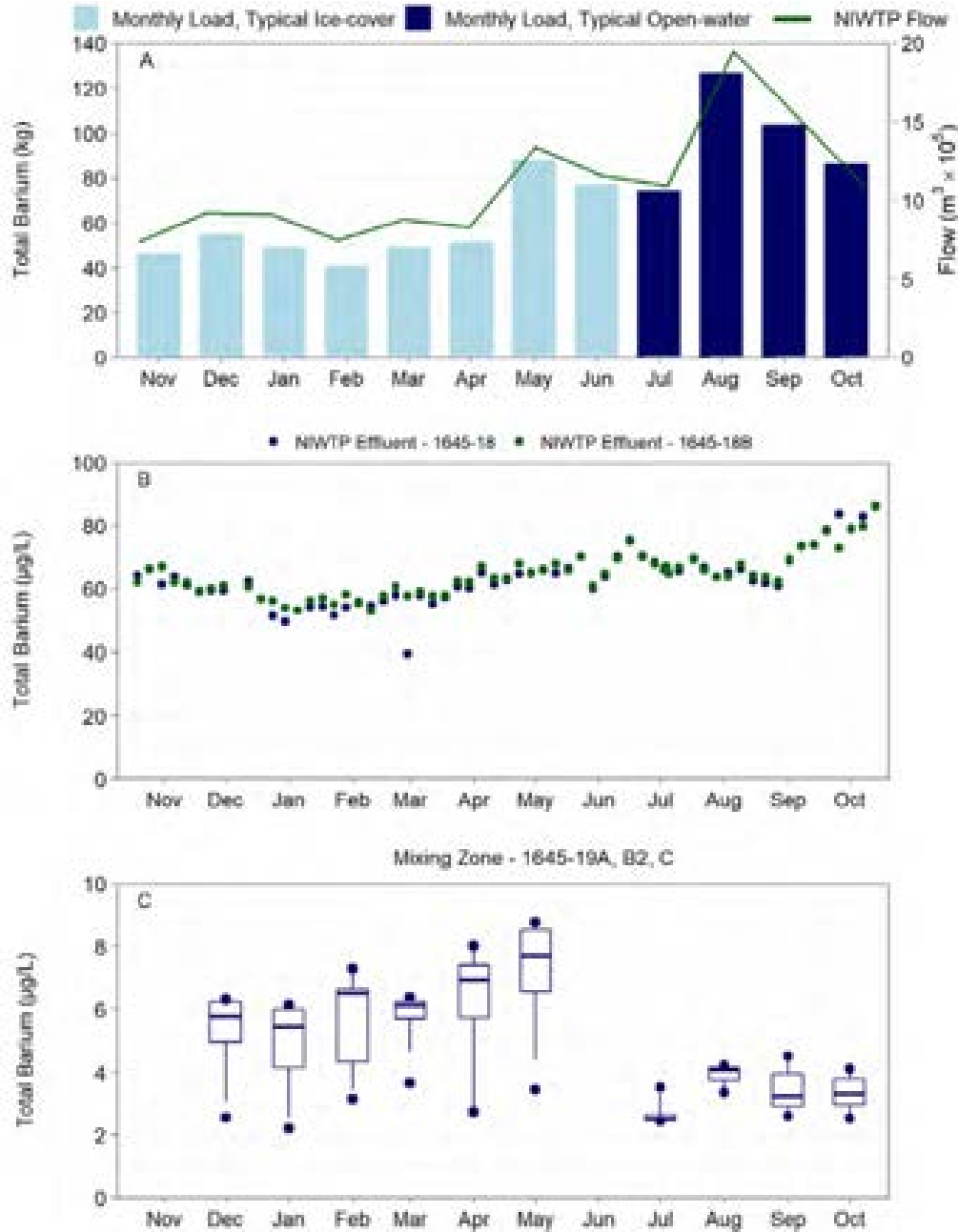
Figure 3-10 Aluminum: A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

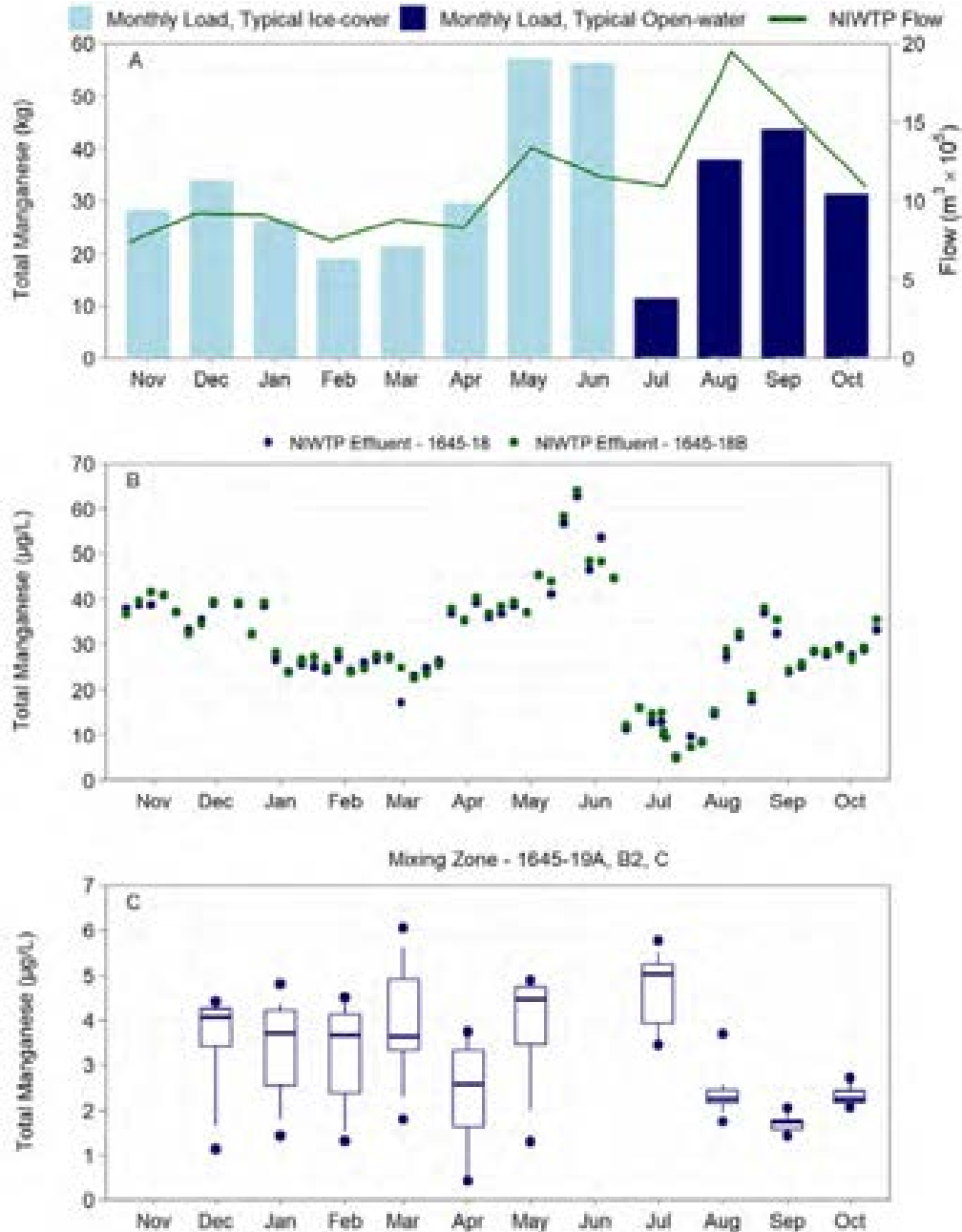
Figure 3-11 Barium: A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

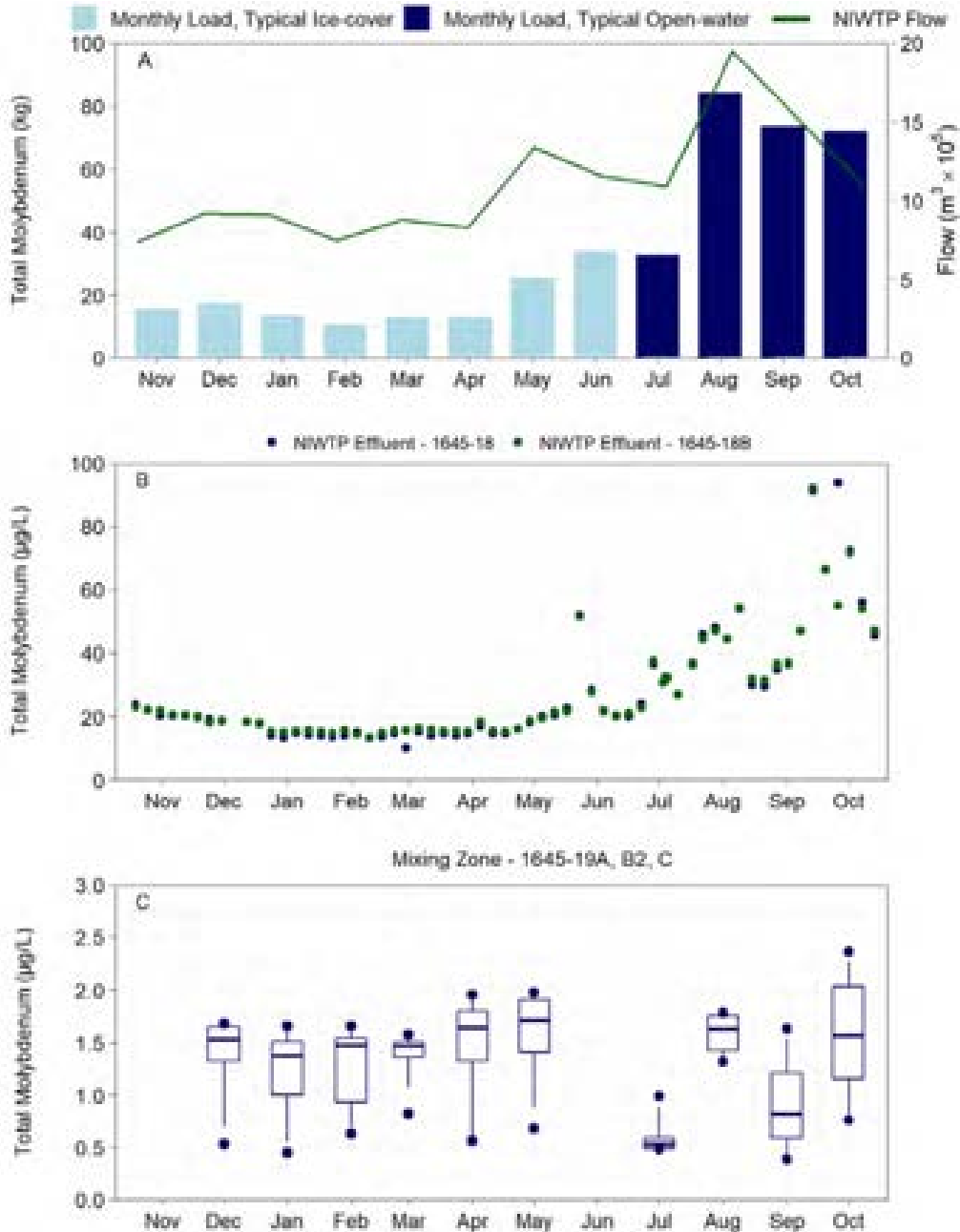
Figure 3-12 Manganese: A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

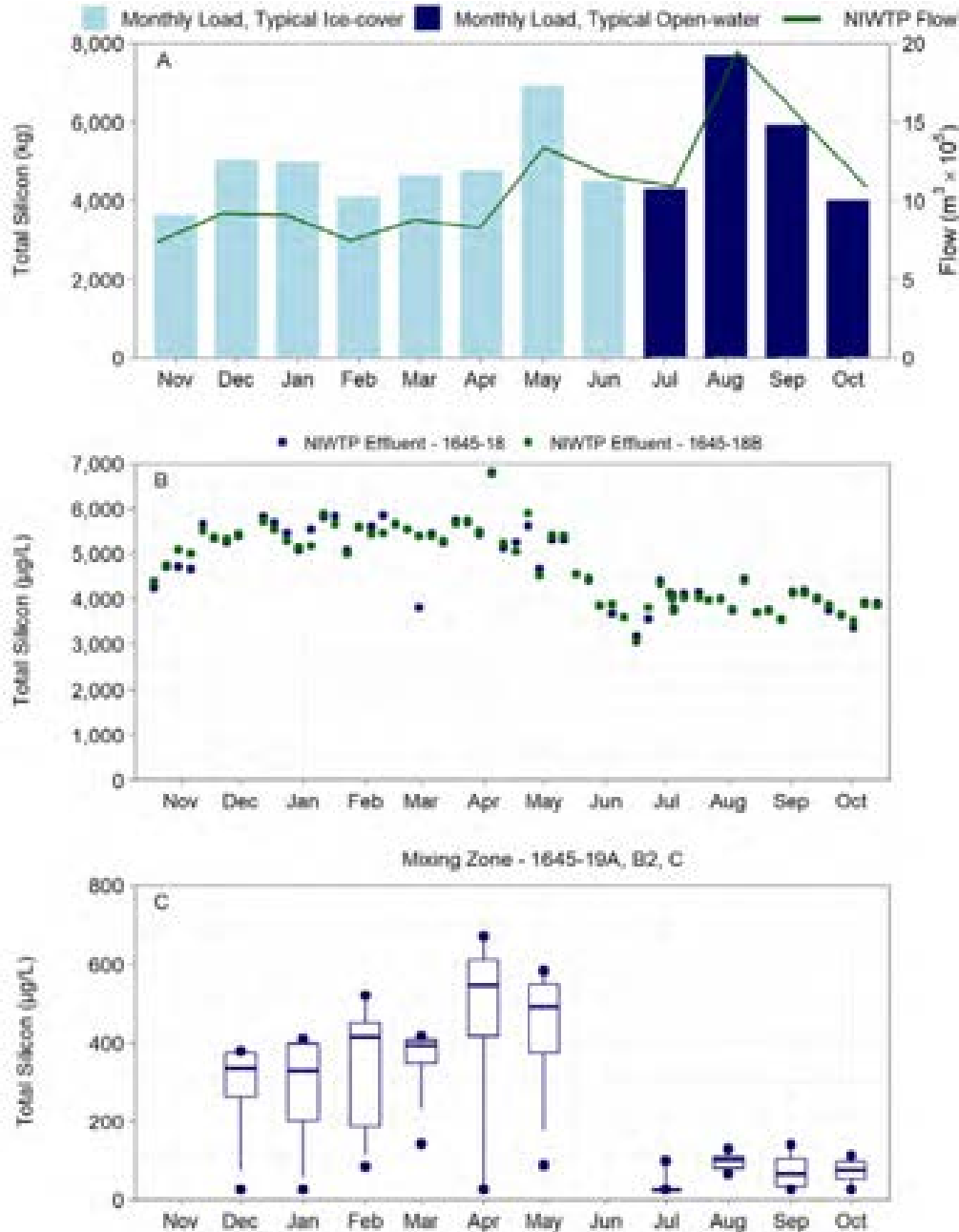
Figure 3-13 Molybdenum: A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

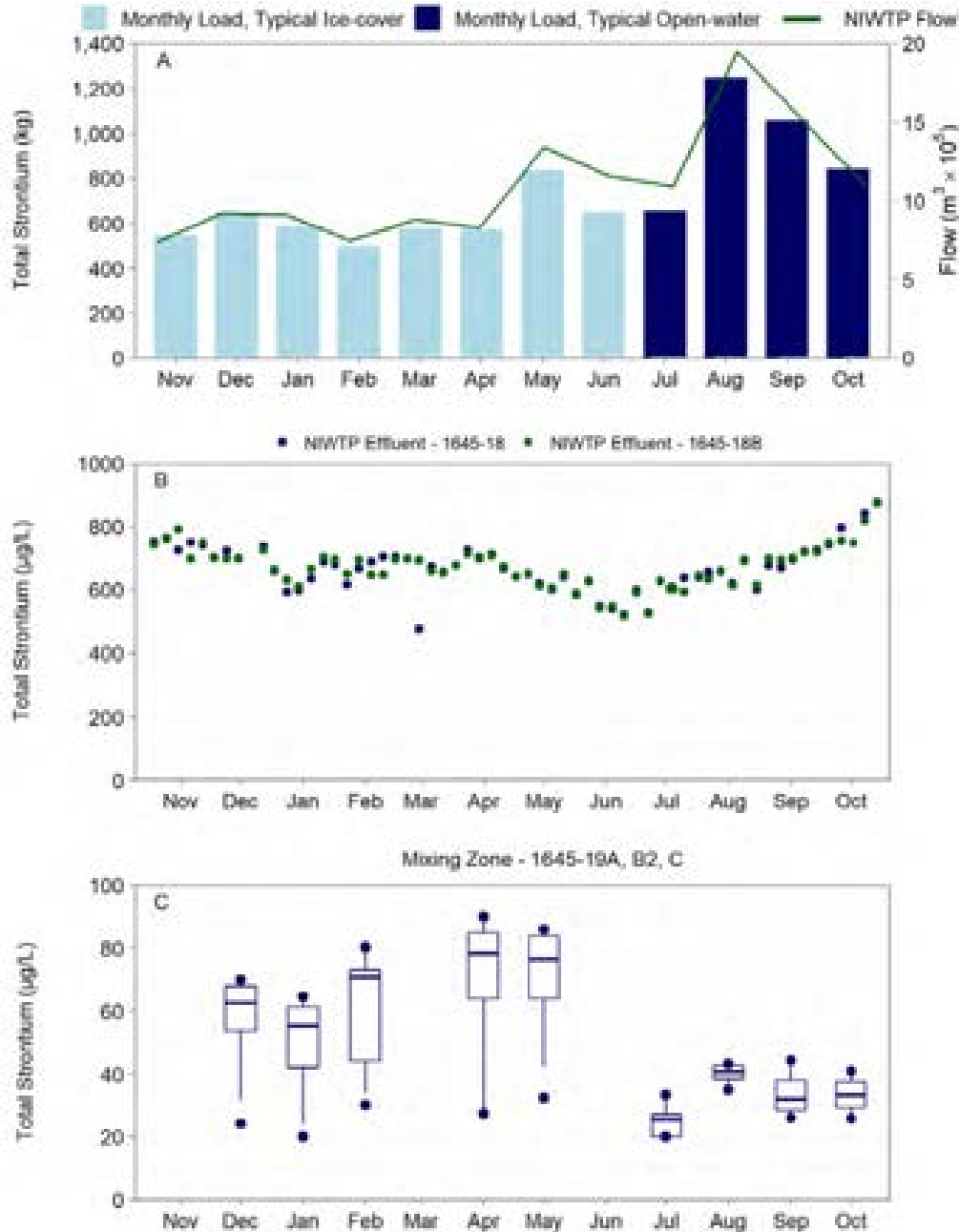
Figure 3-14 Silicon: A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

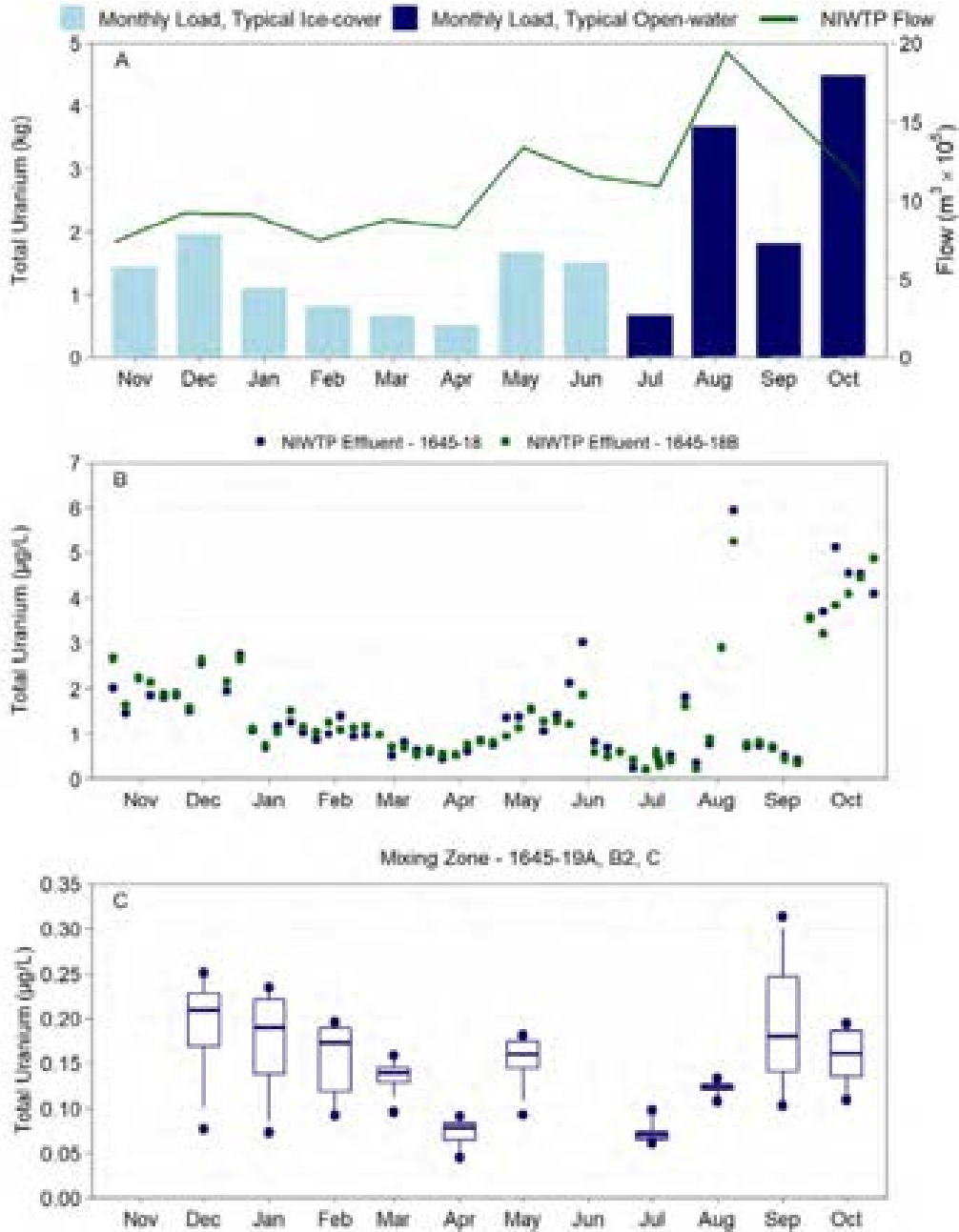
Figure 3-15 Strontium: A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

Figure 3-16 Uranium: A) Monthly Loading Rate from the North Inlet Water Treatment Plant and Concentration in B) Effluent (SNP 1645-18 and SNP 1645-18B) and at C) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in November 2018 as well as June 2019 due to hazardous ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

3.2.4 Comparison to Effluent Quality Criteria

During the 2019 sampling period, concentrations of variables in effluent with EQC were below the maximum allowable concentration in any grab sample (Table 3-2). Similarly, the average concentrations were below EQC for the Maximum Average Concentration at both diffusers.

Concentrations of both of the total aluminum grab samples collected on 31 July 2019 (1645-18: 2,120 µg/L and 1645-18B: 1,730 µg/L) were above the maximum average concentration (1,500 µg/L). Both total aluminum values were removed as anomalous values in the initial data screening (Section 2.3.2), indicating that these were extreme values compared to other effluent samples. Consequently, total aluminum did not trigger Criterion 1 in the SOI selection process (Section 2.3.1).

In addition to the criteria listed in Table 3-2, all discharges from the NIWTP in 2019 to Lac de Gras had pH values between 6.0 to 8.4 (range: 6.1 to 8.1; median: 7.4), per Water Licence requirements (WLWB 2015). The monthly SNP reports submitted to the WLWB provide graphs demonstrating compliance of effluent chemistry with EQCs. These reports are accessible on the WLWB public registry.

3.2.5 Comparison of Mixing Zone Data to Effects Benchmarks

During the 2019 sampling period, nearly all concentrations measured in samples collected at the mixing zone boundary were within the relevant AEMP water quality Effects Benchmarks for the protection of aquatic life and drinking water (Table 3-3). An exception was the total chromium sample at SNP 1645-19C, collected on 17 December 2018 (2.24 µg/L), which exceeded the Effects Benchmark of 1 µg/L. However, the dissolved value associated with this sample was well below the Effects Benchmark (0.088 µg/L), indicating that the total chromium value was likely an error. In addition, this value was identified as an anomalous value during the initial data screening (Section 2.3.2), indicating that it was an extreme value compared to other samples collected at the mixing zone boundary. All other total chromium values were below the Effects Benchmarks. Consequently, total chromium did not trigger Criterion 2 in the SOI selection process (Section 2.3.1).

None of the pH values measured at the mixing zone boundary in 2019 exceeded the upper limits of the aquatic life and drinking water Effects Benchmarks (i.e., 8.5 and 9.0). However, pH values measured at the mixing zone boundary in 2019, particularly during July to October 2019, were below the Effects Benchmark value of 6.5 (Table 3-3). Because the pH of the Mine effluent was slightly alkaline and the pH throughout Lac de Gras was often below the Effects Benchmark of 6.5, during both ice-cover and open-water conditions at various depths, and over time (i.e., 2002 to 2016; Golder 2019c), these exceedances were attributed to natural conditions and unrelated to the Mine discharge. Therefore, pH did not trigger Criterion 2 in the SOI selection process (Section 2.3.1) and was not considered an SOI.

Table 3-2 Comparison of Effluent Chemistry to Effluent Quality Criteria, 1 November 2018 to 31 October 2019

Variable	Units	Effluent Quality Criteria		Effluent Concentration		
		Maximum Average Concentration	Maximum Concentration of Any Grab Sample	Minimum	Maximum	Median
Total ammonia	µg-N/L	6,000	12,000	23	690	410
Total aluminum	µg/L	1,500	3,000	49.5	2,120 ^(a)	207
Total arsenic	µg/L	50	100	0.4	2.2	0.97
Total copper	µg/L	20	40	0.098	1.39	0.3
Total cadmium	µg/L	1.5	3	<0.005	0.017	0.0025
Total chromium	µg/L	20	40	0.39	2.1	0.66
Total lead	µg/L	10	20	<0.005	0.034	0.007
Total nickel	µg/L	50	100	2.2	9.5	3.7
Total zinc	µg/L	10	20	<1	6.5	0.27
Nitrite	µg-N/L	1,000	2,000	<1	290	96
Total suspended solids	mg/L	15.0	25.0	<1	6.5	2.4
Turbidity	NTU	10	15	<0.1	2.9	0.6
Biochemical oxygen demand	mg/L	15.0	25.0	<2	13	1.0
Total petroleum hydrocarbons	mg/L	3.0	5.0	<0.26	<0.44	0.13
Fecal coliforms	CFU/100 mL	10	20	<1	1.0	0.5

a) This value was identified as anomalous during data screening.

µg-N/L = micrograms nitrogen per litre; NTU = nephelometric turbidity unit; CFU = colony forming units.

Table 3-3 Comparison of Mixing Zone Water Chemistry to AEMP Effects Benchmarks, 1 November 2018 to 31 October 2019

Variable	Unit	Effects Benchmarks		Mixing Zone Concentration		
		Protection of Aquatic Life	Drinking Water	Minimum	Maximum	Median
Conventional Parameters						
Dissolved oxygen – field	mg/L	6.5 ^(a)	-	11.1	15.7	13.9
pH – BV Labs	pH Units	6.5 to 9.0	6.5 to 8.5	5.7	7.2	6.8
pH – DDMI Labs	pH Units	6.5 to 9.0	6.5 to 8.5	6.1	7.3	6.8
Total dissolved solids, calculated	mg/L	500	500	16	44	27
Total dissolved solids, measured	mg/L	500	500	16	53	32
Total suspended solids	mg/L	+5 (24 h to 30 days) +25 (24 h period)	-	<1	5.3	1
Turbidity – lab	NTU	2.2 (long term, IC) 2.3 (long term, OW)	-	<0.1	0.52	0.21
Major Ions						
Chloride	mg/L	120	250	3.0	14	6.3
Fluoride	mg/L	0.12	1.5	0.03	0.047	0.036
Sodium (dissolved)	mg/L	52	200	2.1	9.4	3.8
Sulphate	mg/L	100	500	3.8	7.5	5.5
Nutrients						
Ammonia	µg/L	4,730	-	<5	270	59
Nitrate	µg/L	3,000	10,000	5.6	260	136
Nitrite	µg/L	60	1,000	<1	13	1.2
Total Metals						
Aluminum (total)	µg/L	87	100/200	0.39	29	8.2
Aluminum (dissolved)	µg/L	50 ^(b)	-	0.1	16	6.4
Antimony	µg/L	33	6	<0.02	0.052	0.027
Arsenic	µg/L	5	10	0.18	0.44	0.32
Barium	µg/L	1,000	1,000	2.2	8.9	4.3
Boron	µg/L	1,500	5,000	<5	9.9	<5
Cadmium	µg/L	0.1	5	<0.005	<0.005	<0.005
Chromium	µg/L	1 (Cr VI)	50	<0.05	2.24^(c)	0.054
Copper	µg/L	2	1,000	0.47	1.5	0.57
Iron	µg/L	300	300	<1	10	2.5
Lead	µg/L	1	10	<0.005	0.018	<0.005
Manganese	µg/L	-	50	0.36	10	3.3
Mercury	µg/L	0.026	1	<0.002	0.01	<0.002
Molybdenum	µg/L	73	-	0.38	2.5	1.5
Nickel	µg/L	25	-	0.56	2.0	0.78
Selenium	µg/L	1	10	<0.04	0.049	<0.04
Silicon	µg/L	2,100	-	<50	690	190
Silver	µg/L	0.25	-	<0.005	0.046	<0.005
Strontium	µg/L	30,000	-	20	90	40
Thallium	µg/L	0.8	-	<0.002	0.004	<0.002
Tin	µg/L	73	-	<0.01	0.1	<0.01
Uranium	µg/L	15	20	0.041	0.34	0.14
Zinc	µg/L	30	5,000	<0.1	3.8	0.25

Note: **Bold** indicates a value exceeds the relevant Effects Benchmark.

a) The focus of the comparison was on dissolved oxygen concentrations less than 6.5 mg/L.

b) Variable with pH. Benchmark of 50 µg/L based on the median lab pH of 6.8.

c) This value was identified as anomalous during data screening.

- = not available; IC = ice-cover; OW = open-water.

3.2.6 Effluent Toxicity

The results of toxicity testing in 2019 indicated that effluent samples were not toxic to aquatic test organisms (Table 3-4 and Table 3-5). A total of 24 acute and chronic lethal toxicity tests and 22² sublethal toxicity tests were successfully conducted using eight treated effluent samples collected during the 2019 reporting period. Toxicity test results demonstrated no toxic effects to aquatic test organisms in all eight samples submitted for lethal testing. In addition, of the eight treated effluent samples submitted for sublethal testing, no adverse effects were observed. A reduction in reproduction of 78% relative to control was observed in *C. dubia* exposed to the sample collected from SNP 1645-18 on 26 March 2019; however, this reduction fell within the acceptable sublethal effect level of $\geq 50\%$ relative to control. Results of the sublethal *P. subcapitata* growth inhibition tests indicated that the effluent stimulated algal growth in all eight samples, which is not considered a toxic response. The raw toxicity data results (i.e., December 2018, March 2019, April 2019, June 2019, September 2019, and October 2019) are provided in Attachment E.

Table 3-4 Acute and Chronic Lethality Toxicity Testing Results, North Inlet Water Treatment Plant Effluent, 2019

Test Organism	Month	Station	
		SNP 1645-18	SNP 1645-18B
		100% effluent	100% effluent
Rainbow Trout ^(a)	December 2018	Pass	Pass
	March 2019	Pass	Pass
	June 2019	Pass	Pass
	September 2019	Pass	Pass
<i>Daphnia magna</i> ^(a)	December 2018	Pass	Pass
	March 2019	Pass	Pass
	June 2019	Pass	Pass
	September 2019	Pass	Pass
<i>Ceriodaphnia dubia</i> ^(a)	December 2018	Pass	Pass
	March 2019	Pass	Pass
	June 2019	Pass	Pass
	September 2019	Pass	Pass

a) Test is considered a "fail" if mortality is greater than or equal to 50%.

² Two effluent samples were submitted to Nautilus Burnaby in December 2018 to conduct chronic toxicity testing to *P. subcapitata*. The tests failed to meet the control acceptability criterion (i.e., percent increase in control cells of 16-fold from test initiation, per Environment Canada 2007). Consequently, the test results were considered invalid. A re-test was not conducted. The invalid tests are not included in the sublethal toxicity test count for 2019.

Table 3-5 Sublethal Toxicity Testing Results, North Inlet Water Treatment Plant Effluent, 2019

Test Organism	Month	Station	
		SNP 1645-18	SNP 1645-18B
		100% effluent	100% effluent
Rainbow Trout ^(a)	December 2018	Pass	Pass
	March 2019	Pass	Pass
	June 2019	Pass	Pass
	October 2019 ^(b)	Pass	Pass
<i>Pseudokirchneriella subcapitata</i> ^(c,d)	December 2018 ^(e)	-	-
	April 2019 ^(f)	Pass	Pass
	June 2019	Pass	Pass
	September 2019	Pass	Pass
<i>Ceriodaphnia dubia</i> ^(g)	December 2018	Pass	Pass
	March 2019	Pass	Pass
	June 2019	Pass	Pass
	September 2019	Pass	Pass

a) The 7-day Rainbow Trout embryo (early life stage) toxicity test is considered a "fail" if the relative percent difference in embryo viability between the two treatments (control and 100% concentration) is greater than or equal to 50%.

b) The 7-day Rainbow Trout embryo toxicity test was conducted in October 2019 as part of the quarter 3 program because no test was conducted in September 2019.

c) Test is considered a "fail" if reduction in growth compared to control is greater than or equal to 50%.

d) Laboratory results indicate algal growth stimulation compared to control.

e) *P. subcapitata* growth inhibition tests conducted in December 2018 did not meet control validity requirements and were not re-run.

f) *P. subcapitata* growth inhibition tests were conducted in March 2019 but did not meet control validity requirements. Samples were re-collected and tests were re-run in April 2019.

g) Test is considered a "fail" if the reduction in fecundity compared to control is greater than or equal to 50%.

3.2.7 Effluent Dispersion

TDS concentrations measured in the Mine discharge at stations SNP 1645-18 and SNP 1645-18B ranged from 232 to 404 mg/L throughout the 2019 monitoring period (Figure 3-17A). The peak TDS concentration in the effluent occurred in August, which coincided with the peak in effluent flow. At the mixing zone boundary, TDS concentrations ranged from 16 to 44 mg/L (Figure 3-17B). Concentrations measured at the mixing zone indicate that the plume was situated between 10 and 20 m depth. The vertical position is considered further in Section 3.3.

The distribution of TDS concentrations during the 2019 ice-cover season indicated that the effluent was detectable throughout each of the three general sampling areas of Lac de Gras (i.e., NF, MF and FF areas; Table 3-6; Figure 3-18). Concentrations of all TDS samples collected during the ice-cover sampling program in 2019 were greater than the normal range for Lac de Gras. However, the concentration of Mine effluent in the FF areas has remained low.

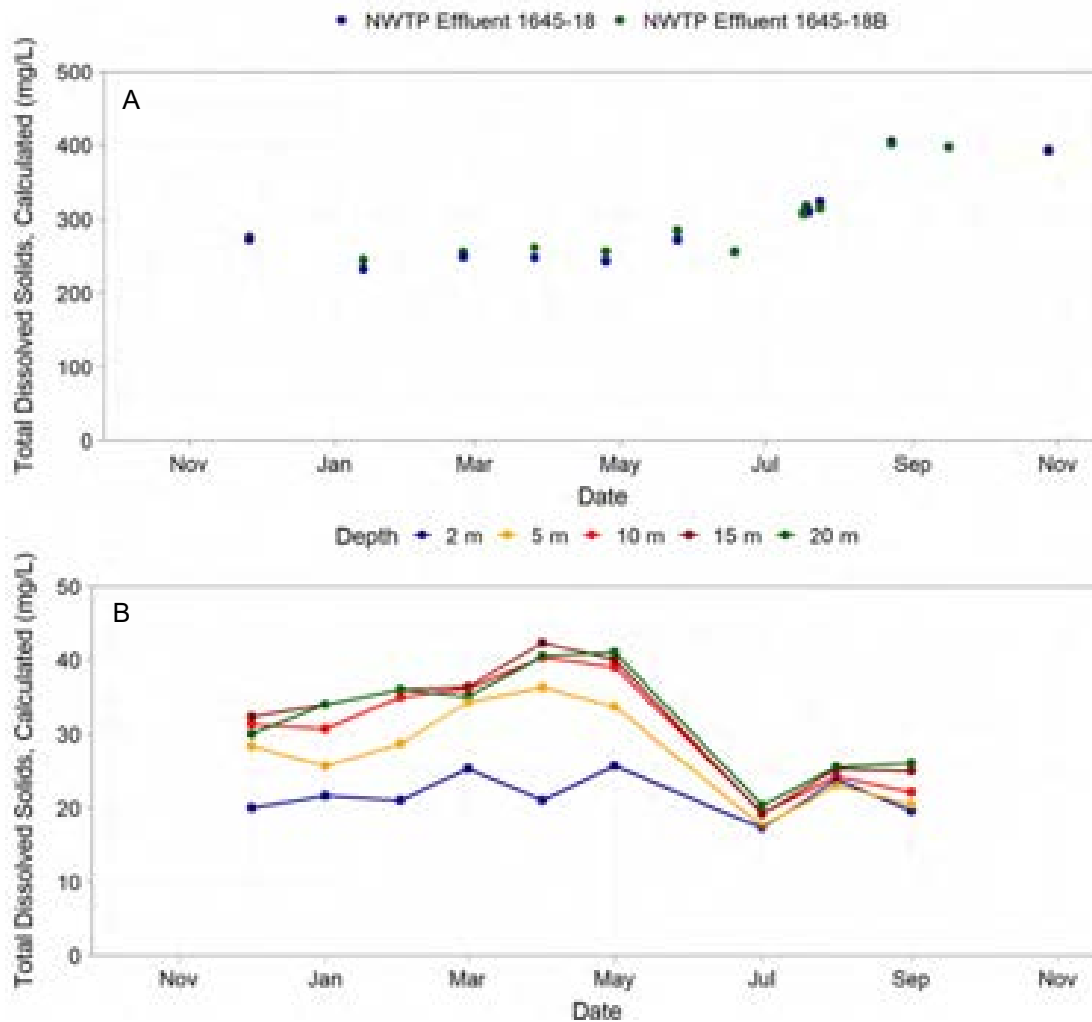
Table 3-6 Summary of Total Dissolved Solids, Calculated Concentration in the FF Areas, Ice-cover Season, 2019

Variable	Unit	Normal Range Upper Limit	Value	Area/Station				
				NF (n = 15)	FF1 (n = 5)	FFB (n = 5)	FFA (n = 5)	LDG-48 (n = 1)
Total dissolved solids, calculated	mg/L	6.5	Minimum	18	13	14	13	17
			Maximum	38	14	14	14	
			Median	26	14	14	14	

Notes: **Bolded** values exceeded the normal range for TDS.

n = number of samples; NF = near-field; FF = far-field; LDG = Lac de Gras; TDS = total dissolved solids.

Figure 3-17 Total Dissolved Solids, Calculated: A) Effluent (SNP 1645-18 and SNP 1645-18B) and at B) the Mixing Zone Boundary (SNP 1645-19), 1 November 2018 to 31 October 2019



Notes: Effluent values represent concentrations in individual samples. Mixing zone values represent average concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) collected at each of five depths (i.e. 2 m, 5 m, 10 m, 15 m, and 20 m).

3.3 Depth Profiles

This section describes the *in situ* (i.e., field-measured) water quality measurements for conductivity, DO, water temperature, pH, and turbidity recorded at AEMP stations (Attachment D). Occasionally, measurements taken near the lake bottom indicated that the probe had come into contact with bottom sediments. These values were not included in the graphical analysis of field measured data but are shown in Attachment B, for reference.

Specific conductivity generally increased with depth in the NF area during the ice-cover season to approximately 12 m depth and then declined slightly with increasing water depth (Figure 3-19). The greater specific gravity of the effluent, combined with the absence of wind and wave-driven mixing during ice-cover conditions, resulted in elevated conductivity in the bottom two-thirds of the water column in the NF area. The greater conductivity at this depth indicated the depth range where the effluent plume was located. Complete vertical mixing of the effluent was observed during ice-cover at all stations along the MF1 transect (Figure 3-20), and at most stations along the MF2 and the MF3 transects. Exceptions were noted at MF2-1 and MF3-1 (Figure 3-21 to Figure 3-22), which are located closest to the NF area and the diffusers along the MF2 and MF3 transects. Specific conductivity at MF2-1 generally increased until approximately 14 m depth and then declined slightly with increasing water depth. Specific conductivity at MF3-1 decreased gradually with depth. Complete vertical mixing was observed during ice-cover at all LDS stations (Figure 3-23). During the open-water season, specific conductivity was typically uniform throughout the water column (Figure 3-19 to Figure 3-23).

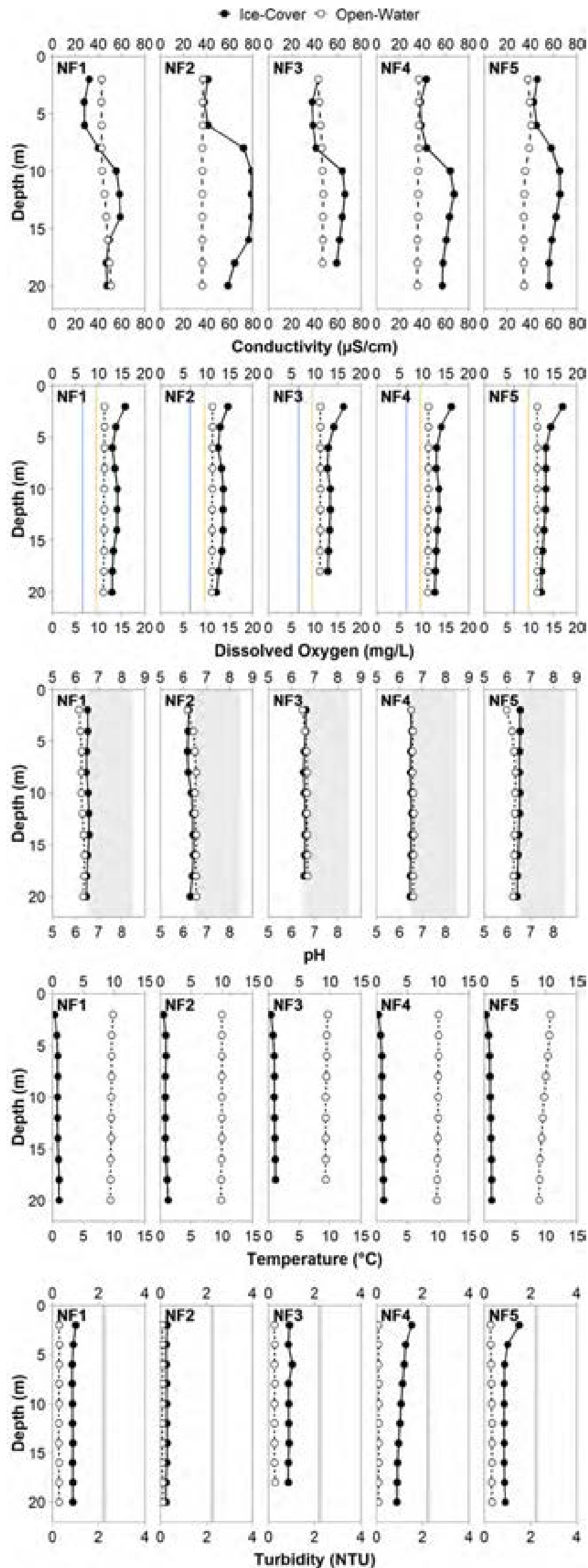
During the ice-cover season, DO concentrations were usually greatest just below the ice and declined slightly with increasing depth. The greatest declines in DO near the lake bottom were measured at MF1-1, MF1-5, FF2-5, MF3-5, FF1, LDS-1 and LDS-2, where near-bottom DO concentrations were at or below the Effects Benchmark of 9.5 mg/L for the protection of aquatic life for early life stages. In addition, some concentrations measured at MF1-1, MF1-5, FF2-5, MF3-5, and FF1 during ice-cover were also below the Effects Benchmark of 6.5 mg/L for the protection of aquatic life for “other” life stages (i.e., non-early life stages). The lower DO values at these stations are not likely Mine-related, as the reduction in DO near the lake bottom is not present in the NF area where the effect would be expected to be greatest, and because the measured values are within the range of concentrations observed during the *Winter Dissolved Oxygen Baseline Survey* undertaken in 2000 prior to initiation of Mine discharge (DDMI 2000). During the open-water season, DO concentrations were typically uniform throughout the water column (Figure 3-19 to Figure 3-23).

During the ice-cover season, pH values typically decreased gradually with depth, with the exception of the NF stations where pH was uniform throughout the water column (Figure 3-19). The slightly greater pH values closer to the water surface likely reflect the removal of dissolved carbon dioxide through photosynthesis. Field pH values were frequently below the aquatic life and drinking water Effects Benchmark value of 6.5 (median = 6.4; range = 5.3 to 6.8). These occurrences were likely natural and unrelated to Mine discharge, as the effluent is slightly alkaline (median pH of 7.4) and because there is no spatial pattern in pH in relation to the diffuser. Further, values of pH below 6.5 naturally occur throughout Lac de Gras, during both the ice-cover and open-water seasons, at various depths, and over time (i.e., 2002 to 2016; Golder 2019c). The pH values measured in Lac de Gras during the open-water season were typically uniform throughout the water column and greater than or similar to values measured during the ice-cover season (Figure 3-19 to Figure 3-23).

Water temperature in Lac de Gras increased gradually with depth at most stations during the ice-cover season (Figure 3-19 to Figure 3-23). During the open-water season, temperature profiles at most stations were vertically homogeneous.

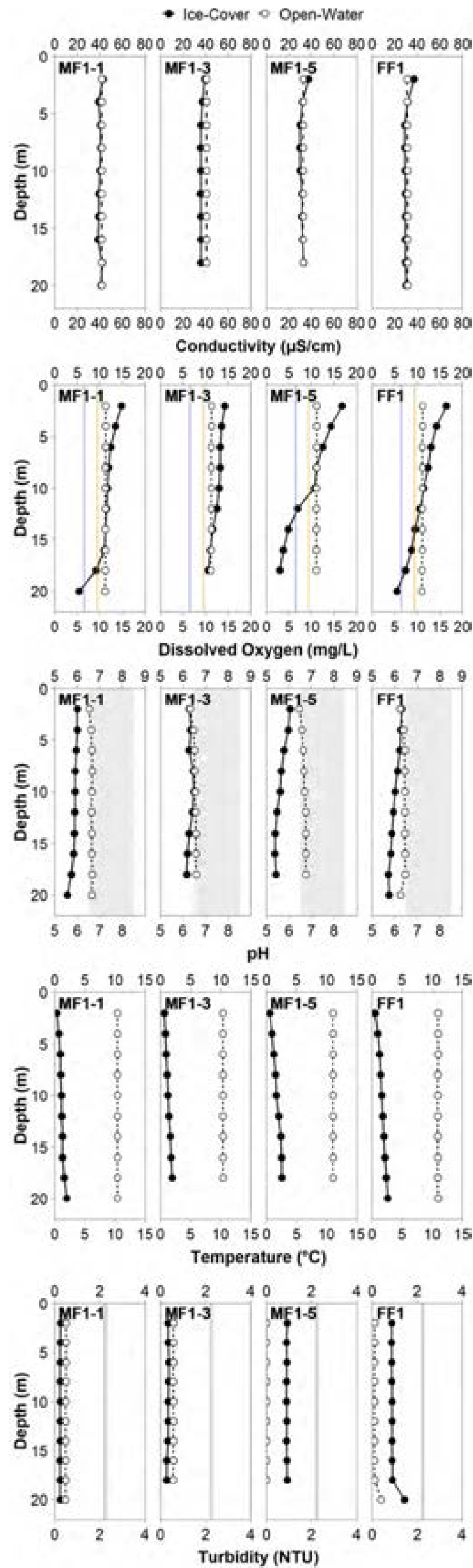
Turbidity was typically uniform throughout the water column during both the ice-cover and open-water seasons. Field turbidity values were within the respective Effects Benchmarks for ice-cover (2.2 NTU) and open-water (2.3 NTU) conditions, for all measurements.

Figure 3-19 Specific Conductivity, Dissolved Oxygen, pH, Temperature, and Turbidity Profiles at NF Stations, 2019



Note: The yellow and blue lines shown on the dissolved oxygen, the grey lines shown on the turbidity profiles, and the grey shaded area shown on the pH profiles are the Effects Benchmarks for these variables. Details are provided in Section 2.3.4.3 and Table 2-5.
NF = near-field; µS/cm = microSiemens per centimetre; NTU = nephelometric turbidity unit.

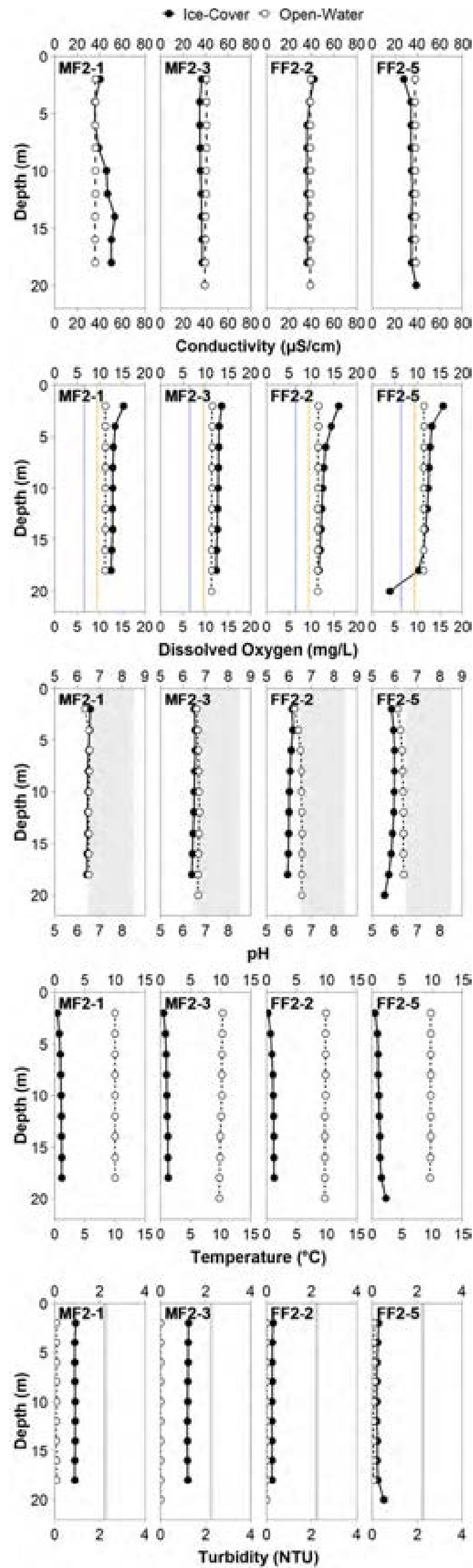
Figure 3-20 Specific Conductivity, Dissolved Oxygen, pH, Temperature, and Turbidity Profiles at MF1 Transect Stations, 2019



Note: The yellow and blue lines shown on the dissolved oxygen, the grey lines shown on the turbidity profiles, and the grey shaded area shown on the pH profiles are the Effects Benchmarks for these variables. Details are provided in Section 2.3.4.3 and Table 2-5.

MF = mid-field; FF = far-field; µS/cm = microSiemens per centimetre; NTU = nephelometric turbidity unit.

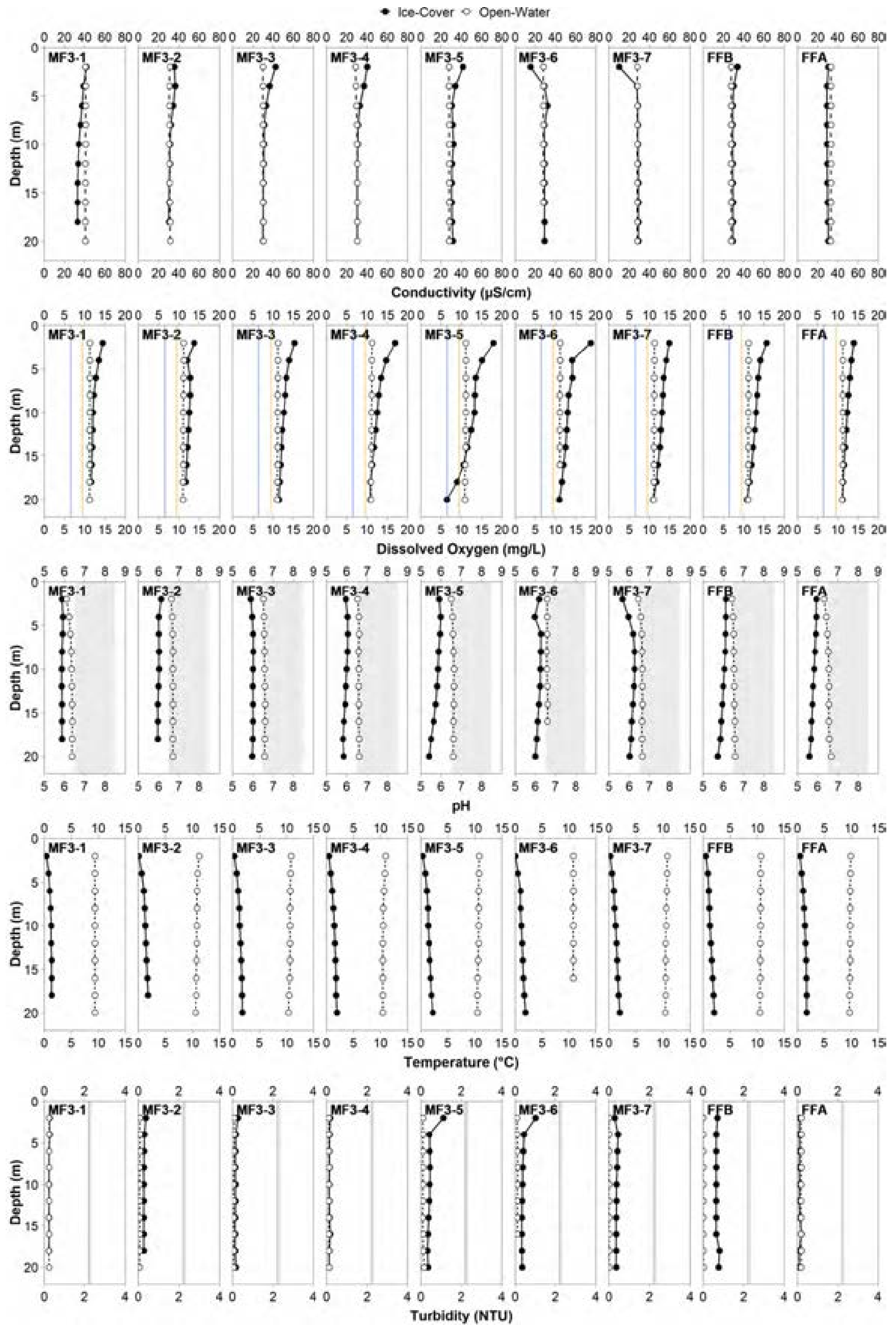
Figure 3-21 Specific Conductivity, Dissolved Oxygen, pH, Temperature, and Turbidity Profiles at MF2 Transect Stations, 2019



Note: The yellow and blue lines shown on the dissolved oxygen, the grey lines shown on the turbidity profiles and the grey shaded area shown on the pH profiles are the Effects Benchmarks for these variables. Details are provided in Section 2.3.4.3 and Table 2-5.

MF = mid-field; FF = far-field; µS/cm = microSiemens per centimetre; NTU = nephelometric turbidity unit.

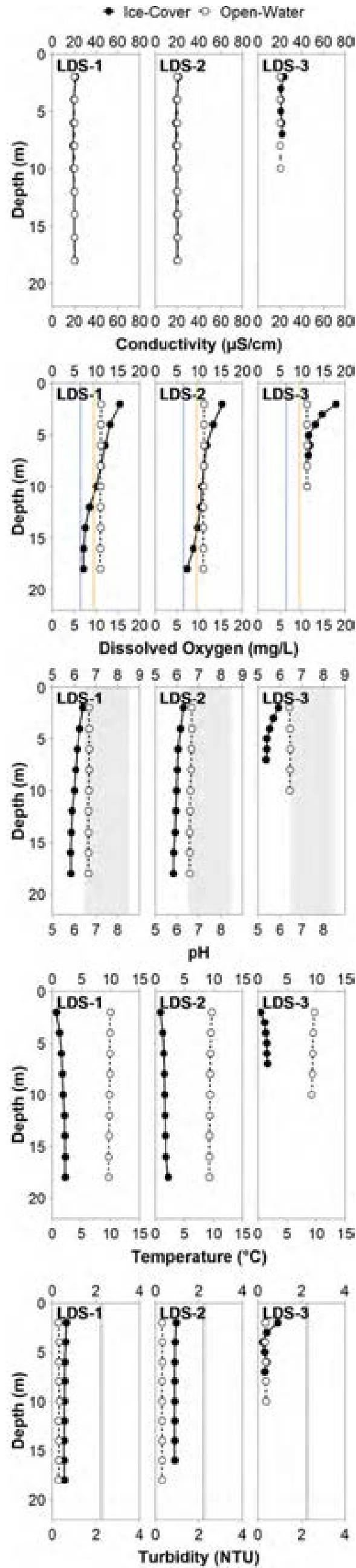
Figure 3-22 Specific Conductivity, Dissolved Oxygen, pH, Temperature, and Turbidity Profiles at MF3 Transect Stations, 2019



Note: The yellow and blue lines shown on the dissolved oxygen, the grey lines shown on the turbidity profiles and the grey shaded area shown on the pH profiles are the Effects Benchmarks for these variables. Details are provided in Section 2.3.4.3 and Table 2-5.

MF = mid-field; FF = far-field; $\mu\text{S}/\text{cm}$ = microSiemens per centimetre; NTU = nephelometric turbidity unit.

Figure 3-23 Specific Conductivity, Dissolved Oxygen, pH, Temperature, and Turbidity Profiles at LDS Stations, 2019



Note: The yellow and blue lines shown on the dissolved oxygen, the grey lines shown on the turbidity profiles and the grey shaded area shown on the pH profiles are the Effects Benchmarks for these variables. Details are provided in Section 2.3.4.3 and Table 2-5.

MF = mid-field; µS/cm = microSiemens per centimetre; NTU = nephelometric turbidity unit; LDS = Lac du Sauvage.

3.4 Comparison of AEMP Data to Effects Benchmarks

Concentrations of water quality variables at AEMP stations (Attachment D) were compared to the Effects Benchmarks listed in Table 2-5. This section provides a summary of benchmark exceedances noted for discrete water quality samples. A comparison of field-measured depth profile data to benchmarks is provided in Section 3.3.

- Two total manganese samples collected during the ice-cover season exceeded the AEMP Drinking Water Effects Benchmark of 50 µg/L which is an aesthetic guideline applied to prevent undesirable tastes in beverages and staining of plumbing fixtures and laundry (Health Canada 2015). The Health Canada guideline from which the AEMP Drinking Water Effects Benchmark for manganese is derived was updated in May 2019 to 20 µg/L; this update has not yet been reflected in the AEMP design plan, but is considered in the screening. Samples with exceedances of the AEMP Drinking Water Effects Benchmark and/or the updated Health Canada criterion include:
 - MF1-5M (21.2 µg/L): the corresponding dissolved sample (2.63 µg/L) was well below the Effects Benchmark and the updated Health Canada guideline, indicating that the sample may have been contaminated or that it may be an error. The sample was not flagged as anomalous in the initial data screening (Section 2.3.2); however, the sample was elevated relative to other nearby stations indicating that the value is unusual compared to other samples collected in Lac de Gras.
 - MF1-5B (298 µg/L): the corresponding dissolved sample (281 µg/L) also exceeded the Effects Benchmark and the updated Health Canada guideline; however, samples collected at nearby stations, were generally well below the Effects Benchmark and the updated guideline, indicating that the sample may have been contaminated. In addition, both the total and dissolved samples were flagged as anomalous in the initial data screening (Section 2.3.2), indicating that the value is extreme compared to other samples collected in Lac de Gras.
 - MF3-5B (159 µg/L): the corresponding dissolved sample (42.5 µg/L) was elevated compared to samples collected at nearby stations but did not exceed the Effects Benchmark or the updated guideline. Field notes from the sampling event indicate that contact was made with the lake bottom during sampling which may have resulted in this elevated value.
- Laboratory pH values were below the Effects Benchmark in five samples collected during the ice-cover season and 75 samples collected during the open-water season (median = 6.49; range = 5.67 to 6.93). However, as is noted in Section 3.3 for field pH values that were below the Effects Benchmark, these occurrences were likely natural and unrelated to the Mine discharge.

Concentrations of all variables in all other samples collected during the 2019 AEMP were below the relevant Effects Benchmarks for the protection of aquatic life and drinking water (Attachment D).

3.5 Action Level Evaluation

Mine-related effects on water quality were categorized according to Action Levels (Table 2-6). Results of the Action Level screening are organized sequentially for each Action Level. Spatial variation in the concentrations of water quality variables that were identified as SOIs in 2019 are presented relative to Action Level values in Figure 3-24 to Figure 3-29.

3.5.1 Action Level 1

Action Level 1 was triggered for variables that had NF area median concentrations that were two times greater than the reference dataset median concentration defined in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019b). In addition, the increase in concentration in the NF area had to be linked to the Mine (i.e., present in the Mine effluent or in another Mine source such as dust) to trigger Action Level 1.

In total, 16 of the water quality variables assessed in 2019 triggered Action Level 1 (Table 3-7). Each of these variables were measured in the NIWTP effluent at concentrations greater than the concentration in Lac de Gras, with the exception of turbidity, which at times had similar concentrations in the effluent to Lac de Gras. Variables that triggered Action Level 1, with the exception of chloride, were also detected in dust, which may be deposited into Lac de Gras from mining activities (*Dust Deposition Report* [Appendix I]). This provides evidence of a link to the Mine, which is required for an Action Level 1 to be triggered. No management action is required under the Response Framework (Table 2-6) when a water quality variable triggers Action Level 1.

Variables that triggered Action Level 1 were retained as SOIs according to Criterion 3 (Section 2.3.1). For some variables that were analyzed in more than one form or as different fractions (e.g., total and dissolved), the most representative of these was included as an SOI to avoid duplication. For example, while both calculated and measured TDS triggered Action Level 1, to avoid redundancy, the analysis was focused on calculated TDS and it was included as the SOI. Total and dissolved calcium and sodium in the NF area triggered Action Level 1, and total magnesium in the NF area triggered Action Level 1. To avoid redundancy and match methods from previous annual reports, graphing and analyses have been conducted on the dissolved fractions of these three variables.

Of the 16 variables that triggered Action Level 1, nine (i.e., TDS, calcium, chloride, sodium, sulphate, nitrate, molybdenum, strontium, and uranium) had NF area median concentrations that exceeded two times the reference dataset median concentration during both the ice-cover and open-water seasons. Ammonia triggered Action Level 1 during the open-water season only. The remaining six variables (i.e., turbidity, magnesium, aluminum, barium, manganese, and silicon) triggered Action Level 1 during the ice-cover season only.

3.5.2 Action Level 2

All SOIs that triggered Action Level 1 were evaluated against Action Level 2. Action Level 2 was triggered if the 5th percentile concentration in the NF area was greater than two times the median concentration in reference datasets, and greater than the normal range for Lac de Gras. Of the 16 SOIs that triggered Action Level 1, nine (i.e., TDS, chloride, sodium, sulphate, ammonia, nitrate, molybdenum, strontium, and uranium) triggered Action Level 2 in one or both sampling seasons (Table 3-8). In most cases, Action Level 2 was triggered during both the ice-cover and open-water seasons. Exceptions were sulphate, ammonia and nitrate, which triggered Action Level 2 only during the open-water season.

Under the Response Framework, when a water quality variable triggers Action Level 2, the required management action is to establish an AEMP Effects Benchmark for that variable, if one does not already exist. Each of the nine variables that triggered Action Level 2 in 2019 have existing Effects Benchmarks (Table 2-5).

3.5.3 Action Level 3

Variables that triggered Action Level 2 were evaluated for an effect at Action Level 3. Action Level 3 was triggered if the 75th percentile concentration at the mixing zone boundary was greater than the normal range plus 25% of the distance between the top of the normal range and the AEMP Effects Benchmark. None of the water quality variables triggered Action Level 3 (Table 3-9). The 75th percentile concentrations of TDS, the major ions and nitrate at the mixing zone were two to six times less than the Action Level 3 criterion in both seasons. The 75th percentile concentrations of ammonia and the total metals were one to two orders of magnitude less than the Action Level 3 criterion in both seasons.

Table 3-7 Comparison of 2019 Water Quality Data to Action Level 1

Variable	Unit	2019 Detection Limit	Action Level 1 Criteria and 2019 AEMP Results					
			Action Level 1 Criterion		2019 AEMP		Action Level 1 Triggered? (Yes/No)	
			2 x Median of Reference Datasets ^(a)		Median of NF values ^(b)			
			Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water
Conventional Parameters								
Total alkalinity	mg/L	0.5	8.8	8.0	6.7	5.6	No	No
Total dissolved solids, calculated	mg/L	-	10.7	10.0	26	18	Yes	Yes
Total dissolved solids, measured	mg/L	1	30	20	31	23	^(c)	^(c)
Total suspended solids	mg/L	1	1.0	1.0	<1	<1	No	No
Total organic carbon	mg/L	0.2	5.2	4.4	2.1	2.3	No	No
Turbidity – lab	NTU	0.1	0.10	0.42	0.17	0.31	Yes	No
Major Ions								
Calcium (dissolved)	mg/L	0.01	2.2	2.0	2.9	2.1	Yes	Yes
Chloride	mg/L	0.5	1.6	2.0	6.9	3.5	Yes	Yes
Fluoride	mg/L	0.01	0.048	0.044	0.035	0.030	No	No
Magnesium (dissolved)	mg/L	0.005	1.38	1.4	1.36	1.1	Yes^(d)	No
Potassium (dissolved)	mg/L	0.01	1.26	1.2	1.15	1.0	No	No
Sodium (dissolved)	mg/L	0.01	1.0	1.0	4.0	2.3	Yes	Yes
Sulphate	mg/L	0.5	4.4	3.8	5.1	4.0	Yes	Yes
Nutrients								
Ammonia ^(e)	µg/L	5	36	5	27	15	No	Yes
Nitrate	µg-N/L	2	6.8	2.0	128	20	Yes	Yes
Nitrite	µg-N/L	1	2	2	<1	<1	No	No
Total Metals								
Aluminum	µg/L	0.2	5.8	8.8	7.9	5.4	Yes	No
Antimony	µg/L	0.02	0.02	0.02	<0.02	<0.02	No	No
Arsenic	µg/L	0.02	0.38	0.34	0.31	0.26	No	No
Barium	µg/L	0.02	3.86	3.62	4.89	2.45	Yes	No
Beryllium	µg/L	0.01	0.01	0.01	<0.01	<0.01	No	No
Bismuth	µg/L	0.005	0.005	0.005	<0.005	<0.005	No	No
Boron	µg/L	5	5	5	<5	<5	No	No
Cadmium	µg/L	0.005	0.005	0.005	<0.005	<0.005	No	No
Calcium	mg/L	0.01	2.04	1.92	2.92	2.06	^(c)	^(c)
Chromium	µg/L	0.05	0.06	0.06	<0.05	<0.05	No	No
Cobalt	µg/L	0.005	0.022	0.04	0.01	0.01	No	No
Copper	µg/L	0.05	0.6	0.6	0.55	0.53	No	No
Iron	µg/L	1	5	10	1.8	2.5	No	No
Lead	µg/L	0.005	0.005	0.005	<0.005	<0.005	No	No
Lithium	µg/L	0.5	2.8	2.4	2.29	2.03	No	No
Magnesium	mg/L	0.005	1.32	1.26	1.39	1.06	^(c,d)	No
Manganese	µg/L	0.05	2.42	4.88	3.66	2.45	Yes	No
Mercury	µg/L	0.002	0.01	0.01	<0.002	<0.002	No	No
Molybdenum	µg/L	0.05	0.14	0.18	1.04	0.57	Yes	Yes

Table 3-7 Comparison of 2019 Water Quality Data to Action Level 1 (continued)

Variable	Unit	2019 Detection Limit	Action Level 1 Criteria and 2019 AEMP Results					
			Action Level 1 Criterion		2019 AEMP		Action Level 1 Triggered? (Yes/No)	
			2 x Median of Reference Datasets ^(a)		Median of NF values ^(b)			
			Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water
Nickel	µg/L	0.02	1.94	1.9	0.74	0.57	No	No
Potassium	mg/L	0.01	1.16	1.08	1.15	0.96	No	No
Selenium	µg/L	0.04	0.04	0.04	<0.04	<0.04	No	No
Silicon	µg/L	50	50	50	257	<50	Yes	No
Silver	µg/L	0.005	0.005	0.005	<0.005	<0.005	No	No
Sodium	mg/L	0.01	1.28	1.26	4.05	2.30	(c)	(c)
Strontium	µg/L	0.05	15.2	14.6	47	26	Yes	Yes
Sulphur	mg/L	0.5	1.96	1.82	1.73	1.56	No	No
Thallium	µg/L	0.002	0.002	0.002	<0.002	<0.002	No	No
Tin	µg/L	0.01	0.01	0.01	<0.01	<0.01	No	No
Titanium	µg/L	0.5	0.5	0.5	<0.5	<0.5	No	No
Uranium	µg/L	0.002	0.056	0.056	0.12	0.08	Yes	Yes
Vanadium	µg/L	0.05	0.1	0.1	<0.05	<0.05	No	No
Zinc	µg/L	0.1	1.8	1.5	0.15	0.25	No	No
Zirconium	µg/L	0.05	0.05	0.05	<0.05	<0.05	No	No

a) The two times median value was based on the reference dataset median concentrations presented in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). In cases where the median concentration was less than the DL, the reference area median value was considered to be equal to 0.5 of the DL.

b) The median of NF area values was calculated from data pooled across all sample depths, dates and stations (n = 15 samples).

c) Action Level 1 comparison was applied to an alternate form or fraction of this substance (e.g., dissolved rather than total; calculated rather than measured) to avoid duplication.

d) Total concentration in the NF area triggered Action Level 1 in 2019. However, Action Level 1 was applied to the dissolved form even though the NF area concentration in 2019 was just below the threshold value used at Action Level 1. This approach was taken to be consistent with the convention used in previous reports.

e) Based on the results of the ammonia investigation, the ALS ammonia dataset was used in the ice-cover season and the BV ammonia dataset was used in the open-water season (Section 2.4.1, Attachment B).

Note: **Bold** indicates a value exceeds the Action Level 1 criterion.

- = not applicable; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; 2 x = two times; NF = near-field.

Table 3-8 Comparison of 2019 Water Quality Data to Action Level 2

Variable	Unit	2019 Detection Limit	Action Level 2 Criteria and 2019 AEMP Results							
			Action Level 2 Criteria				2019 AEMP Result		Action Level 2 Triggered? (Yes/No)	
			2 x Median of Reference Areas ^(a)		Top of Normal Range		5th Percentile of NF values ^(b)			
			Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water
Conventional Parameters										
Total dissolved solids, calculated	mg/L	-	10.7	10.0	6.5	5.8	18.0	16.8	Yes	Yes
Turbidity – lab	NTU	0.1	0.1	0.42	0.18	0.29	<0.1	0.14	No	No
Major Ions										
Calcium (dissolved)	mg/L	0.01	2.2	2.0	1.3	1.1	2.1	2.0	No	No
Chloride	mg/L	0.5	1.6	2.0	1.0	1.0	3.3	3.3	Yes	Yes
Magnesium (dissolved)	mg/L	0.005	1.4	1.4	0.8	0.8	1.2	1.0	No	No
Sodium (dissolved)	mg/L	0.01	1.0	1.0	1.0	1.0	2.3	2.2	Yes	Yes
Sulphate	mg/L	0.5	4.4	3.8	2.5	2.1	4.0	3.9	No	Yes
Nutrients										
Ammonia ^(c)	µg-N/L	5	36	5	23	5	19	11	No	Yes
Nitrate	µg-N/L	2	6.8	2	15.2	2	12	12	No	Yes
Total Metals										
Aluminum	µg/L	0.2	5.8	8.8	3.9	6.2	1.5	2.3	No	No
Barium	µg/L	0.02	3.86	3.62	2.18	1.94	2.66	2.28	No	No
Manganese	µg/L	0.05	2.42	4.88	1.95	4.67	0.84	2.1	No	No
Molybdenum	µg/L	0.05	0.14	0.18	0.09	0.13	0.49	0.38	Yes	Yes
Silicon	µg/L	50	50	50	50	50	<50	<50	No	No
Strontium	µg/L	0.05	15.2	14.6	8.78	8.01	24.4	23.3	Yes	Yes
Uranium	µg/L	0.002	0.056	0.056	0.030	0.029	0.077	0.066	Yes	Yes

a) The two times median value was based on the reference dataset median concentrations presented in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019b). In cases where the median concentration was less than the DL, the reference area median value was considered to be equal to 0.5 of the DL. Normal ranges are those presented in the *AEMP Reference Conditions Report, Version 1.4* (Golder 2019b).

b) The 5th percentile concentration of NF area values was calculated from data pooled across all sample depths, dates and stations (n = 15 samples).

c) Based on the results of the ammonia investigation, the ALS ammonia dataset was used in the ice-cover season and the BV ammonia dataset was used in the open-water season (Section 2.4.1, Attachment B).

Note: **Bold** indicates a value exceeds the Action Level 2 Criteria.

- = not applicable; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; 2 x = two times; NF = near-field.

Table 3-9 Comparison of 2019 Water Quality Data to Action Level 3

Variable	Unit	2019 Detection Limit	AEMP Effects Benchmark ^(a)	Action Level 3 Criteria and 2019 AEMP Results					
				Action Level 3 Criterion		2019 AEMP Results		Action Level 3 Triggered (Yes/No)	
				Normal Range ^(b) + 25% of Effects Benchmark		75th Percentile of Mixing Zone Values ^(c)			
				Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water
Conventional Parameters									
Total dissolved solids, calculated	mg/L	-	500	129.9	129.4	37	24.9	No	No
Major Ions									
Chloride	mg/L	0.5	120	30.8	30.8	11	5.0	No	No
Sodium (dissolved)	mg/L	0.01	52	13.8	13.8	5.9	3.5	No	No
Sulphate	mg/L	0.5	100	26.9	26.6	5.9	6.3	No	No
Nutrients									
Ammonia	µg-N/L	5	4,730	1,200	1,186	70.5	72.8	No	No
Nitrate	µg-N/L	2	3,000	761	752	174	148	No	No
Total Metals									
Total Molybdenum	µg/L	0.05	73	18.3	18.3	1.65	1.65	No	No
Total Strontium	µg/L	0.05	30,000	7,507	7,506	80	40	No	No
Total Uranium	µg/L	0.002	15	3.77	3.77	0.18	0.17	No	No

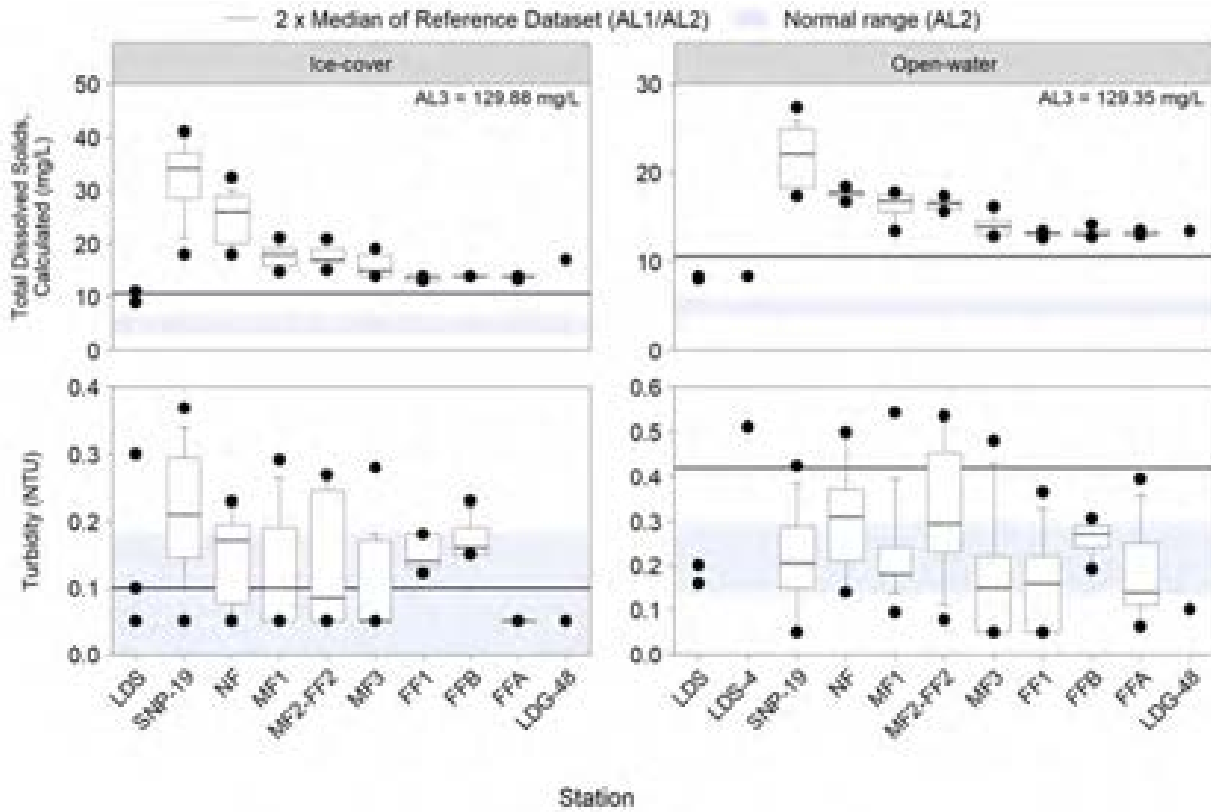
a) The AEMP Effects Benchmarks are described in the *AEMP Design Plan Version 4.1* (Golder 2017a) and in Section 2.3.4.3.

b) Normal ranges are those presented in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019b).

c) The 75th percentile of mixing zone values were calculated from data pooled across all sample depths, dates and stations.

- = not applicable; µg-N/L = micrograms nitrogen per litre.

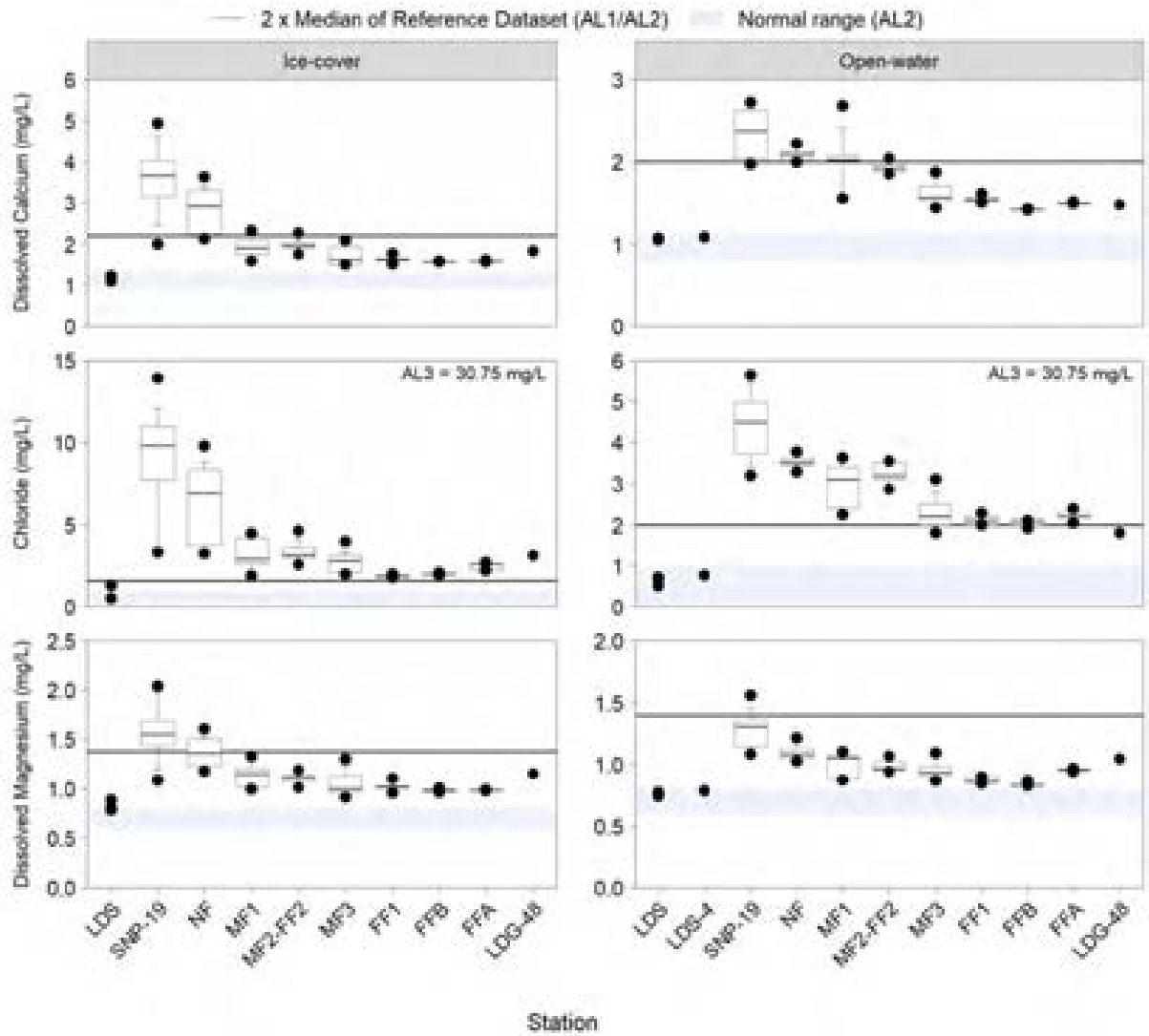
Figure 3-24 Total Dissolved Solids, Calculated, and Turbidity at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2019



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Black circles represent the 5th and 95th percentile concentrations.

AL = Action Level; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

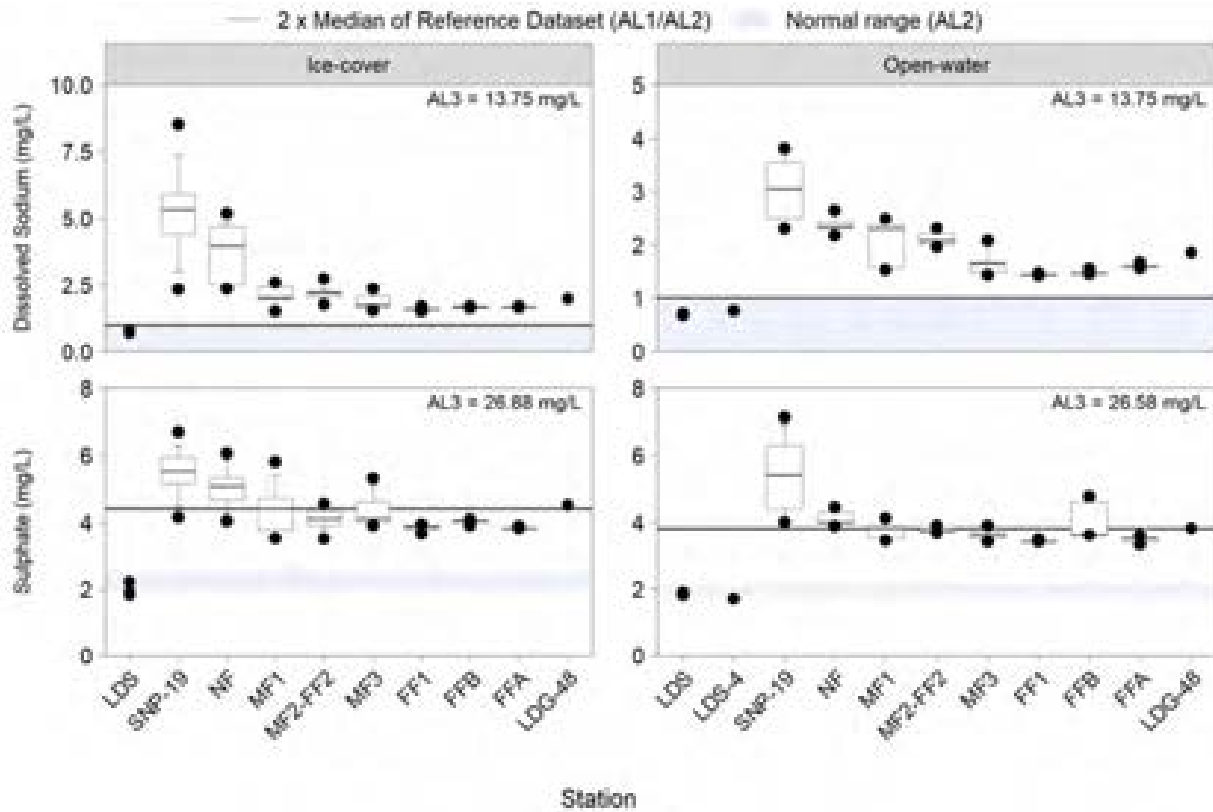
Figure 3-25 Concentration of Dissolved Calcium, Chloride, and Dissolved Magnesium at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2019



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Black circles represent the 5th and 95th percentile concentrations.

AL = Action Level; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

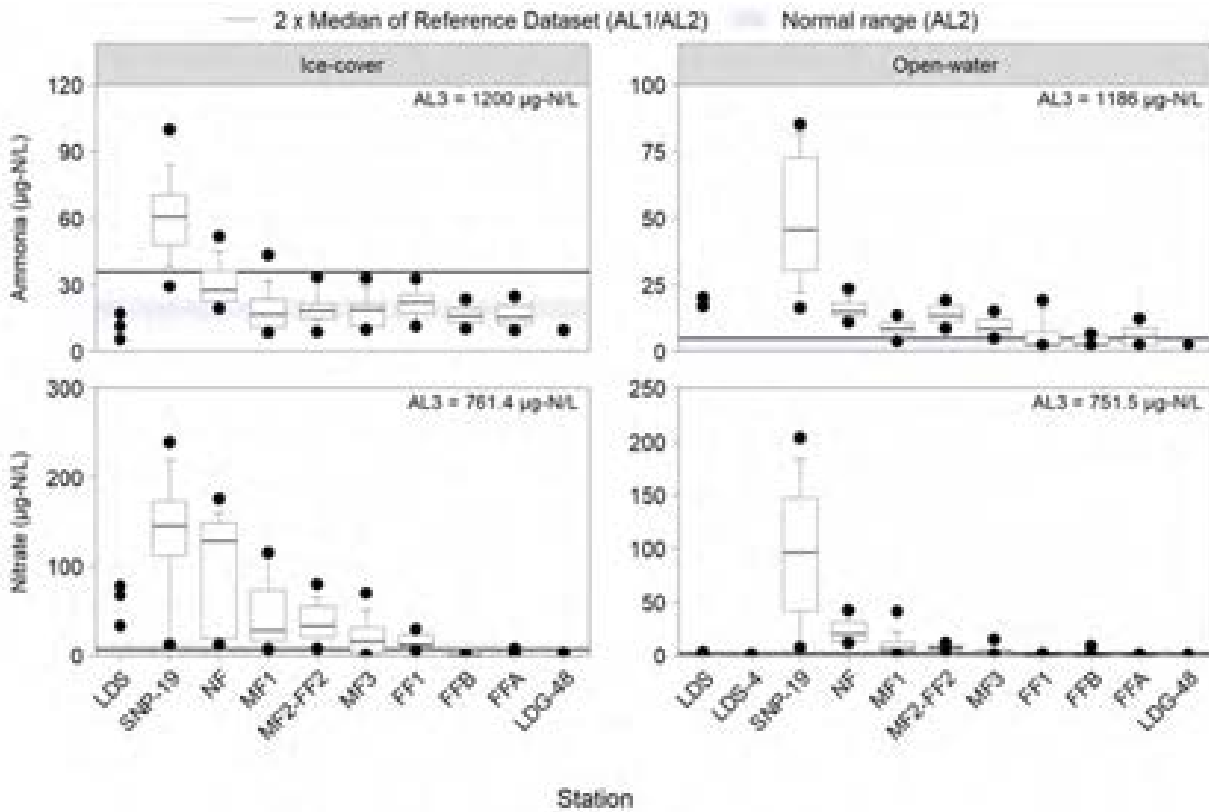
Figure 3-26 Concentration of Dissolved Sodium and Sulphate at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2019



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Black circles represent the 5th and 95th percentile concentrations.

AL = Action Level; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-27 Concentration of Ammonia and Nitrate at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2019

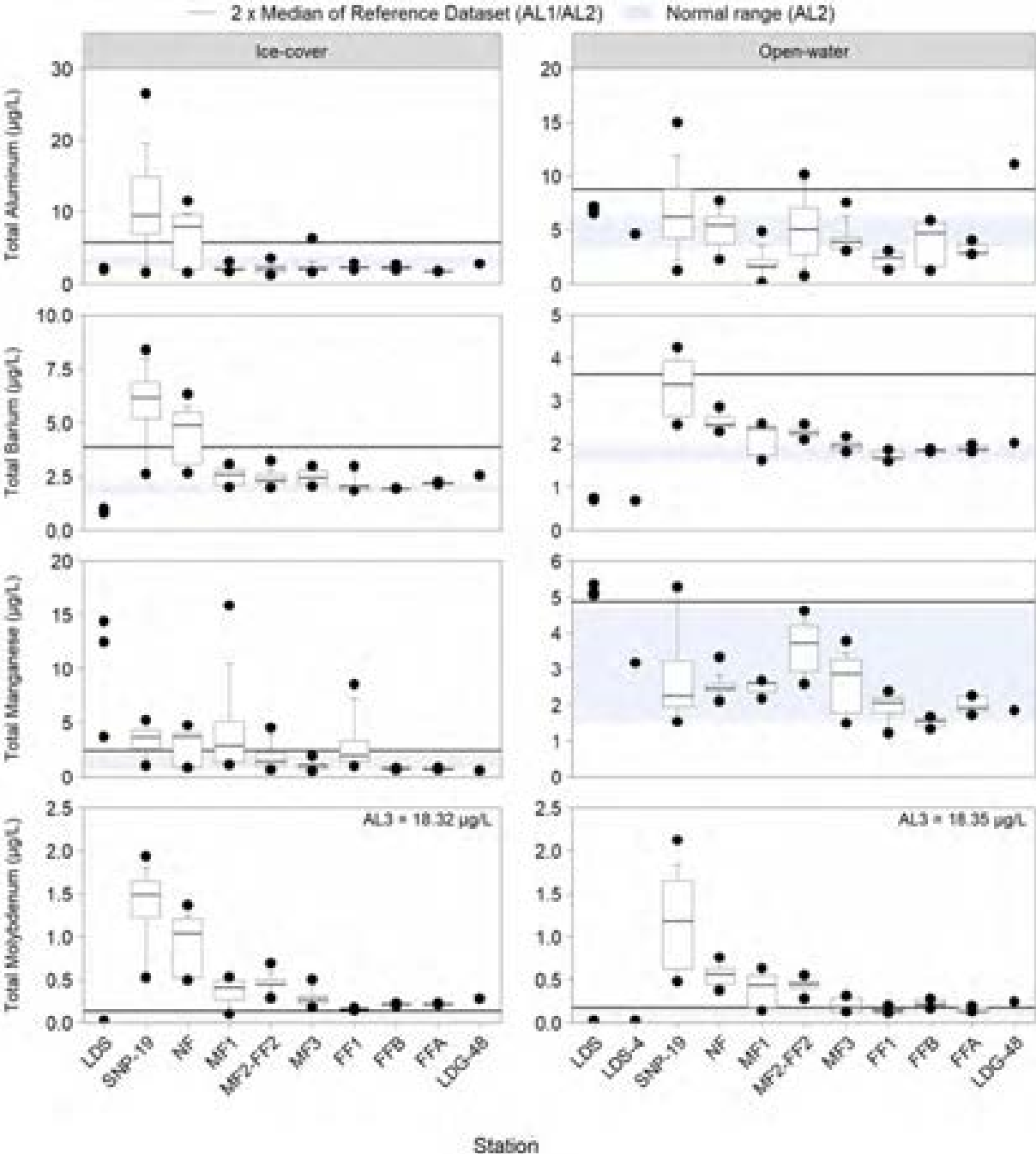


Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Black circles represent the 5th and 95th percentile concentrations.

Based on the results of the ammonia investigation, the ALS ammonia dataset was used in the ice-cover season and the BV ammonia dataset was used in the open-water season (Section 2.4.1, Attachment B).

AL = Action Level; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

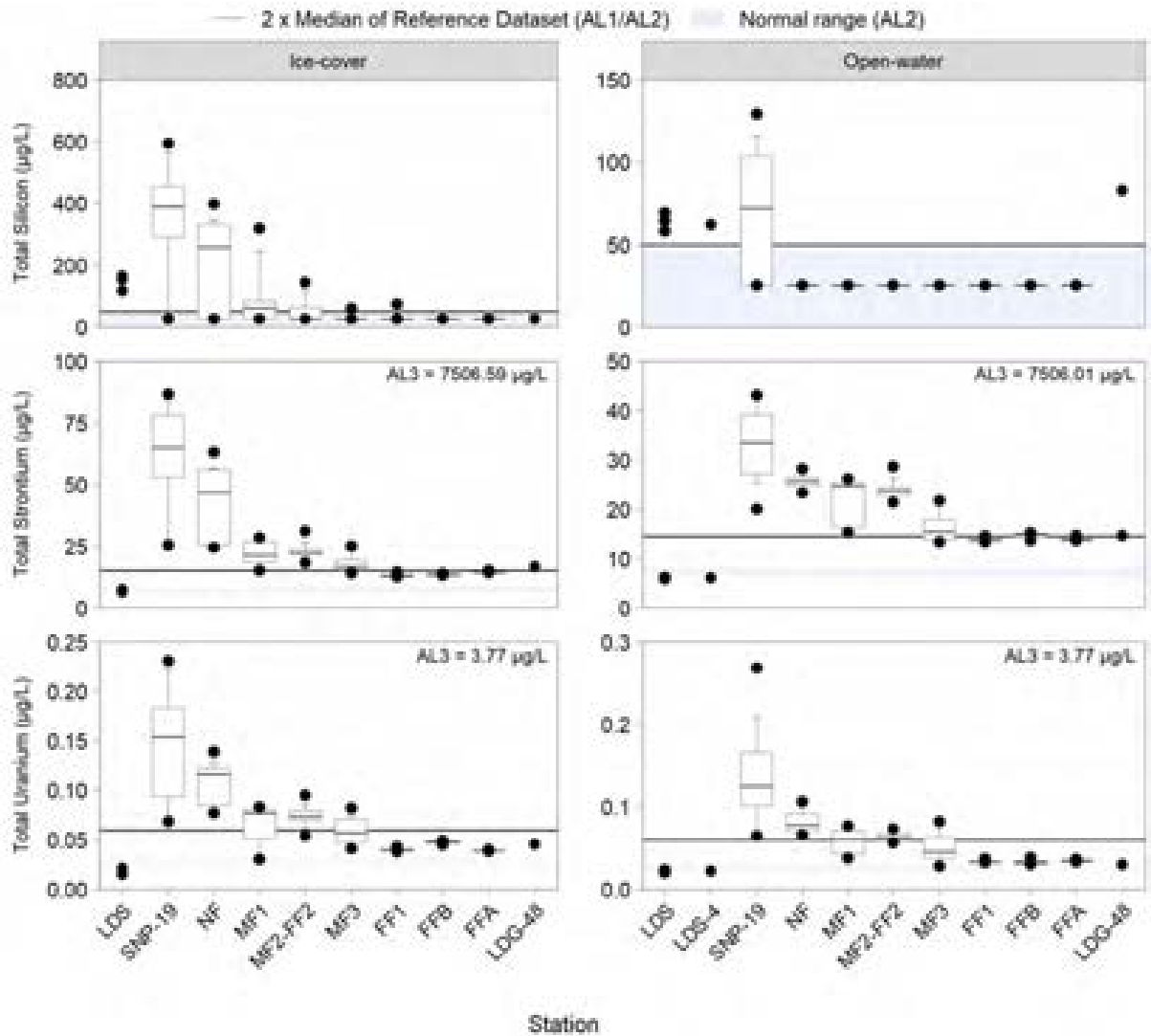
Figure 3-28 Concentration of Total Aluminum, Total Barium, Total Manganese, and Total Molybdenum at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2019



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Black circles represent the 5th and 95th percentile concentrations.

AL = Action Level; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-29 Concentration of Total Silicon, Total Strontium, and Total Uranium at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2019



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Black circles represent the 5th and 95th percentile concentrations.

AL = Action Level; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

3.6 Gradient Analysis

Substances of interest were evaluated statistically to determine whether there were trends in the concentrations of SOIs along the three MF transects. A pattern of decreasing concentration with increasing distance from the diffusers was considered confirmation that the increases observed in the NF area were related to the Mine effluent discharge. Trends were identified using linear regression analysis (Section 2.3.6.2.1) and a graphical (i.e., visual) evaluation of the data arranged by distance from the diffusers (Figure 3-30 to Figure 3-45).

The concentrations of SOIs at the Lac de Gras outflow to the Coppermine River (LDG 48), in Lac du Sauvage (LDS-1, LDS-2, LDS-3), and the Lac du Sauvage outflow to Lac de Gras (LDS-4), were compared qualitatively to those at AEMP stations within the main body of Lac de Gras to evaluate differences in SOI concentrations flowing into and out of the lake.

In general, clear spatial trends of decreasing concentrations with distance from the Mine effluent diffusers were evident for most variables that triggered Action Levels. Spatial trends were generally more pronounced during the ice-cover season than during open-water conditions. Further details are provided in the subsections that follow for individual SOIs (Section 2.3.1).

A subset of the SOIs demonstrated increasing patterns at stations located at the far end of the MF3 transect, extending through the FFB and FFA areas, or had greater concentrations at the outflow of Lac de Gras compared to the FFA or FFB areas. These responses may indicate a cumulative effect on water quality in Lac de Gras, resulting from the combined influence of the Diavik and Ekati mine effluent discharges. An evaluation of potential cumulative effects in Lac de Gras is provided in Section 3.10.

3.6.1 Conventional Variables, Total Dissolved Solids, and Associated Ions

Results of the gradient analysis indicated that most major ions (i.e., calcium, chloride, magnesium, and sulphate) had significant decreasing trends with distance from the diffuser along all three MF transects, during both seasons (Table 3-10; Figure 3-30 to Figure 3-36). Sodium and TDS had significant decreasing trends along only two (i.e., MF1 and MF2) of the three MF transects during both the ice-cover and open-water seasons. Turbidity had a significant decreasing trend along only one (i.e., MF1) of the three MF transects during the open-water season.

The spatial analysis of the MF3 transect involved the use of a piecewise model (Model 3) during both the ice-cover and open-water seasons for TDS, calcium, chloride, magnesium, and sodium, and during the open-water season for sulphate. Breakpoints in the piecewise model generally occurred between two and eight kilometres from the effluent discharge. The piecewise analysis for these parameters indicated a more pronounced decrease in concentration at stations closer to the effluent discharge (i.e., stations located within 2 to 8 km of the effluent discharge) compared to stations farther away, and compared to SOIs that were analyzed using a standard linear approach. Calcium and magnesium during the open-water season had more distant breakpoints at approximately 25 km from the effluent discharge, indicating a more gradual decrease in concentration with distance from the diffuser (Figure 3-32 and Figure 3-34). The trend direction for calcium, chloride and magnesium in the open-water season changed from a decreasing trend for the first slope (extending from the NF area to the breakpoint) to an increasing trend for the second slope

(extending from the breakpoint through the FFA area). A similar pattern occurred in sodium concentration during the open-water season; however, the regression on the MF3 transect was not significant.

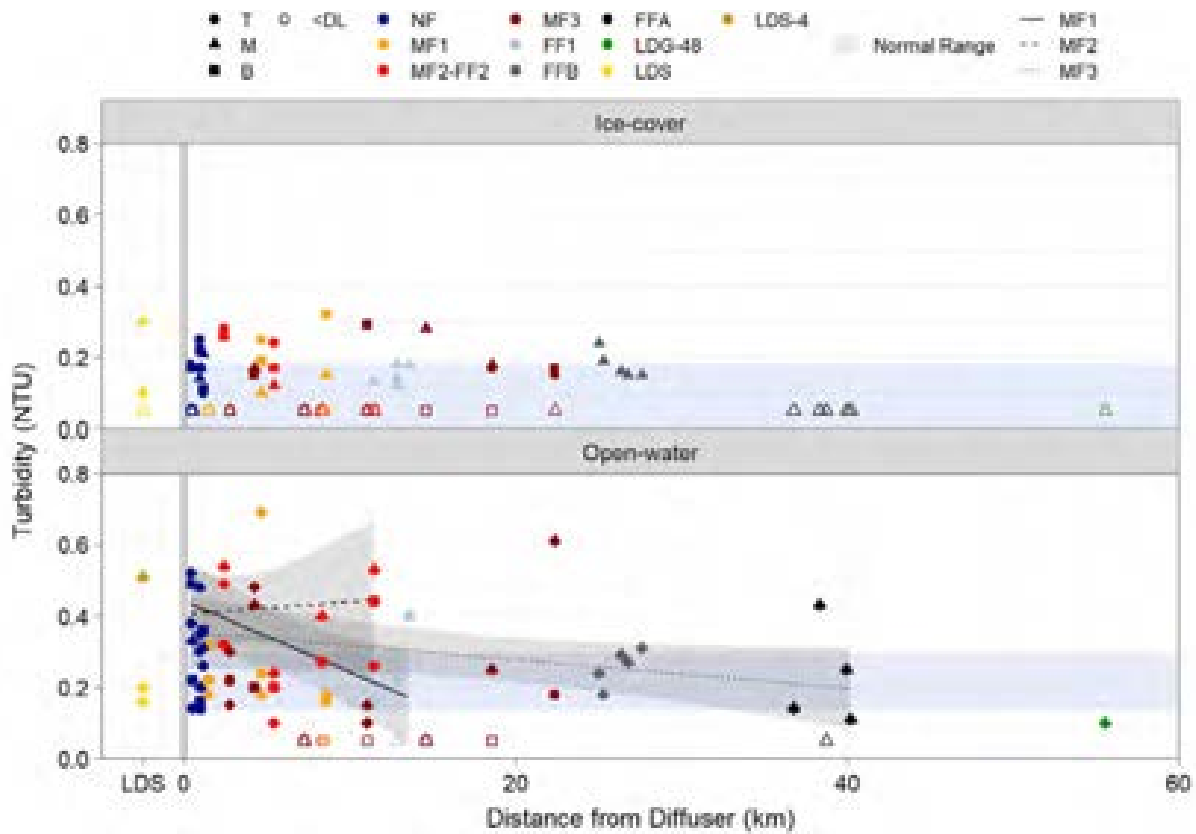
Concentrations of TDS, calcium, chloride, magnesium, sodium, and sulphate were generally smaller at the LDS stations compared to stations located in the main body of Lac de Gras, whereas turbidity was within a similar range in LDS as the stations located in the body of Lac de Gras. During the ice-cover season, concentrations of most SOIs at LDG-48 were slightly greater than those encountered at the far end of the MF3 transect (i.e., the FFA area) whereas concentrations at LDG-48 were generally similar those at the far end of the MF3 transect in the open-water season.

Table 3-10 Gradient Analysis for Conventional Variables, Total Dissolved Solids, and Associated Ions, 2019

Variable	Season	Model	Box-Cox Transformation	Gradient	Slope Direction ^(a)	Break-point (km) ^(b)	P-value ^(c)	R ² or r ^{2(d)}
Turbidity - lab	Ice-cover	n/a						
	Open-water	Model 1	1	MF1	↓	-	0.01	0.21
				MF2	↑	-	0.796	
				MF3	↓	-	0.074	
Total Dissolved Solids, calculated	Ice-cover	Model 2	0	MF1	↓	-	<0.001	0.88
		Model 3		MF2	↓	-	<0.001	0.93
				MF3 (1st slope)	↓	2.7	0.087	
	Open-water	Model 2	1	MF1	↓		-	<0.001
				MF2	↓	-	<0.001	
		Model 3		MF3 (1st slope)	↓	5.0	0.095	0.95
MF3 (2nd slope)	↓	-						
Calcium (dissolved)	Ice-cover	Model 2	0	MF1	↓	-	<0.001	0.82
		Model 3		MF2	↓	-	<0.001	0.94
				MF3 (1st slope)	↓	3.1	<0.001	
	Open-water	Model 2	0	MF1	↓		-	<0.001
				MF2	↓	-	0.001	
		Model 3		MF3 (1st slope)	↓	24.7	0.001	0.85
MF3 (2nd slope)	↑	-						
Chloride	Ice-cover	Model 2	0	MF1	↓	-	<0.001	0.9
		Model 3		MF2	↓	-	<0.001	0.9
				MF3 (1st slope)	↓	3.4	<0.001	
	Open-water	Model 2	1	MF1	↓		-	<0.001
				MF2	↓	-	0.031	
		Model 3		MF3 (1st slope)	↓	8.6	<0.001	0.93
MF3 (2nd slope)	↑	-						
Magnesium (dissolved)	Ice-cover	Model 2	0	MF1	↓	-	<0.001	0.76
		Model 3		MF2	↓	-	<0.001	0.83
				MF3 (1st slope)	↓	1.9	0.001	
	Open-water	Model 2	0	MF1	↓		-	<0.001
				MF2	↓	-	0.001	
		Model 3		MF3 (1st slope)	↓	25.9	<0.001	0.81
MF3 (2nd slope)	↑	-						
Dissolved Sodium	Ice-cover	Model 2	0	MF1	↓	-	<0.001	0.87
		Model 3		MF2	↓	-	<0.001	0.97
				MF3 (1st slope)	↓	3.1	0.248	
	Open-water	Model 2	0	MF1	↓		-	<0.001
				MF2	↓	-	<0.001	
		Model 3		MF3 (1st slope)	↓	5.2	0.052	0.94
MF3 (2nd slope)	↑	-						
Sulphate	Ice-cover	Model 1	0	MF1	↓	-	<0.001	0.79
				MF2	↓	-	<0.001	
				MF3	↓	-	<0.001	
	Open-water	Model 2	0	MF1	↓	-	<0.001	0.88
				MF2	↓	-	0.002	
		Model 3		MF3 (1st slope)	↓	3.9	<0.001	0.85
MF3 (2nd slope)	↓	-						

a) Slope direction was represented by an upward arrow (↑) indicating an increasing trend with distance from the diffuser, or a downward arrow (↓) indicating a decreasing trend with distance from the diffuser.
 b) The breakpoint is the location from the effluent discharge where the slopes of the linear regressions along the MF3 transect changed value.
 c) P-values were not calculated for the second MF3 slope.
 d) For Model 3 (i.e., MF3 broken stick models), r² is calculated because there is only one predictor, which is distance; for the other models, R² is calculated, since there is more than one predictor, i.e., distance and gradient.
 Note: **Bold** indicates P-value significant at <0.05. The P-value relevant to the second slope is not reported by the statistical software because it cannot be estimated (Muggeo 2008).
 - = not applicable; MF = mid-field.

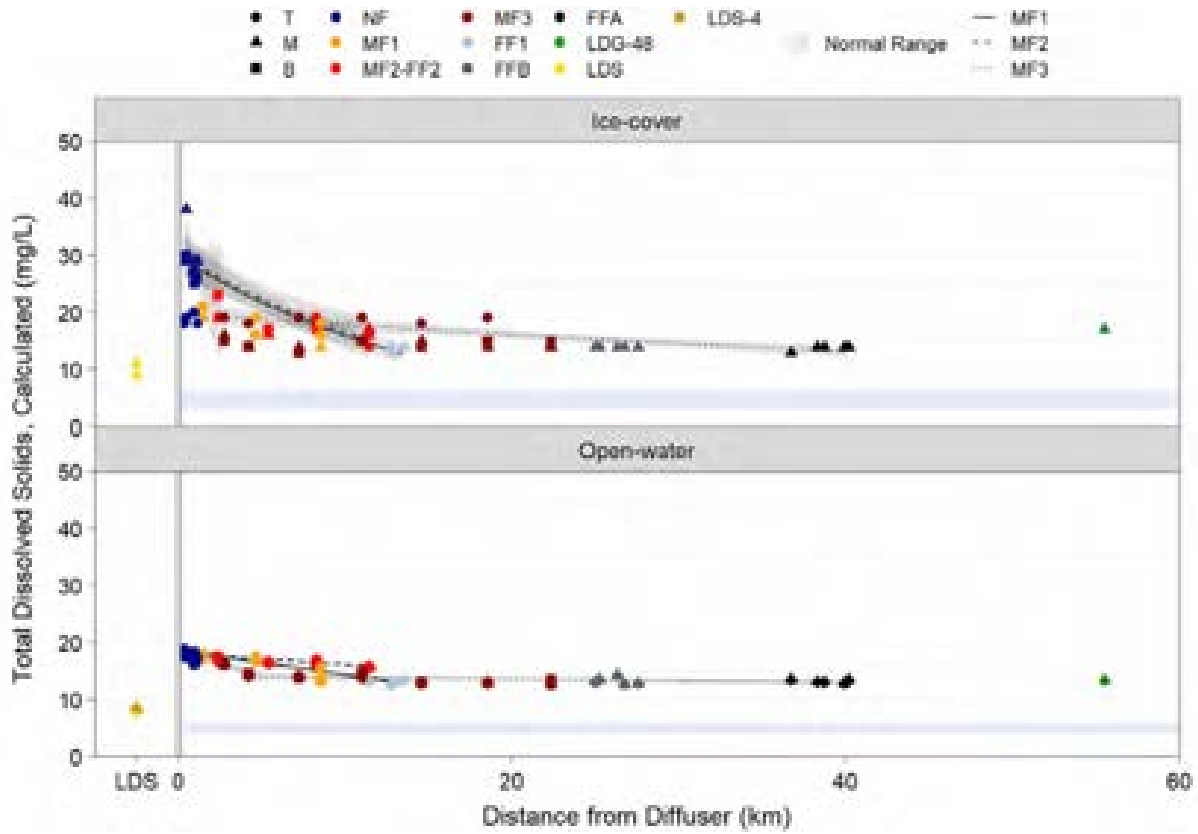
Figure 3-30 Turbidity According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; x = statistical outlier; NTU = nephelometric turbidity unit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

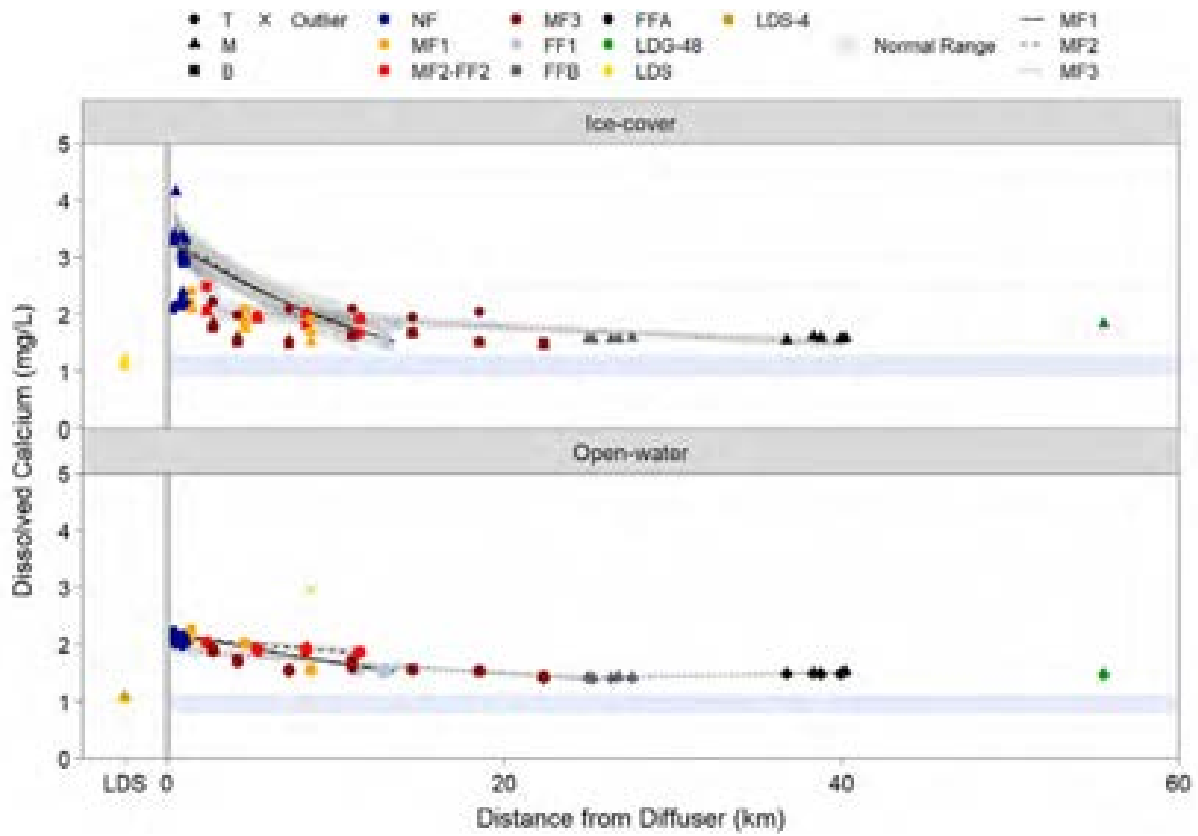
Figure 3-31 Concentrations of Total Dissolved Solids (Calculated) According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

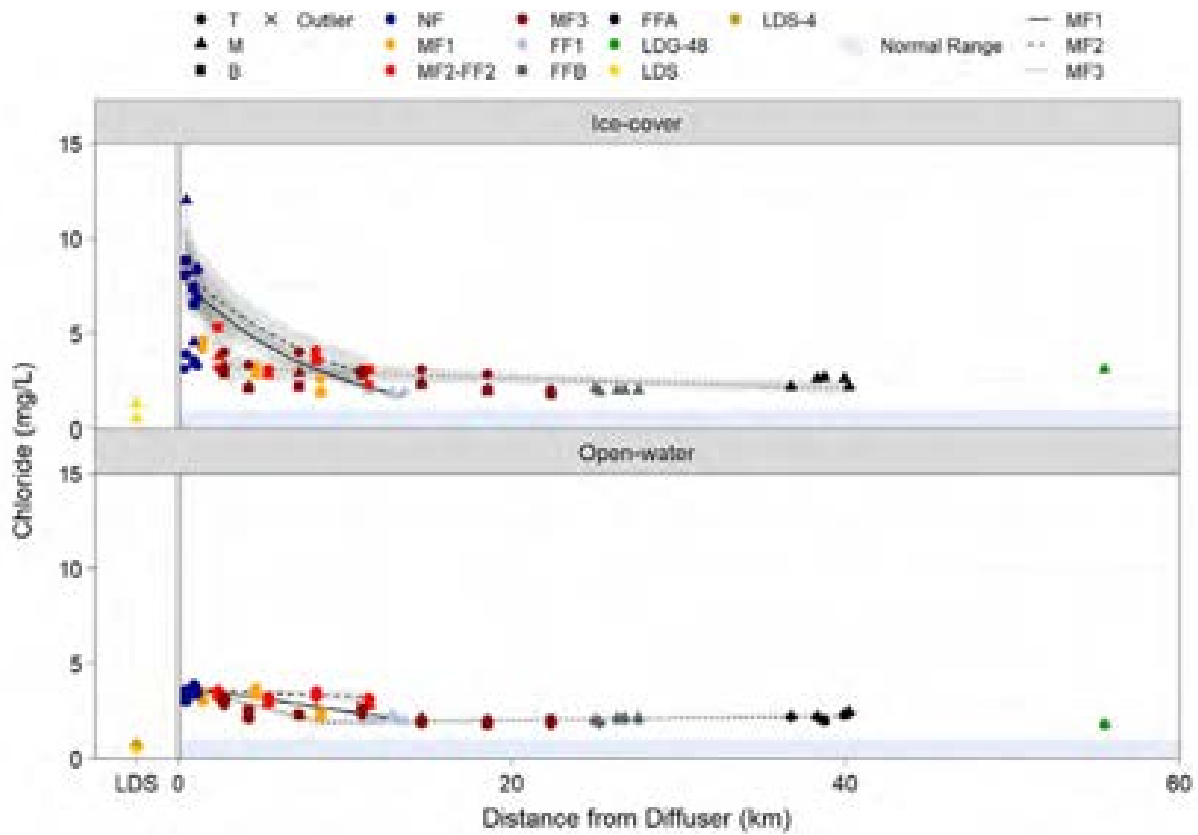
Figure 3-32 Concentrations of Calcium (Dissolved) According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage

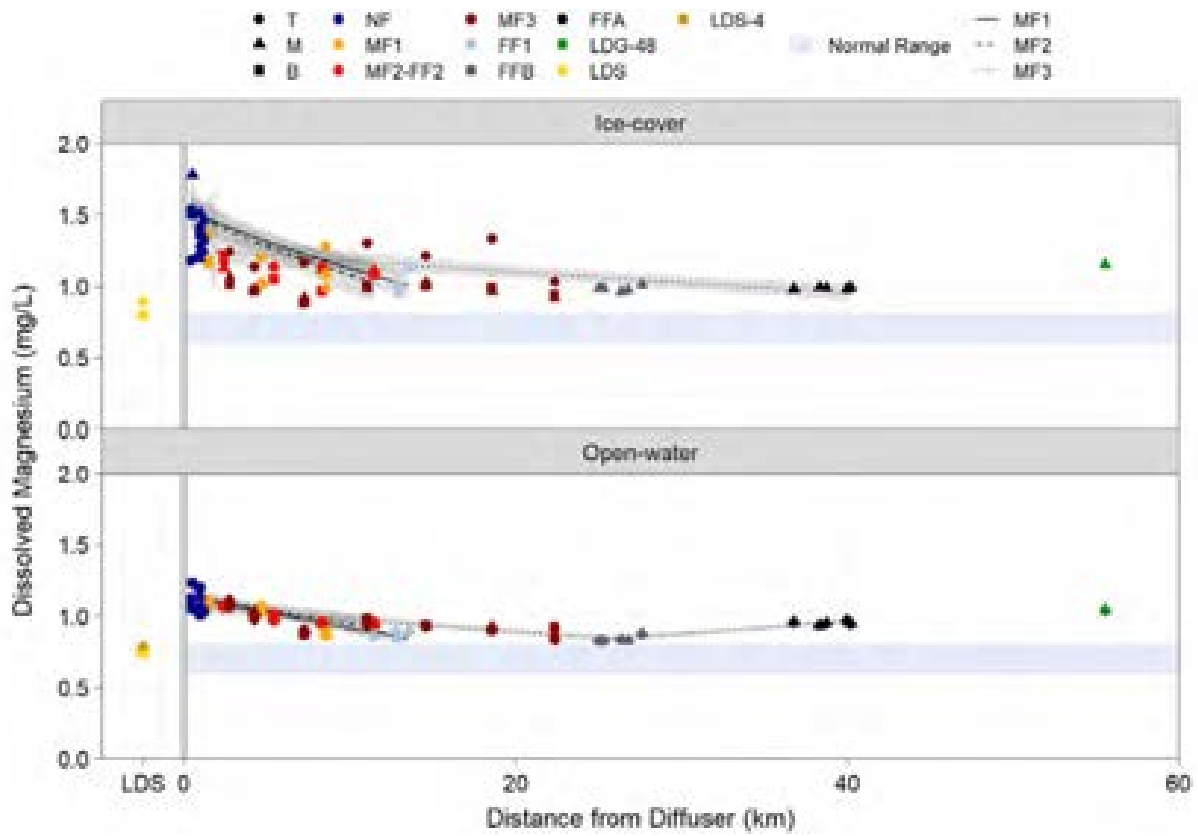
Figure 3-33 Concentration of Chloride According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; x = statistical outlier; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

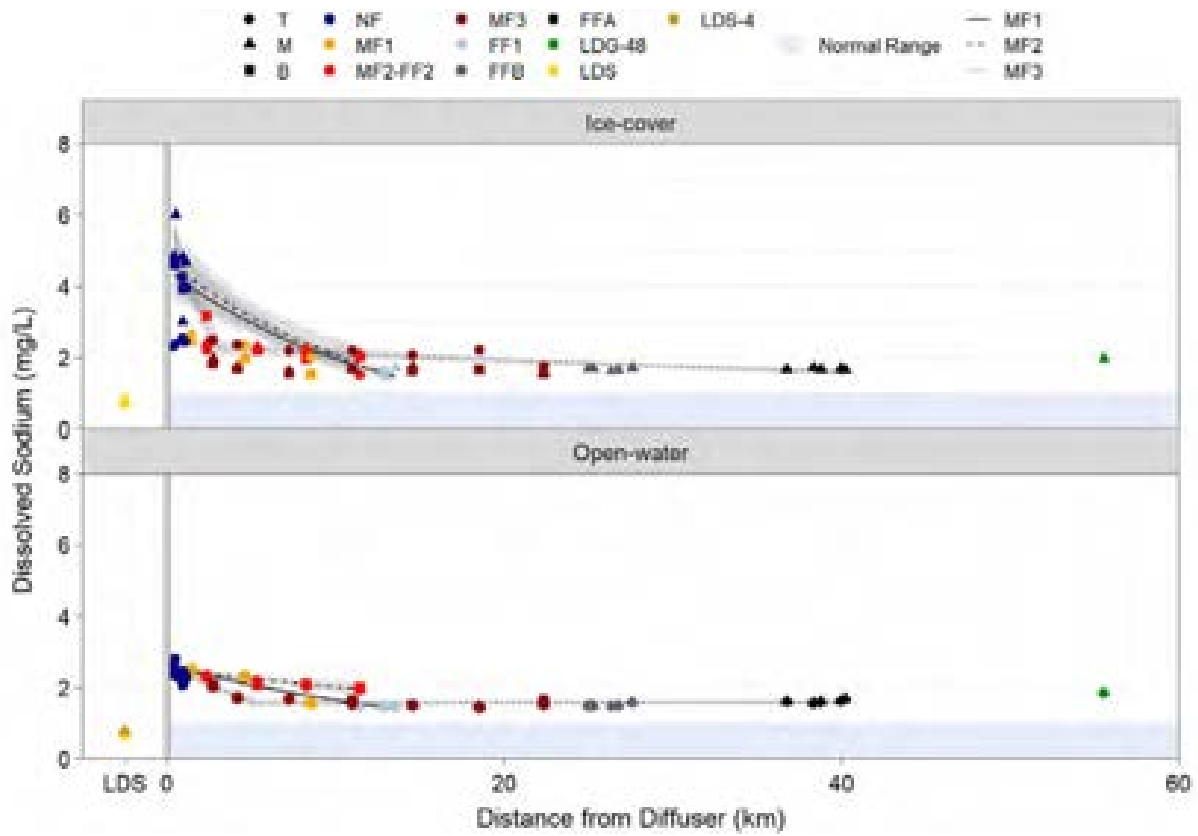
Figure 3-34 Concentrations of Magnesium (Dissolved) According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

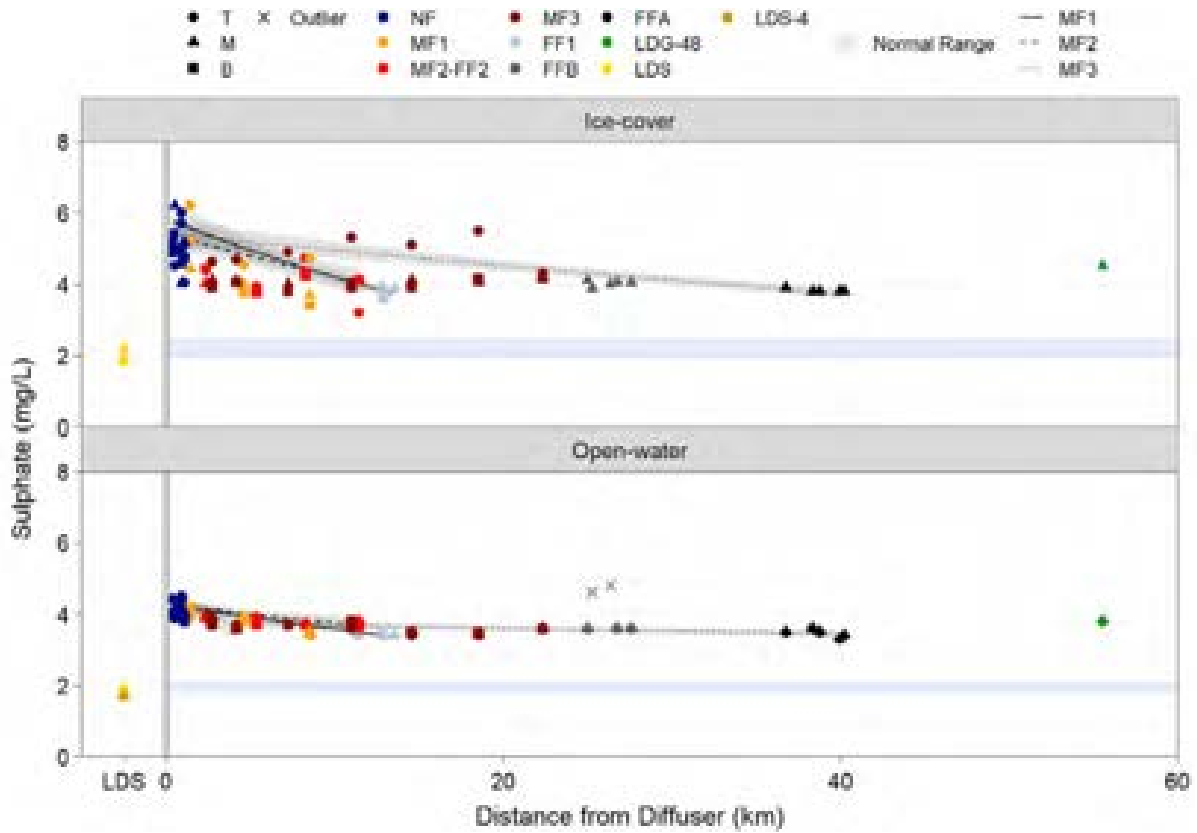
Figure 3-35 Concentration of Sodium (Dissolved) According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-36 Concentration of Sulphate According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

3.6.2 Nitrogen Variables

The slopes of the linear regressions for ammonia were significantly different from zero for the MF1 and MF3 transects in both seasons, and for the MF2 transect in the ice-cover season (Table 3-11). The regression coefficient for the MF2 transect in the open-water season was not significant. These slopes were negative, indicating decreasing concentrations with distance from the effluent discharge. The spatial analysis of the MF3 transect during open-water identified a breakpoint at 4.2 km from the effluent discharge.

The statistical analysis of nitrate concentration along the MF1, MF2, and MF3 transects was restricted to the ice-cover season, due to high censoring of datasets during open-water conditions (Section 2.3.6.2.1). Nitrate had significant decreasing trends with distance from the diffuser along all three MF transects during the ice-cover season (Table 3-11). The spatial analysis of the MF3 transect for nitrate involved a breakpoint at 4.2 km from the effluent discharge. During open-water, concentrations of nitrate were elevated (based on a visual assessment) at stations closest to the diffuser, but were less than the DL at stations farther away from the effluent discharge.

Concentrations of ammonia and nitrate at the LDS stations were generally similar to those in Lac de Gras (Figure 3-37 and Figure 3-38). Concentrations of ammonia and nitrate at LDG-48 were similar to those in the FFA area during both seasons.

Table 3-11 Gradient Analysis for Nitrogen Variables, 2019

Variable	Season	Model	Box-Cox Transformation	Gradient	Slope ^(a)	Breakpoint (km) ^(b)	P-value ^(c)	R ² or r ^{2(d)}
Ammonia ^(e)	Ice-cover	Model 1	0	MF1	↓	-	0.001	0.45
				MF2	↓	-	0.027	
				MF3	↓	-	<0.001	
	Open-water	Model 2	1	MF1	↓	-	<0.001	0.91
				MF2	↓	-	0.055	
		Model 3		MF3 (1st slope)	↓	4.2	0.034	0.75
MF3 (2nd slope)	↓	-						
Nitrate	Ice-cover	Model 2	1	MF1	↓	-	<0.001	0.78
				MF2	↓	-	0.001	
		Model 3		MF3 (1st slope)	↓	4.2	<0.001	0.92
				MF3 (2nd slope)	↓		-	
	Open-water	n/a						

a) Slope direction was represented by an upward arrow (↑) indicating increasing trend with distance from the diffuser, or a downward arrow (↓) indicating a decreasing trend with distance from the diffuser.

b) The breakpoint is the location from the effluent discharge where the slopes of the linear regressions along the MF3 transect changed value.

c) P-values were not calculated for the second MF3 slope.

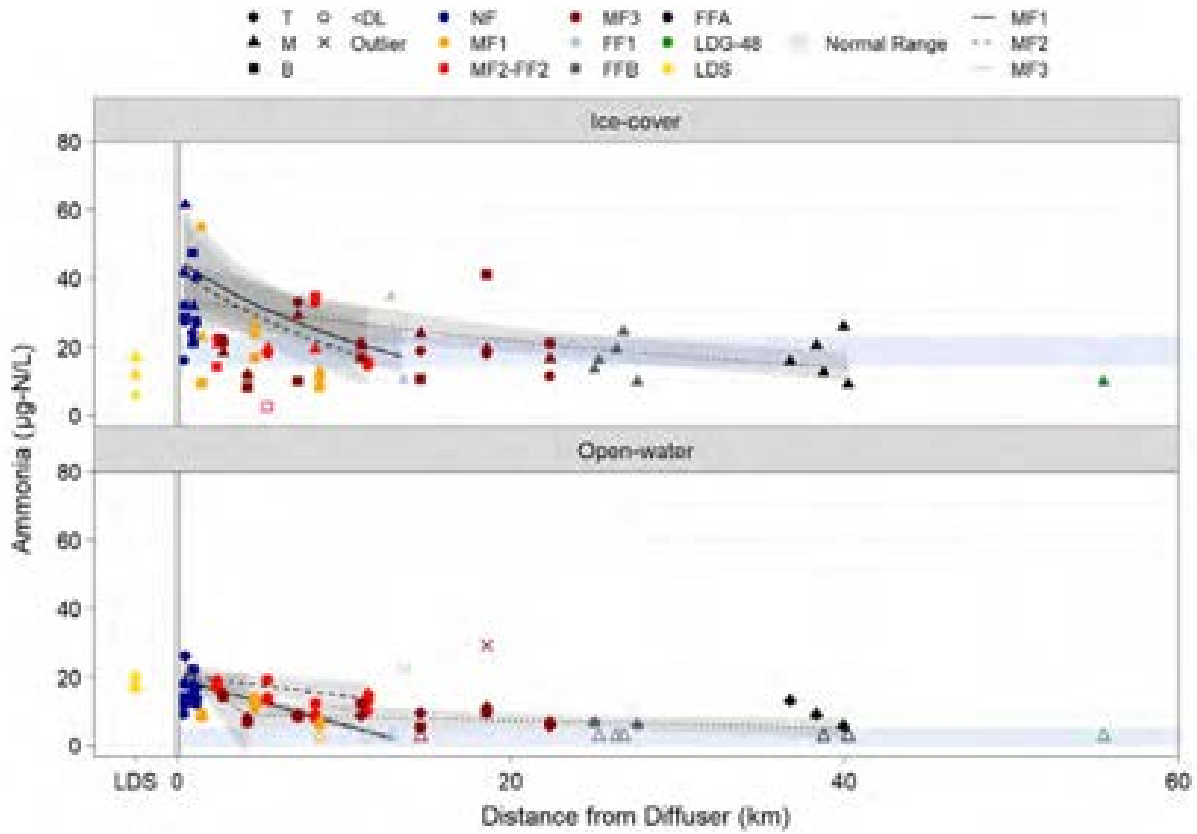
d) For Model 3 (i.e., MF3 broken stick models), r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2 is calculated, since there is more than one predictor, i.e., distance and gradient.

e) Based on the results of the ammonia investigation, the ALS ammonia dataset was used in the ice-cover season and the BV ammonia dataset was used in the open-water season (Section 2.4.1, Attachment B).

Note: **Bold** indicates P-value significant at <0.05.

- = not applicable; n/a = not analyzed; MF = mid-field.

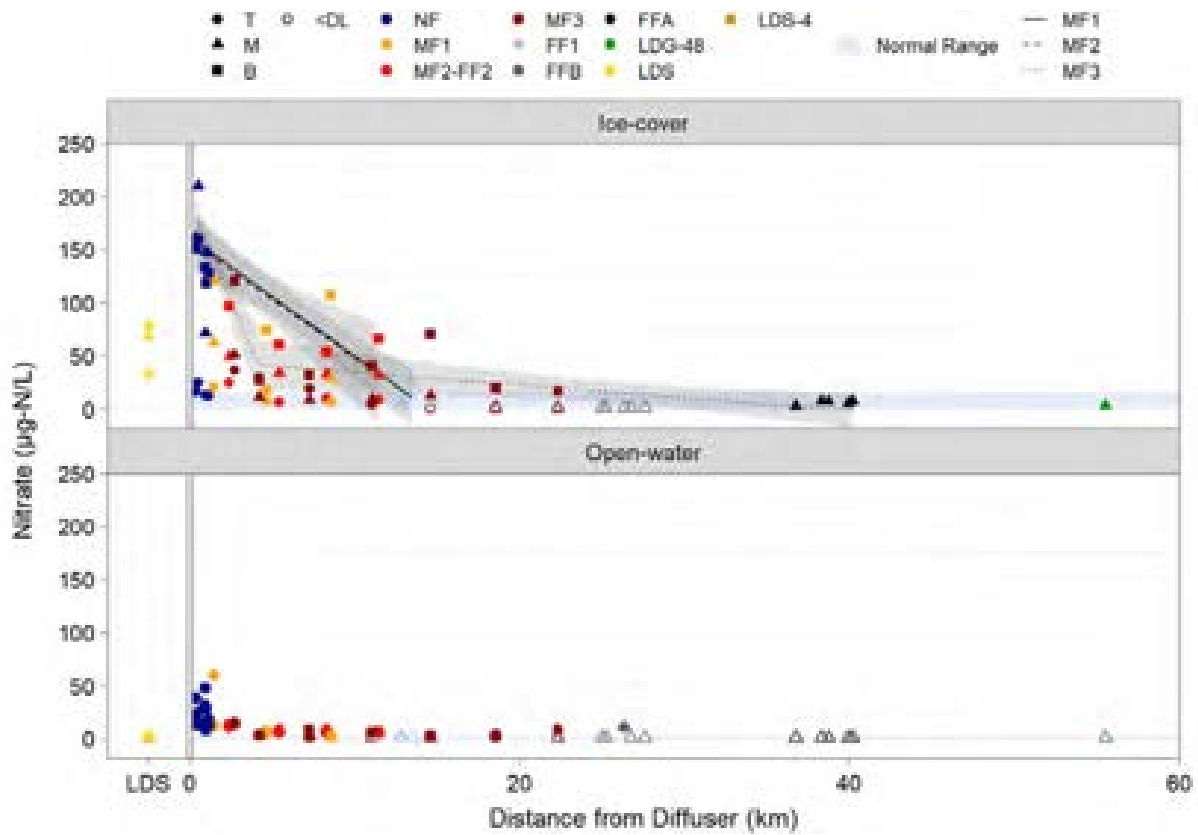
Figure 3-37 Concentrations of Ammonia According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; µg-N/L = micrograms of nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-38 Concentrations of Nitrate According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; µg-N/L = micrograms of nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

3.6.3 Total Metals

The total metal SOIs for which linear regression analysis was completed included aluminum, barium, manganese, molybdenum, strontium, and uranium (Figure 3-39 to Figure 3-42, Figure 3-44 and Figure 3-45). Linear regressions were not performed for silicon (both seasons; Figure 3-43), due to the considerations discussed in Section 2.3.6.2.1; however, spatial trends are discussed qualitatively herein.

During the ice-cover season, concentrations of nearly all total metals decreased significantly with distance away from the diffuser along at least two of three MF transects (Table 3-12). The exception was manganese, which had non-significant slopes along all three MF transects. In all cases with significant results, slopes were significantly different from zero at the MF1 and MF2 transects. The slopes of linear regressions for aluminum, strontium and uranium were also significantly different from zero along the MF3 transect.

During the open-water season, slopes of the majority of the linear regressions were significantly different from zero along the MF1 and MF2 transects. Exceptions occurred for aluminum and barium, which had significant regressions along the MF1 transect, but not the MF2 transect. The slopes of linear regressions for barium, manganese and strontium were also significantly different from zero at the MF3 transect. In most cases, slopes were negative, indicating decreasing concentrations with distance from the effluent discharge. However, slopes of linear regressions were positive in direction along the MF2 transect for aluminum and manganese in the open-water season, indicating increasing concentrations with distance from the effluent discharge. The elevated concentrations along the MF2 transect appear to be influenced by the inflow to Lac de Gras from Lac du Sauvage. Concentrations of aluminum at LDS stations were similar to those measured in the NF area of Lac de Gras and concentrations of manganese were similar to those measured at the end of the MF2 transect.

Piecewise regression was used for the analysis of the MF3 transect for all total metals, with the exception of aluminum (both seasons) and manganese (open-water), which used a standard linear approach. Breakpoints identified by the piecewise analysis generally occurred between 2.5 and 5.5 km from the effluent discharge. Exceptions included molybdenum and uranium during the open-water season, which had breakpoints at approximately 23.5 and 21.3 km from the effluent discharge, respectively. The trend direction for uranium in the open-water season changed from a decreasing trend for the first slope (extending from the NF area to the breakpoint) to an increasing trend for the second slope (extending from the breakpoint through the FFA area). A similar pattern occurred in molybdenum during the ice-cover season; however, the regression along the MF3 transect was not significant. The trend direction in other total metal SOIs with significant regressions along the MF3 transect was a decrease in concentration with distance away from the diffusers.

Concentrations of barium, molybdenum, strontium, and uranium in both seasons were generally smaller at the LDS stations compared to stations located in the main body of Lac de Gras, whereas the concentrations of manganese (ice-cover) and silicon (both seasons) were slightly greater at the LDS stations compared to stations in Lac de Gras. Concentrations of aluminum (both seasons) and manganese (open-water) were generally similar at the LDS stations to concentrations measured in the body of Lac de Gras. Concentrations of most total metal SOIs at LDG-48 were similar to those encountered in the FFA area during both seasons. The exceptions were aluminum and silicon during open-water, which had greater concentrations at LDG-48 than at FFA.

Table 3-12 Gradient Analysis for Total Metals, 2019

Variable	Season	Model	Box-Cox Transformation	Gradient	Slope ^(a)	Break-point (km) ^(b)	P-value ^(c)	R ² or r ^{2(d)}
Aluminum	Ice-cover	Model 1	0	MF1	↓	-	<0.001	0.71
				MF2	↓	-	<0.001	
				MF3	↓	-	<0.001	
	Open-water	Model 1	0	MF1	↓	-	0.042	0.35
				MF2	↑	-	0.102	
				MF3	↓	-	0.05	
Barium	Ice-cover	Model 2	0	MF1	↓	-	<0.001	0.72
		Model 3		MF2	↓	-	<0.001	0.88
				MF3 (1st slope)	↓	2.7	0.154	
	Open-water	Model 2	0	MF1	↓	-	<0.001	0.82
				MF2	↓	-	0.064	
				MF3 (1st slope)	↓	4.7	0.001	0.79
MF3 (2nd slope)	↓	-						
Manganese	Ice-cover	Model 2	0	MF1	↓	-	0.723	-0.09
		Model 3		MF2	↓	-	0.423	
				MF3 (1st slope)	↓	4.2	0.158	
	Open-water	Model 1	0	MF1	↓	-	0.015	0.57
				MF2	↑	-	0.002	
				MF3	↓	-	0.001	
Molybdenum	Ice-cover	Model 2	0	MF1	↓	-	<0.001	0.92
		Model 3		MF2	↓	-	<0.001	
				MF3 (1st slope)	↓	23.5	0.303	
	MF3 (2nd slope)	↑	-					
	Open-water	Model 2	0	MF1	↓	-	<0.001	0.86
				MF2	↓	-	0.02	
MF3 (1st slope)				↓	4.0	0.052	0.77	
MF3 (2nd slope)	↓	-						
Silicon	Ice-cover	n/a						
	Open-water	n/a						
Strontium	Ice-cover	Model 2	0	MF1	↓	-	<0.001	0.89
		Model 3		MF2	↓	-	<0.001	
				MF3 (1st slope)	↓	3.2	<0.001	
	MF3 (2nd slope)	↓	-					
	Open-water	Model 2	1	MF1	↓	-	<0.001	0.9
				MF2	↓	-	0.006	
MF3 (1st slope)				↓	5.1	<0.001	0.97	
MF3 (2nd slope)	↓	-						
Uranium	Ice-cover	Model 2	0	MF1	↓	-	<0.001	0.94
		Model 3		MF2	↓	-	<0.001	
				MF3 (1st slope)	↓	3.2	0.087	
	MF3 (2nd slope)	↓	-					
	Open-water	Model 2	0	MF1	↓	-	<0.001	0.96
				MF2	↓	-	0.006	
MF3 (1st slope)				↓	21.3	<0.001	0.88	
MF3 (2nd slope)	↑	-						

a) Slope direction was represented by an upward arrow (↑) indicating increasing trend with distance from the diffuser, or a downward arrow (↓) indicating a decreasing trend with distance from the diffuser.

b) The breakpoint is the location from the effluent discharge where the slopes of the linear regressions along the MF3 transect changed value.

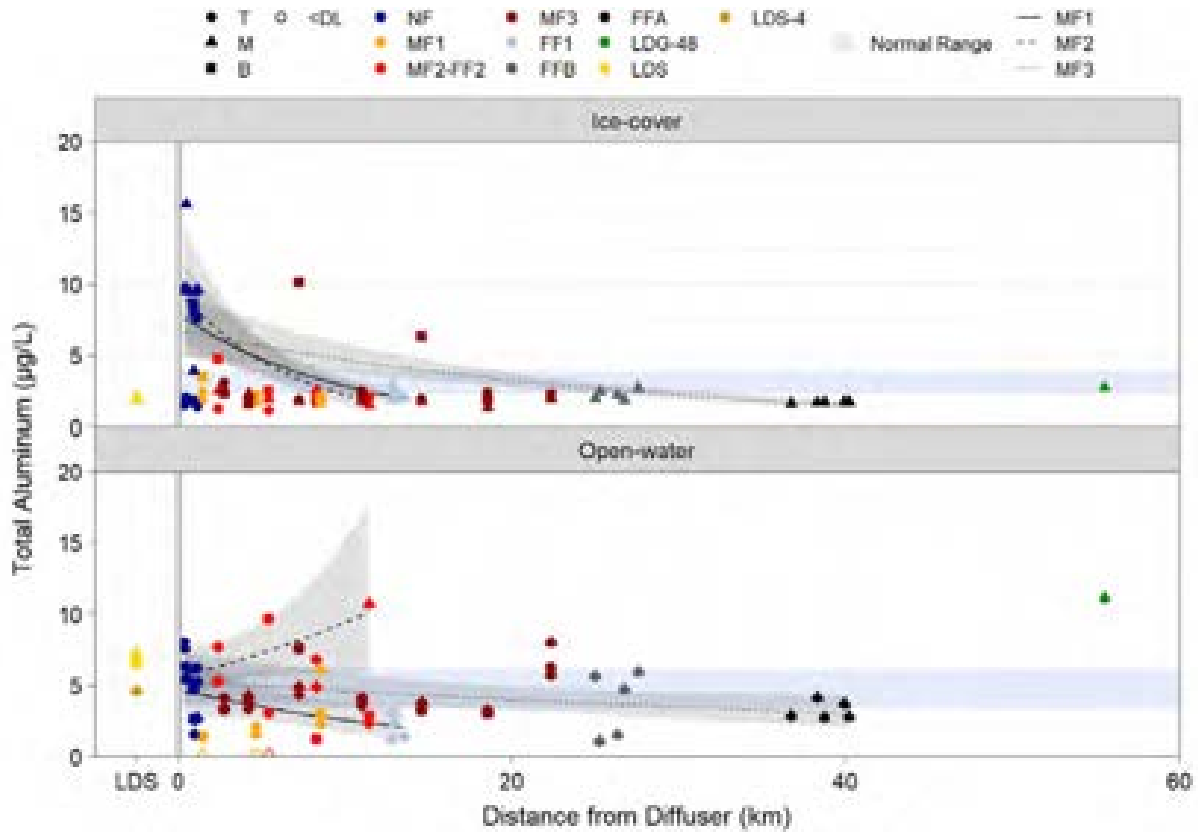
c) P-values were not calculated for the second MF3 slope.

d) For Model 3 (i.e., MF3 broken stick models), r² is calculated because there is only one predictor, which is distance; for the other models, R² is calculated, since there is more than one predictor, i.e., distance and gradient.

Note: **Bold** indicates P-value significant at <0.05.

- = not applicable; n/a = not analyzed; MF = mid-field.

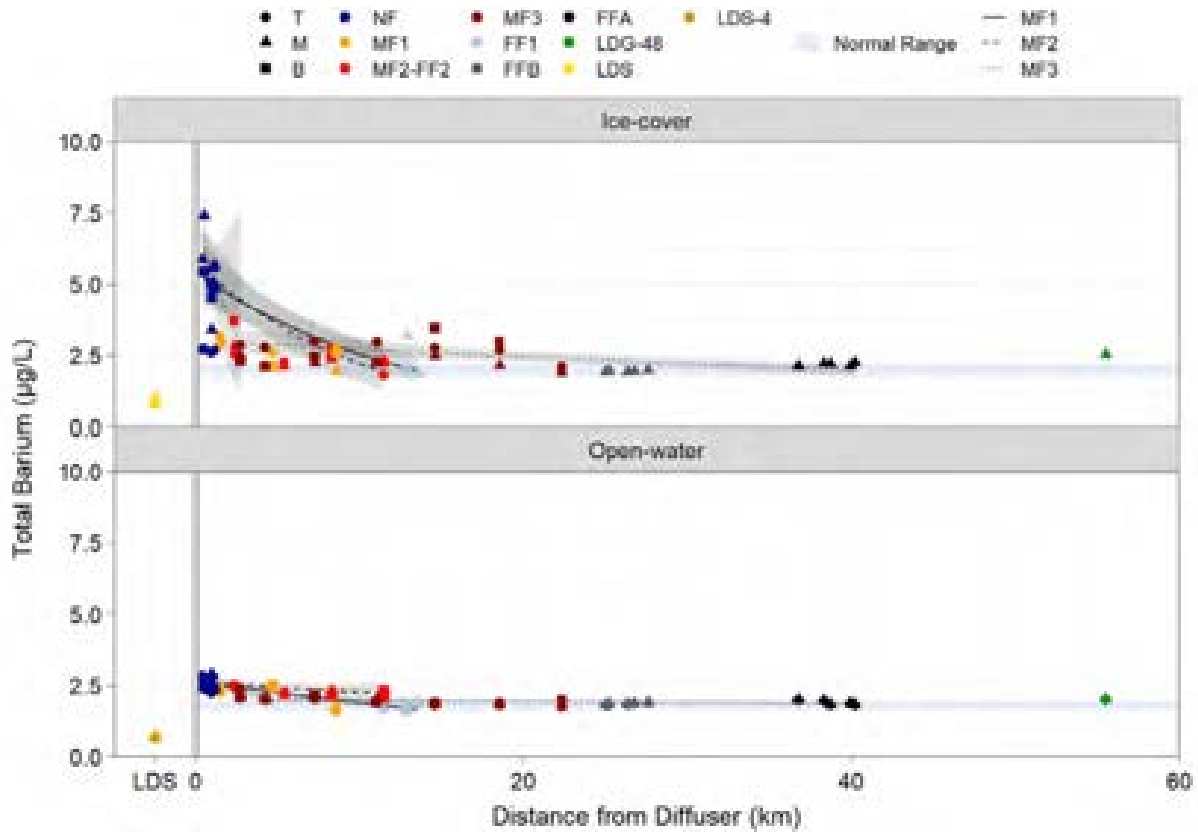
Figure 3-39 Concentration of Total Aluminum According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

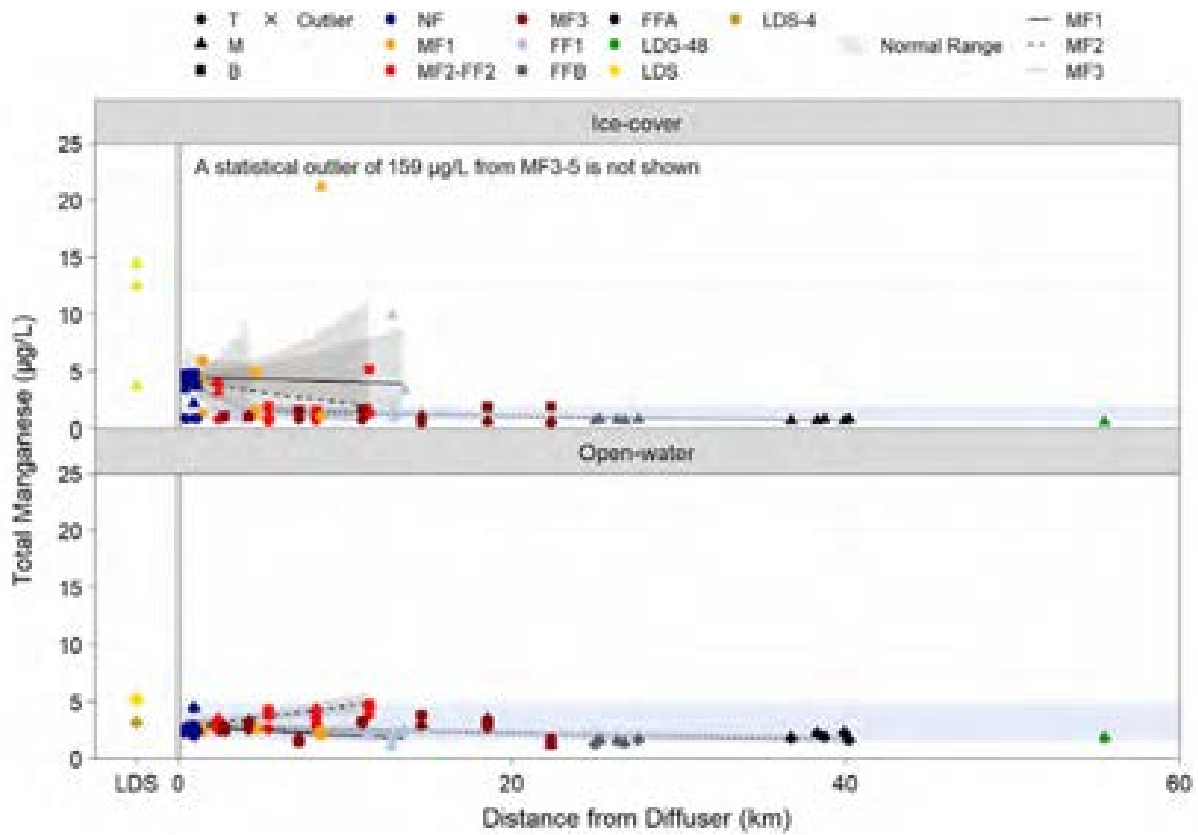
Figure 3-40 Concentration of Total Barium According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

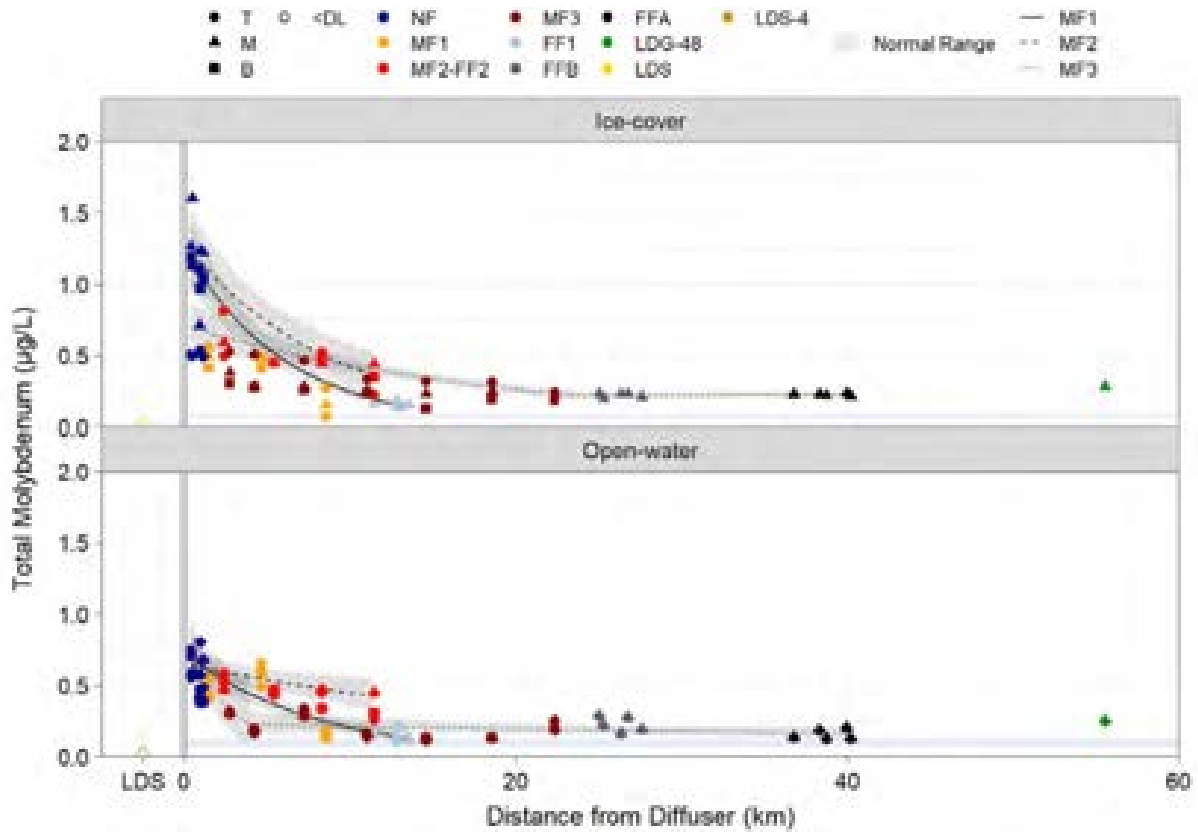
Figure 3-41 Concentration of Total Manganese According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T= top depth; M = middle depth; B = bottom depth; x = statistical outlier; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

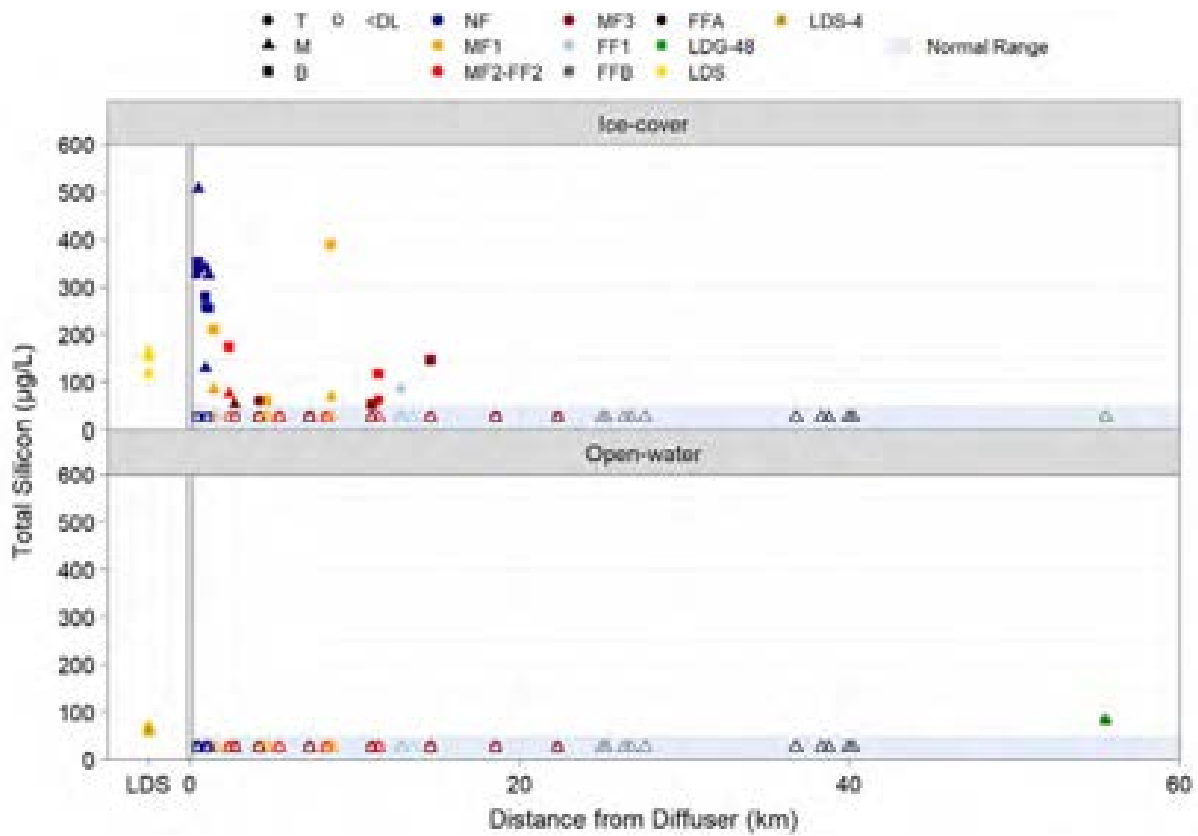
Figure 3-42 Concentration of Total Molybdenum According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

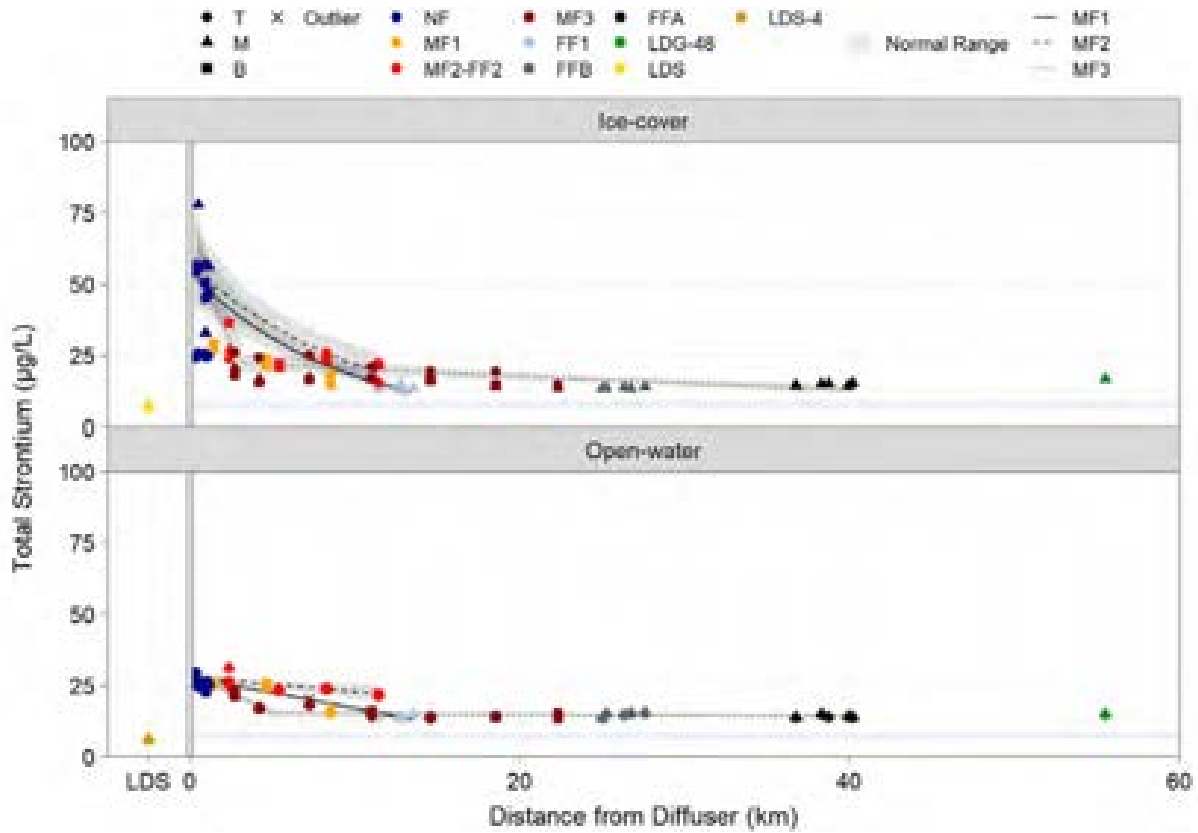
Figure 3-43 Concentration of Total Silicon According to Distance from the Mine Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T= top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

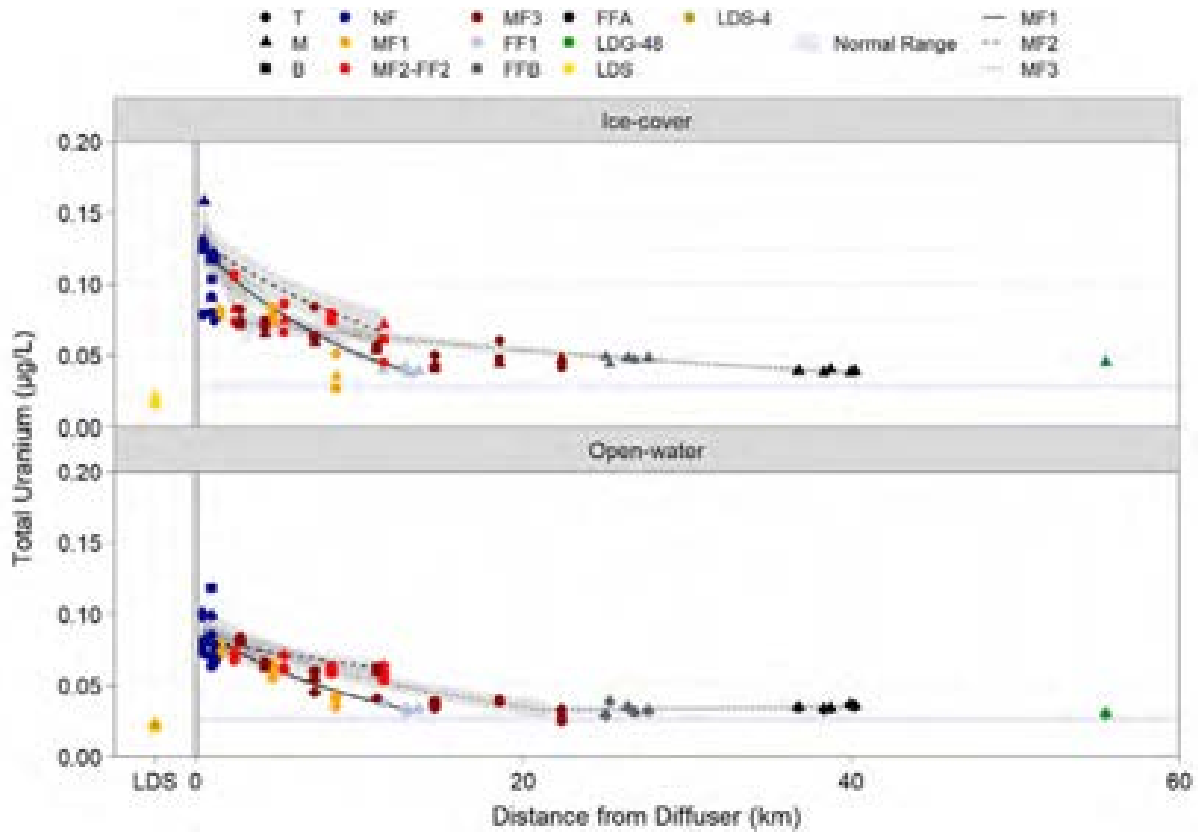
Figure 3-44 Concentration of Total Strontium According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-45 Concentration of Total Uranium According to Distance from the Effluent Discharge, 2019



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T= top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

3.7 Near-Field versus Far-Field Area Comparisons

Substances of interest were evaluated statistically to determine whether concentrations measured in the NF area (Section 3.5) were significantly greater relative to the FF areas. Of the 16 SOIs tested, 14 had NF mean concentrations significantly greater than FF area mean concentrations in both sampling seasons (Table 3-13). The exceptions were turbidity, which was not significantly different between the NF and FF areas in either season, and silicon, which had a significant difference during the ice-cover season only.

Significant differences among FF areas occurred during the ice-cover season for turbidity, chloride, sulphate, nitrate, aluminum, barium, manganese, molybdenum, strontium, and uranium (Table 3-13). During the open-water season, significant differences among FF areas were noted for calcium, magnesium, sodium, sulphate, and manganese. The difference between individual FF area means for most of these variables, however, was small when compared with the overall difference between the NF and FF area means.

Table 3-13 Statistical Comparisons of Water Quality Variable Concentrations in Lac de Gras, 2019

Variable	Season	Statistical Test	Overall Comparison	NF vs FF Area Comparison		FF Area Comparisons		
				NF vs FF1+FFB+FFA		FF1 vs FFA	FF1 vs FFB	FFA vs FFB
				P	P	NF vs FF	P	P
Conventional Parameters								
Turbidity - lab	Ice-cover	ANOVA	0.003	0.189	ns	0.014	0.750	0.002
	Open-water	ANOVA	ns	-	-	0.991	0.644	0.806
Total Dissolved Solids, calculated	Ice-cover	ANOVA	<0.001	<0.001	[NF >FF]	0.860	0.427	0.860
	Open-water	ANOVA	<0.001	<0.001	[NF >FF]	0.952	0.805	0.981
Major Ions								
Calcium (dissolved)	Ice-cover	ANOVA	<0.001	<0.001	[NF >FF]	0.551	0.431	0.996
	Open-water	ANOVA	<0.001	<0.001	[NF >FF]	0.181	<0.001	0.023
Chloride	Ice-cover	ANOVA	<0.001	<0.001	[NF >FF]	<0.001	0.644	0.003
	Open-water	ANOVA	<0.001	<0.001	[NF >FF]	0.577	0.729	0.135
Magnesium (dissolved)	Ice-cover	ANOVA	<0.001	<0.001	[NF >FF]	0.297	0.253	1
	Open-water	ANOVA	<0.001	<0.001	[NF >FF]	0.064	0.788	0.011
Sodium (dissolved)	Ice-cover	ANOVA	<0.001	<0.001	[NF >FF]	0.205	0.243	0.999
	Open-water	ANOVA	<0.001	<0.001	[NF >FF]	<0.001	0.406	0.002
Sulphate	Ice-cover	ANOVA	<0.001	<0.001	[NF >FF]	1	0.020	0.023
	Open-water	ANOVA	0.003	0.005	[NF >FF]	0.997	0.027	0.040
Nutrients								
Ammonia ^(a)	Ice-cover	ANOVA	0.006	0.001	[NF >FF]	0.788	0.785	1
	Open-water	One-sample t-test	0.015	-	-	-	-	-
Nitrate	Ice-cover	ANOVA ^{log}	<0.001	<0.001	[NF >FF]	0.030	<0.001	<0.001
	Open-water	One-sample t-test	0.017	-	-	-	-	-
Total Metals								
Total Aluminum	Ice-cover	ANOVA	<0.001	<0.001	[NF >FF]	0.029	0.97	0.063
	Open-water	ANOVA	0.065	0.019	[NF >FF]	0.758	0.45	0.949
Total Barium	Ice-cover	KW	0.002	0.0001	[NF >FF]	0.369	0.970	0.035
	Open-water	ANOVA	<0.001	<0.001	[NF >FF]	0.237	0.484	0.951
Total Manganese	Ice-cover	ANOVA ^{rank}	<0.001	<0.001	[NF >FF]	<0.001	0.001	0.985
	Open-water	ANOVA	0.004	0.002	[NF >FF]	0.963	0.200	0.091
Total Molybdenum	Ice-cover	ANOVA	<0.001	<0.001	[NF >FF]	<0.001	<0.001	0.984
	Open-water	ANOVA	<0.001	<0.001	[NF >FF]	0.999	0.527	0.604
Total Silicon	Ice-cover	One-sample t-test	0.059	-	-	-	-	-
	Open-water	nt	-	-	-	-	-	-
Total Strontium	Ice-cover	ANOVA	<0.001	<0.001	[NF >FF]	0.004	0.906	0.015
	Open-water	ANOVA	<0.001	<0.001	[NF >FF]	0.987	0.313	0.480
Total Uranium	Ice-cover	ANOVA	<0.001	<0.001	[NF >FF]	0.882	0.003	<0.001
	Open-water	ANOVA	<0.001	<0.001	[NF >FF]	0.998	0.999	0.991

a) Based on the results of the ammonia investigation, the ALS ammonia dataset was used in the ice-cover season and the BV ammonia dataset was used in the open-water season (Section 2.4.1, Attachment B).

P = probability; ns = not significant; nt = not tested, as outlined in Section 2.3.6.2.2; - = not applicable, overall comparison is non-significant; NF = near-field; FF = far-field; KW = Kruskal-Wallis test; ANOVA = analysis of variance (transformation is indicated by superscript)

Note: **Bold** indicates P-value significant at <0.1 for overall comparison, NF vs. FF area comparisons, and parametric FF area comparisons and at <0.15 for non-parametric FF area comparisons.

3.8 Effects from the A21 Dike

There was no dike effect evident for any of the SOIs in 2019 (Figure 3-46 to Figure 3-49). Review of plots of SOI concentrations with distance from the Mine effluent diffusers indicated that concentrations of turbidity and other sediment associated variables (i.e., total metals) were within expected ranges at stations located closest to the A21 dike, based on the typical pattern of exposure to Mine effluent throughout the lake. Furthermore, there was no indication of an effect of the A21 Dike on non-SOIs, based on review of concentrations at stations nearest to the dike (i.e., MF3-3 and MF3-4). Previous AEMP monitoring in Lac de Gras (i.e., 2016 and 2018 AEMPs) identified clear increases in the concentrations of a number of sediment-associated variables, including certain total metals, at stations MF3-3 and MF3-4. These responses were evident in the results of AEMP sampling, which occurred when instream construction work for the A21 Dike was ongoing in 2016, and when pit dewatering activities were ongoing in 2018. These responses were not present in 2019, indicating that previously identified effects have not persisted in Lac de Gras. This is consistent with the expected response in water quality from dike construction-related sediment releases, which are typically of short duration and cease after the activity ends. Thus, evaluation of dike-related effects on water quality will be discontinued, unless changes in Mine configuration occur that would render this analysis potentially useful to characterize aquatic effects.

3.9 Effects from Dust Deposition

In 2019, median concentrations of 11 SOIs met Criterion 4 in the SOI selection process (Section 2.3.1; i.e., TDS, turbidity, calcium, chloride, sodium, sulphate, ammonia, nitrate, molybdenum, strontium, and uranium), because their concentration exceeded two times the median of the reference dataset at one or more of the four MF area stations located within the estimated ZOI from dust deposition (i.e., MF1-1, MF2-1, MF3-1 and MF3-2; Table 3-14). Spatial trends for these variables are shown on Figure 3-46 to Figure 3-49.

Each of the 11 SOIs that met Criterion 4 in the SOI selection process also triggered Action Level 1 in the NF area (Table 3-14), indicating that the exceedances of the dust criterion at the MF stations were likely caused by dispersion of Mine effluent into the lake; however, as the NF area is located within the ZOI, there is some potential that dust deposition may also be contributing to the increases observed in these variables in the NF area. For these SOIs, the increases observed at the four MF area stations within the ZOI were generally less than or similar to those observed in the NF area, based on a visual evaluation. Exceptions were turbidity, sodium, ammonia, strontium, and uranium which had median concentrations at one or more of the four MF stations that were slightly elevated compared to the median of the NF area concentrations. These results indicate that the elevated values within the ZOI may not be solely related to dispersion of effluent in the lake.

Turbidity exceeded the criterion at MF2-1 and MF3-2. The median turbidity values at both MF2-1 and MF3-2 were slightly greater than the median reported in the NF area. While there is some potential that these turbidity increases may be related to dust deposition, this interpretation is not supported by similar increases in the concentrations of other sediment associated variables such as total metals. In addition, turbidity was slightly elevated at stations outside of the ZOI (i.e. FF2-5, FF1-1, LDS-4) relative to other nearby stations in 2019. These slight elevations in turbidity may be caused by noise in the data, which can occur when concentrations are measured close to the analytical DL.

Concentrations of ammonia exceeded Criterion 4 at all four MF area stations located within the ZOI. The median concentration at MF2-1 was greater than the median reported in the NF area. While there is some potential that these concentration increases may be related to dust deposition, the laboratory quality control issues that have been observed for ammonia indicate that these increases may be due to high variability in the reported concentrations (due to the considerations noted in Section 2.4 and Attachment B), rather than a result of dust deposition.

Concentrations of sodium, strontium, and uranium exceeded Criterion 4 at all four MF area stations located within the ZOI. The median concentrations of sodium, strontium, and uranium were slightly greater than the median reported in the NF area at MF1-1, MF2-1, and MF3-1, respectively. While there is some potential that these slight increases may be related to dust deposition, this interpretation is not supported by similar increases in the concentrations of other sediment associated variables such as total metals.

Overall, analysis of the 2019 AEMP water quality data did not provide clear evidence to suggest an effect of dust deposition from the Mine site on the water quality of Lac de Gras. Although some variables had slightly greater concentrations at one or two MF area stations within the ZOI compared to the NF median, increases relative to the NF median were very slight, and nearly all MF station medians were less than the greatest NF station median, as expected when the source of a parameter is the Mine effluent. Spatial trends in variables triggering Action Level 1 showed clear gradients related to the Mine discharge *within* the ZOI from dust deposition, with the exception of turbidity, which was highly variable throughout the lake. A step change (i.e., decline) in concentration was not apparent outside the ZOI for any of the evaluated variables. These results suggest that dust deposition is unlikely to be an important source of effects on water quality of Lac de Gras.

In 2019, DDMI conducted a special study evaluating the effects of dust deposition on water quality in Lac de Gras at areas most likely to be affected by dustfall. The results of this study are presented in Appendix XII. The findings of the special study support the conclusion outlined above that dust deposition is unlikely to be an important source of effects on water quality of Lac de Gras.

Table 3-14 Evaluation of Effects from Dust Deposition and Dike Construction in Lac de Gras, 2019

Variable	Unit	2019 Detection Limit	Screening Value	2019 AEMP Result (Open-water)						Median of MF Station >2× Median of Reference Dataset ^(a) (Yes/No)
			2× Median of Reference Areas ^(a)	Median of NF Values	Highest NF Station Median Value	Median of MF Values ^(b)				
						MF1-1	MF2-1	MF3-1	MF3-2	
Conventional Parameters										
Total alkalinity	mg/L	0.5	8	5.57	5.69	5.65	5.53	5.52	5.35	No
Total dissolved solids, calculated	mg/L	-	10.6	18	18	18	17	16	14	Yes ^(c)
Total dissolved solids, measured	mg/L	1	20	22.8	25.6	24.8	20.4	22.0	19.2	^(d)
Total suspended solids	mg/L	1	1	<1	1.1	<1	<1	<1	<1	No
Total organic carbon	mg/L	0.2	4.4	2.3	2.4	2.3	2.5	2.4	2.1	No
Turbidity – lab	NTU	0.1	0.42	0.31	0.49	0.22	0.49	0.22	0.43	Yes ^(c)
Major Ions										
Calcium (dissolved)	mg/L	0.01	2.0	2.1	2.2	2.1	2.0	1.9	1.7	Yes ^(c)
Chloride	mg/L	0.5	2.0	3.5	3.6	3.1	3.5	3.1	2.2	Yes ^(c)
Fluoride	mg/L	0.01	0.044	0.03	0.032	0.032	0.030	0.029	0.028	No
Magnesium (dissolved)	mg/L	0.005	1.4	1.1	1.2	1.1	1.1	1.1	1.0	No
Potassium (dissolved)	mg/L	0.01	1.2	0.99	1.1	1.0	0.99	0.89	0.77	No
Sodium (dissolved)	mg/L	0.01	1.0	2.3	2.6	2.4	2.3	2.1	1.7	Yes ^(c)
Sulphate	mg/L	0.5	3.8	4.0	4.4	4.0	3.9	3.9	3.6	Yes ^(c)
Nutrients										
Ammonia ^(e)	µg-N/L	5	5	15	19	8.6	18	14	7.8	Yes ^(c)
Nitrate	µg-N/L	2	2	20	37	12	11	15	3.6	Yes ^(c)
Nitrite	µg-N/L	1	2	<1	1.5	<1	<1	<1	<1	No
Total Metals										
Aluminum	µg/L	0.2	8.8	5.43	7.61	1.45	5.34	3.47	3.91	No
Antimony	µg/L	0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	No
Arsenic	µg/L	0.02	0.34	0.26	0.30	0.25	0.26	0.23	0.19	No
Barium	µg/L	0.02	3.62	2.45	2.76	2.37	2.45	2.08	2.01	No
Beryllium	µg/L	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	No
Bismuth	µg/L	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	No
Boron	µg/L	5	5	<5	6.5	<5	<5	<5	<5	No
Cadmium	µg/L	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	No
Calcium	mg/L	0.01	1.92	2.06	2.15	2.03	2.03	1.91	1.7	^(d)
Chromium	µg/L	0.05	0.06	<0.05	0.078	0.056	<0.05	<0.05	<0.05	No
Cobalt	µg/L	0.005	0.04	0.013	0.016	0.016	0.013	0.011	0.018	No
Copper	µg/L	0.05	0.6	0.53	0.58	0.55	0.58	0.49	0.52	No
Iron	µg/L	1	10	2.5	7	3	3.1	4	6.1	No

Table 3-14 Evaluation of Effects from Dust Deposition and Dike Construction in Lac de Gras, 2019 (continued)

Variable	Unit	2019 Detection Limit	Screening Value	2019 AEMP Result (Open-water)						Median of MF Station >2× Median of Reference Dataset ^(a) (Yes/No)
			2× Median of Reference Areas ^(a)	Median of NF Values	Highest NF Station Median Value	Median of MF Values ^(b)				
Lead	µg/L	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	No
Lithium	µg/L	0.5	2.4	2.03	2.22	1.1	2.1	1.4	1.4	No
Magnesium	mg/L	0.005	1.26	1.06	1.13	1.06	1.05	1.06	1.02	No
Manganese	µg/L	0.05	4.88	2.45	2.87	2.6	2.7	2.53	3.06	No
Mercury	µg/L	0.002	0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	No
Molybdenum	µg/L	0.05	0.18	0.57	0.71	0.44	0.53	0.30	0.19	Yes ^(c)
Nickel	µg/L	0.02	1.9	0.57	0.65	0.623	0.686	0.585	0.748	No
Potassium	mg/L	0.01	1.08	0.96	1.03	0.988	0.992	0.837	0.783	No
Selenium	µg/L	0.04	0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	No
Silicon	µg/L	50	50	<50	<50	<50	<50	<50	<50	No
Silver	µg/L	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	No
Sodium	mg/L	0.01	1.26	2.3	2.48	2.39	2.29	2.00	1.71	^(d)
Strontium	µg/L	0.05	14.6	25.7	27.5	25.4	26.4	21.7	16.8	Yes ^(c)
Sulphur	mg/L	0.5	1.82	1.6	1.8	1.63	1.56	1.15	1.13	No
Thallium	µg/L	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	No
Tin	µg/L	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	No
Titanium	µg/L	0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	No
Uranium	µg/L	0.002	0.056	0.078	0.099	0.073	0.073	0.082	0.066	Yes ^(c)
Vanadium	µg/L	0.05	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	No
Zinc	µg/L	0.1	1.5	0.25	0.44	0.34	0.62	0.28	0.71	No
Zirconium	µg/L	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	No

a) The two times the median value was based on the reference area median concentrations presented in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). In cases where the median concentration was less than the DL, the reference area median value was considered to be equal to half of the DL.

b) The median of MF area values was calculated from data pooled across all sample depths (i.e., top, middle, and bottom).

c) Concentration in the NF area triggered both Action Level 1 (during one or both seasons) and an effect equivalent to Action Level 1 at one or more MF area stations located within the estimated zone of influence from dust deposition.

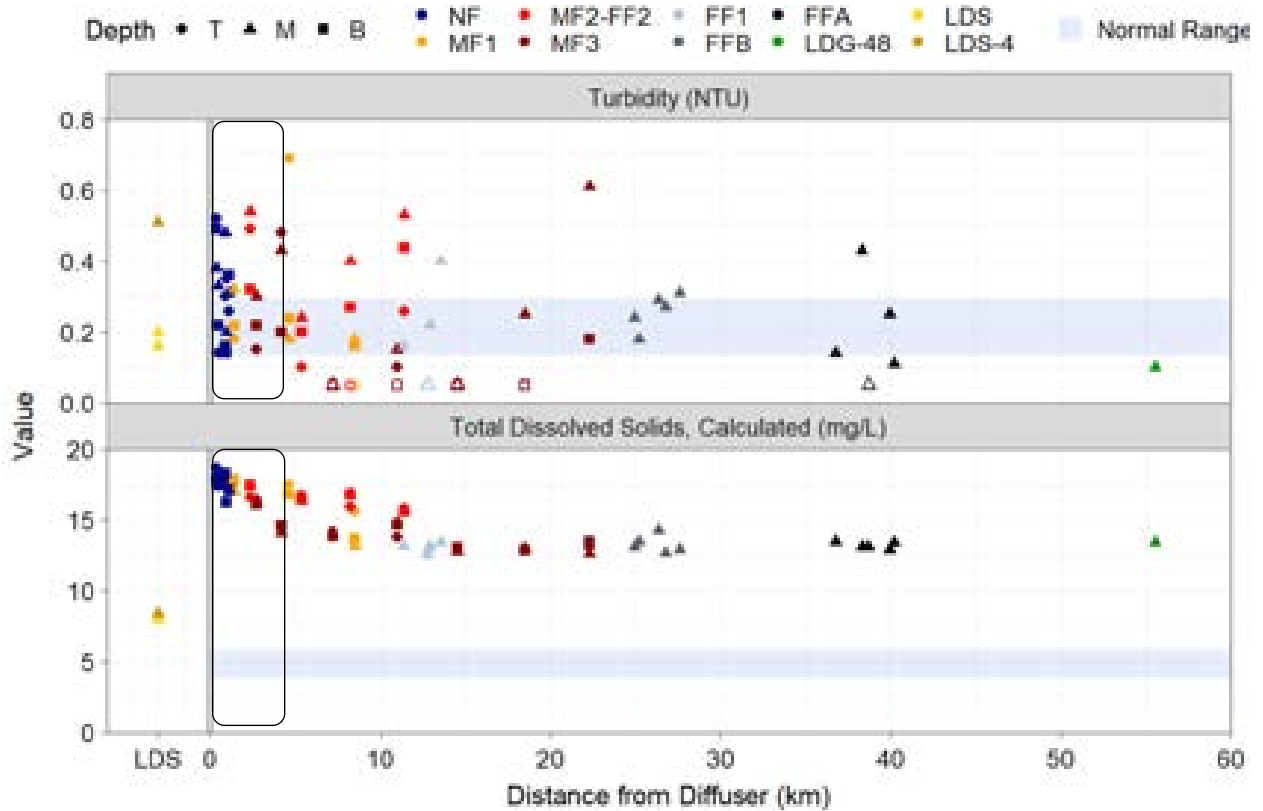
d) "Yes" applied to dissolved or calculated value to avoid duplication.

e) Based on the results of the ammonia investigation, the ALS ammonia dataset was used in the ice-cover season and the BV ammonia dataset was used in the open-water season (Section 2.4.1, Attachment B).

Note: **Bold** indicates that an MF median value exceeds two times the reference dataset median.

NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; >= greater than; < = less than; 2 x = two times; NF = near-field; MF = mid-field.

Figure 3-46 Spatial Variation in Turbidity and Total Dissolved Solids, Calculated According to Distance from the Effluent Discharge, Open-water Season, 2019

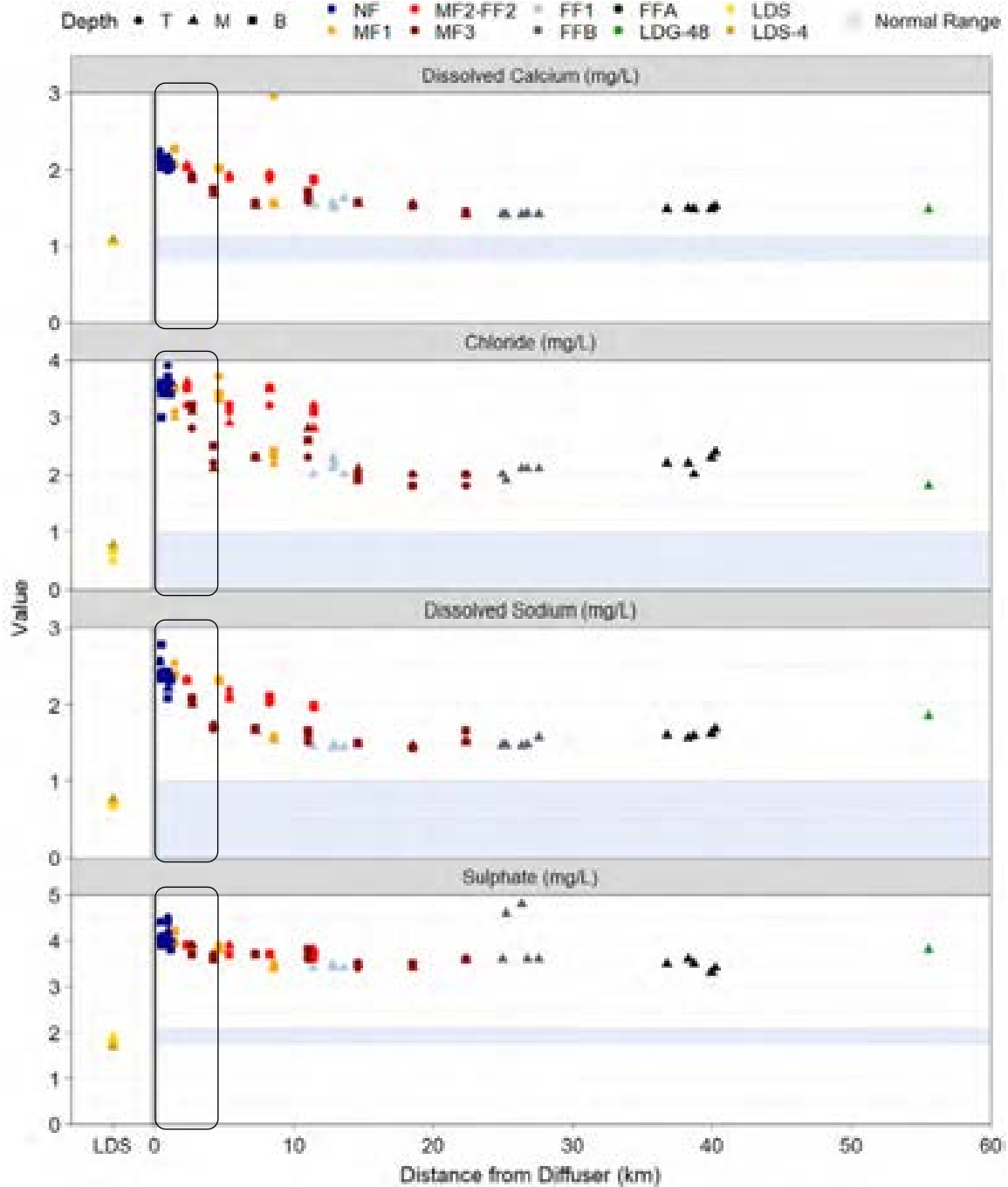


Notes: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; NTU = nephelometric turbidity unit; LDG = Lac de Gras; LDS = Lac du Sauvage.

○ Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.3.1)

Figure 3-47 Spatial Variation in Calcium (Dissolved), Chloride, Sodium (Dissolved), and Sulphate Concentrations According to Distance from the Effluent Discharge, Open-water Season, 2019



Notes: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.


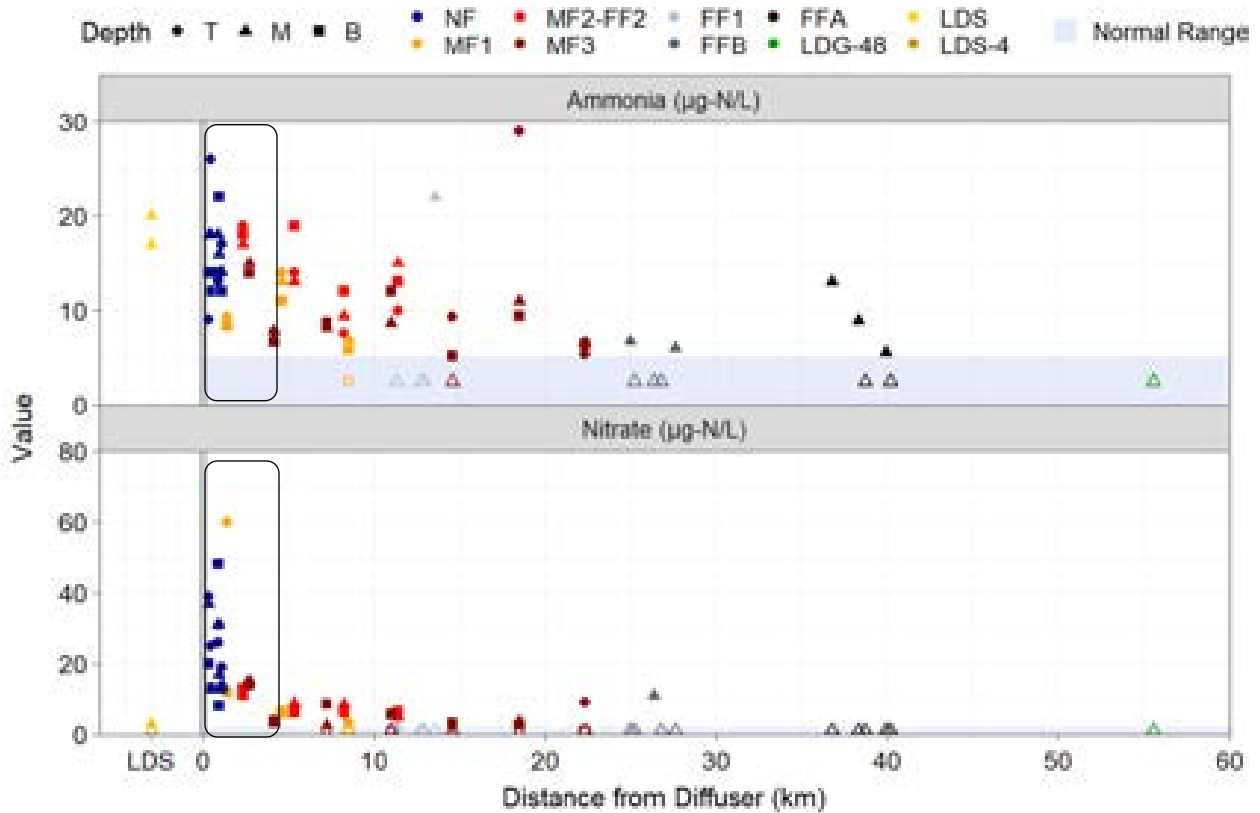
 Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.3.1)

Figure 3-48 Spatial Variation in Ammonia and Nitrate Concentrations According to Distance from the Effluent Discharge, Open-water Season, 2019

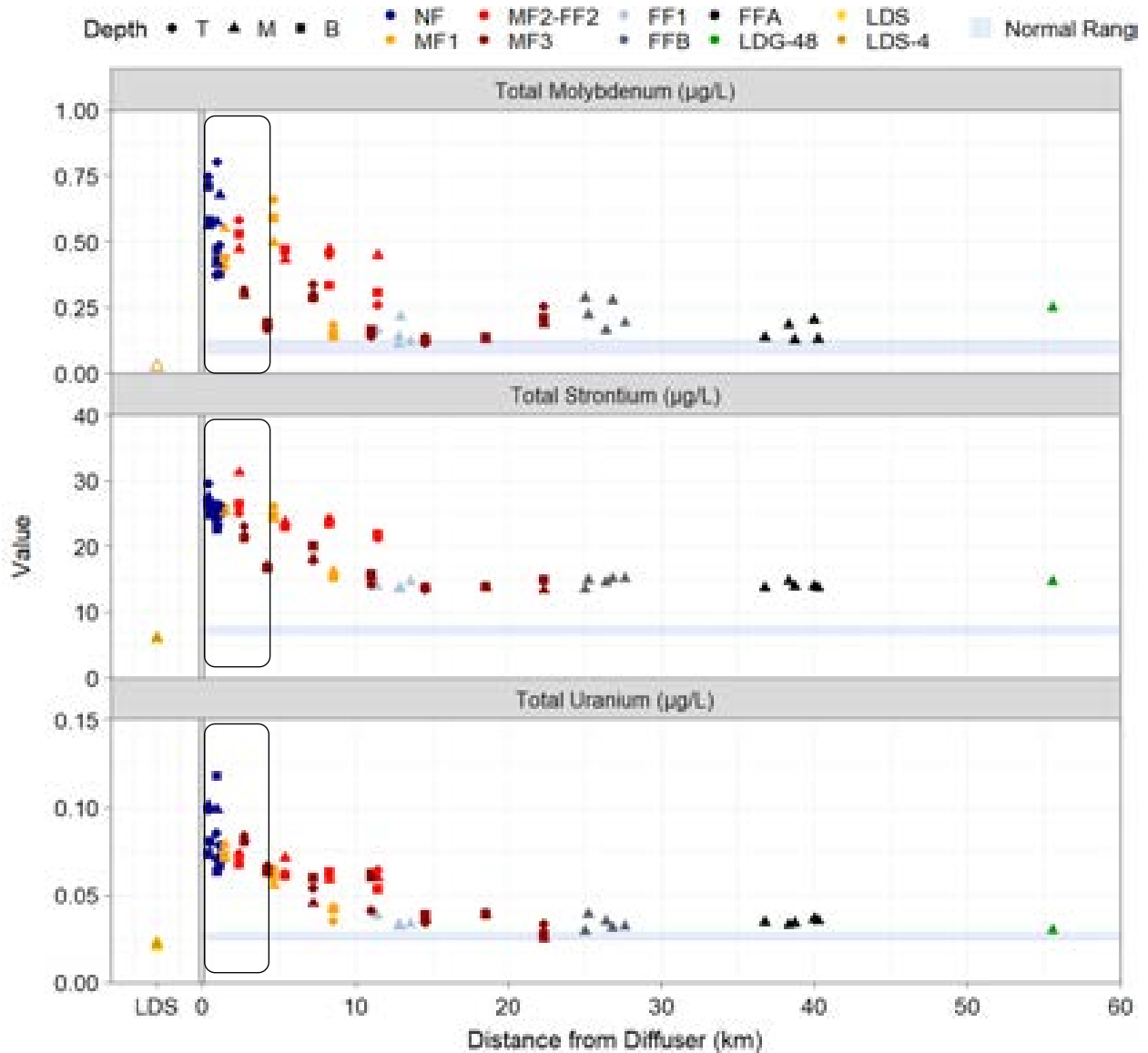


Notes: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth NF = near-field; MF = mid-field; FF = far-field; µg-N/L = micrograms nitrogen per litre; LDG = Lac de Gras; LDS = Lac du Sauvage.


○ Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.3.1)

Figure 3-49 Spatial Variation in Molybdenum, Strontium, and Uranium Concentrations According to Distance from the Effluent Discharge, Open-water Season, 2019



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

 Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.3.1)

3.10 Cumulative Effects in Lac de Gras

Potential cumulative effects of the Diavik and Ekati mines on SOI concentrations in Lac de Gras were investigated using a graphical (i.e., visual) approach. Review of the distance plots shown in Figure 3-50 to Figure 3-65 indicated that the concentrations of 13 of 16 SOIs in 2019 (i.e., TDS, calcium, chloride, magnesium, sodium, sulphate, aluminum, barium, manganese molybdenum, silicon, strontium and uranium) were greater at the lake outlet (LDG-48) compared to one or both of the FFB or FFA sampling areas, which are closer to the Diavik Mine. These increases were typically more pronounced during the ice-cover season, and in many cases were not evident during open-water. In most cases, SOI concentrations at stations in the FFB and FFA areas, and LDG-48 exceeded the normal range for Lac de Gras. Exceptions occurred for barium, manganese and silicon, which had concentrations that were not consistently above normal ranges, and aluminum, which was frequently reported at concentrations below the normal range. The remaining SOIs in 2019 (i.e., turbidity, nitrate, ammonia) had concentrations at the lake outlet that were similar to those measured in the body of Lac de Gras, at the northwest end.

Of the 13 aforementioned SOIs, eight (i.e., calcium, chloride, magnesium, sodium, barium, molybdenum, strontium, uranium) had consistent increases in concentration that extended from the FFB area through the FFA area, with a further increase at station LDG-48, during one or both seasons. This pattern is a reversal from the expected response of a decrease in concentration with distance from the Diavik diffuser. These observations are consistent with the results of the spatial gradient analysis (Section 3.6.1), which identified increasing trends in the concentrations of calcium, chloride, magnesium, sodium, molybdenum and uranium extending from the variable-specific breakpoint along the MF3 transect through the FFA area; whereas the trend direction in these variables was a decrease from the NF area to the breakpoint. Breakpoints for barium and strontium were closer to the Diavik discharge compared to other variables, and as a result, the slope of the regressions extending from the breakpoint location to FFA was negative, indicating a continued decline in concentration.

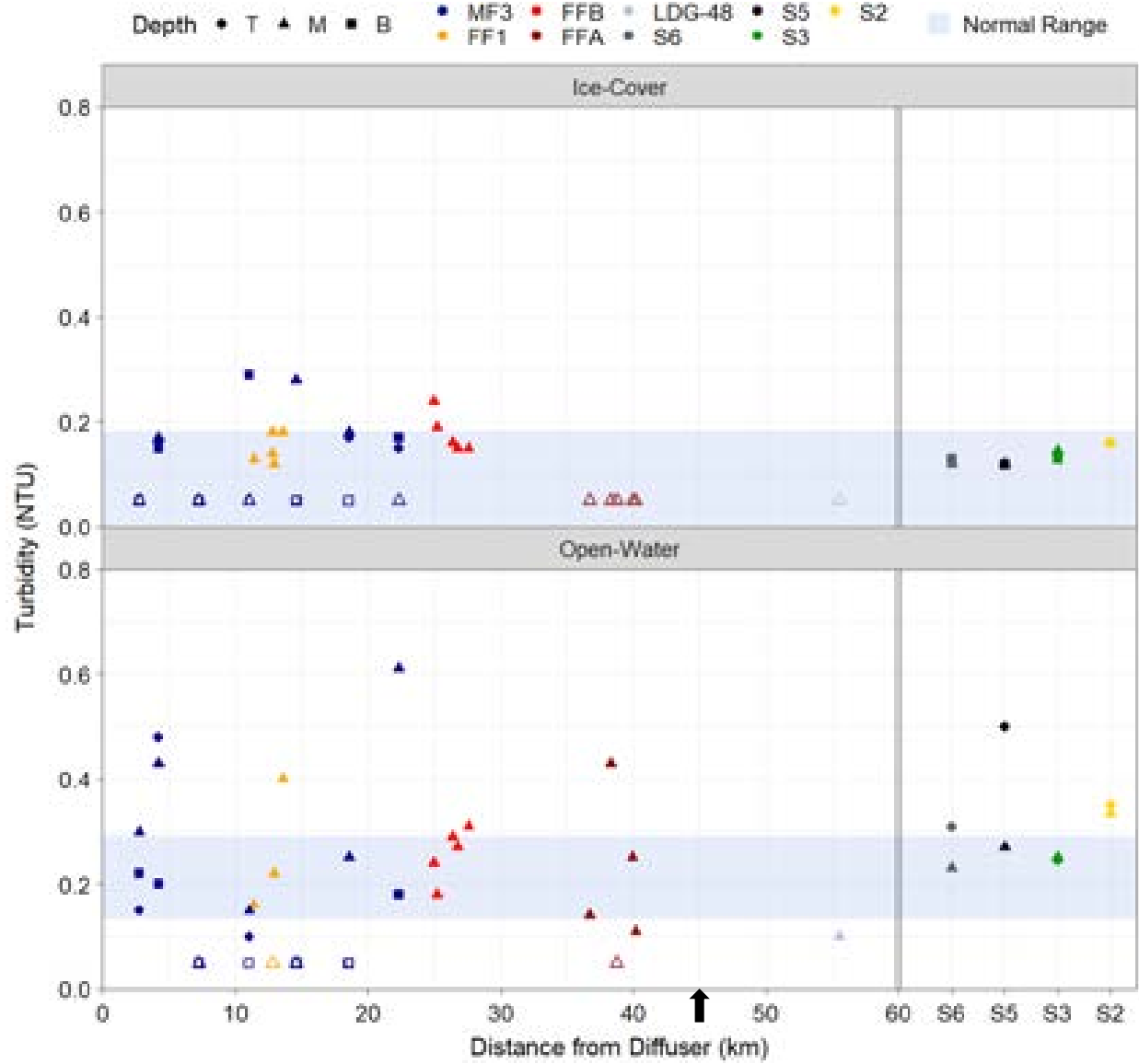
The presence of a spatial trend with distance from the Diavik diffusers that is reversed as one moves west from the MF3 or FFB areas would suggest that effluent from both mines are a potential influence on the variable in question. This interaction would constitute a cumulative effect, since both mines are contributing to an increase in the concentration of a variable. It is also possible that an increase in concentration at station LDG-48 relative to either of FFB or FFA (i.e., the responses in TDS, sulphate, aluminum, manganese, silicon), without an overall increasing trend from FFB to FFA to LDG-48, may also constitute a cumulative effect. However, the evidence for a cumulative effect in these cases is somewhat less conclusive than with a consistent trend. There was no indication of a cumulative effect at FFB in 2019, as concentrations were within expected ranges based on the pattern of exposure to the Diavik Mine effluent.

The observed responses in the 13 SOIs with elevated concentrations at the Lac de Gras outflow suggest that the Slipper Lake inflow, which conveys mine water from the Ekati Mine, was a possible influence on the SOI concentrations at LDG-48, and in certain cases in the FFA area. Concentrations of several of these SOIs were elevated at the Ekati Slipper Bay monitoring stations in Lac de Gras. Based on a review of the 2018 AEMP data for the Ekati mine (ERM 2019a), concentrations of each of the 13 aforementioned Diavik SOIs were elevated at S2, but declined from S3 to S6 (Figure 3-50 to Figure 3-65). Concentrations at S6 in 2018 were generally similar to the FFB area concentrations in 2019. These results suggest that the Ekati discharge was an additional source of these constituents to Lac de Gras; however, SOI concentrations in the vicinity of the zone of confluence remained low, indicating that the combined effluent discharges from Ekati and Diavik resulted in a low magnitude effect on Lac de Gras water quality.

A comparison of the 2019 Diavik data to the 2018 Ekati Data did not suggest that using data from different years has introduced a bias that might affect the interpretation of trends. However, there remains some potential that year-to-year variability in water quality and, potentially, differences in discharge (i.e., effluent flow, loading rates and timing of discharge) could influence the interpretation of results. Therefore, comparisons of 2019 Diavik data to 2018 Ekati data (Figure 3-50 to Figure 3-65) should be considered with caution. Despite the limitations of using different years in these comparisons, the Diavik results, when considered in isolation from the Ekati data, suggest that the Slipper Lake inflow was a possible influence on the SOI concentrations at the northwest end of Lac de Gras. The Ekati data provide additional evidence to support this interpretation.

The results indicating cumulative effects for some water quality variables in 2019 are generally consistent with the results of previous Diavik AEMP Re-evaluation Reports (Golder 2014; Golder 2018), which included an evaluation of potential cumulative effects in Lac de Gras. In addition, the results are largely consistent with another recent evaluation of potential cumulative effects. Using data collected prior to 2015 and similar plotting methods to those employed herein, Zajdlík & Associates Inc. (2016) concluded that cumulative effects from the Diavik and Ekati mine effluents were detected at the western end of Lac de Gras for conductivity and chloride. They also stated that there was evidence, although somewhat limited, for augmentation of the Diavik plume by the Ekati discharge for strontium and copper as well.

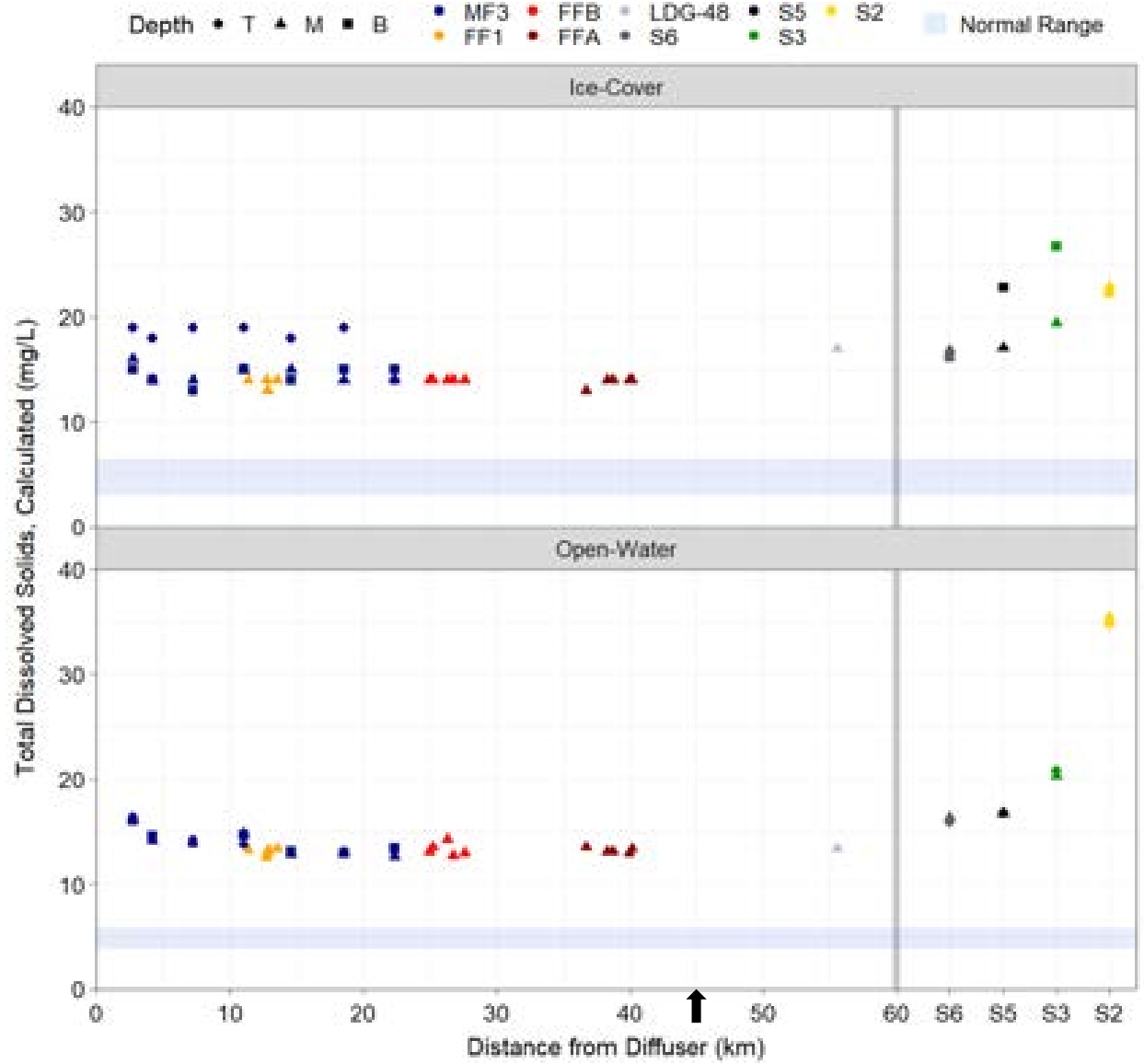
Figure 3-50 Spatial Variation in Turbidity at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

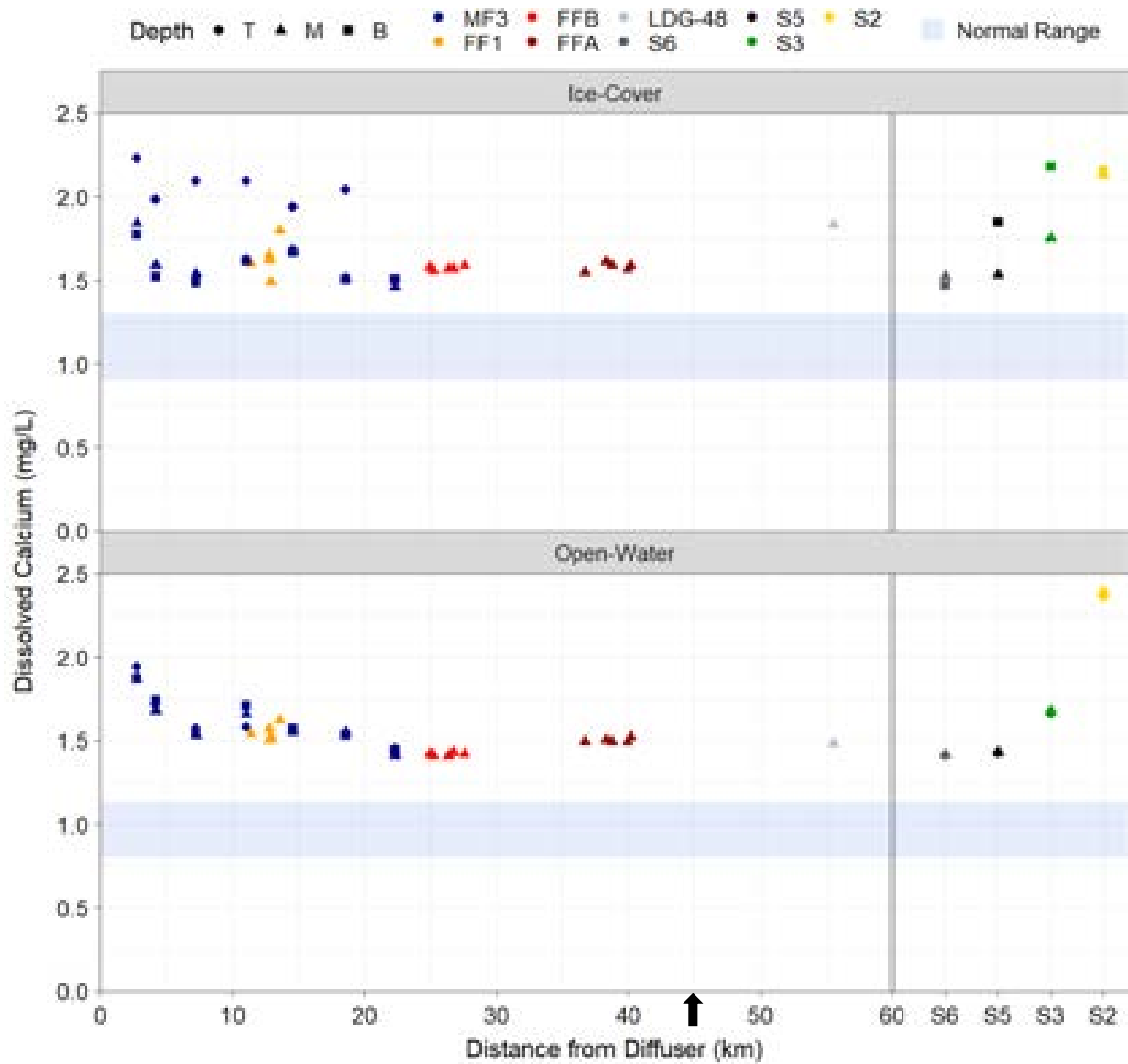
Figure 3-51 Spatial Variation in Total Dissolved Solids (Calculated) at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

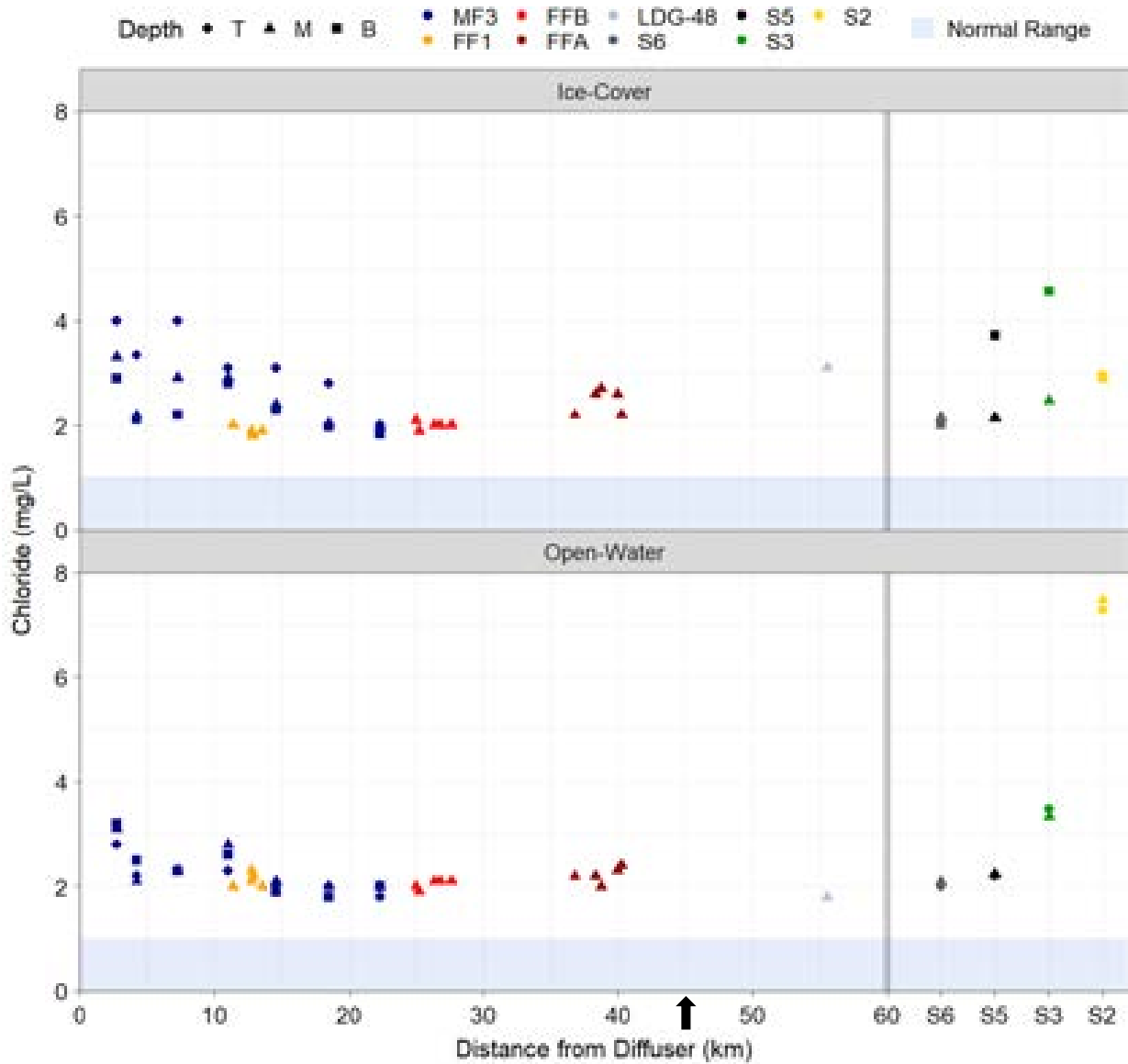
Figure 3-52 Spatial Variation in Dissolved Calcium at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

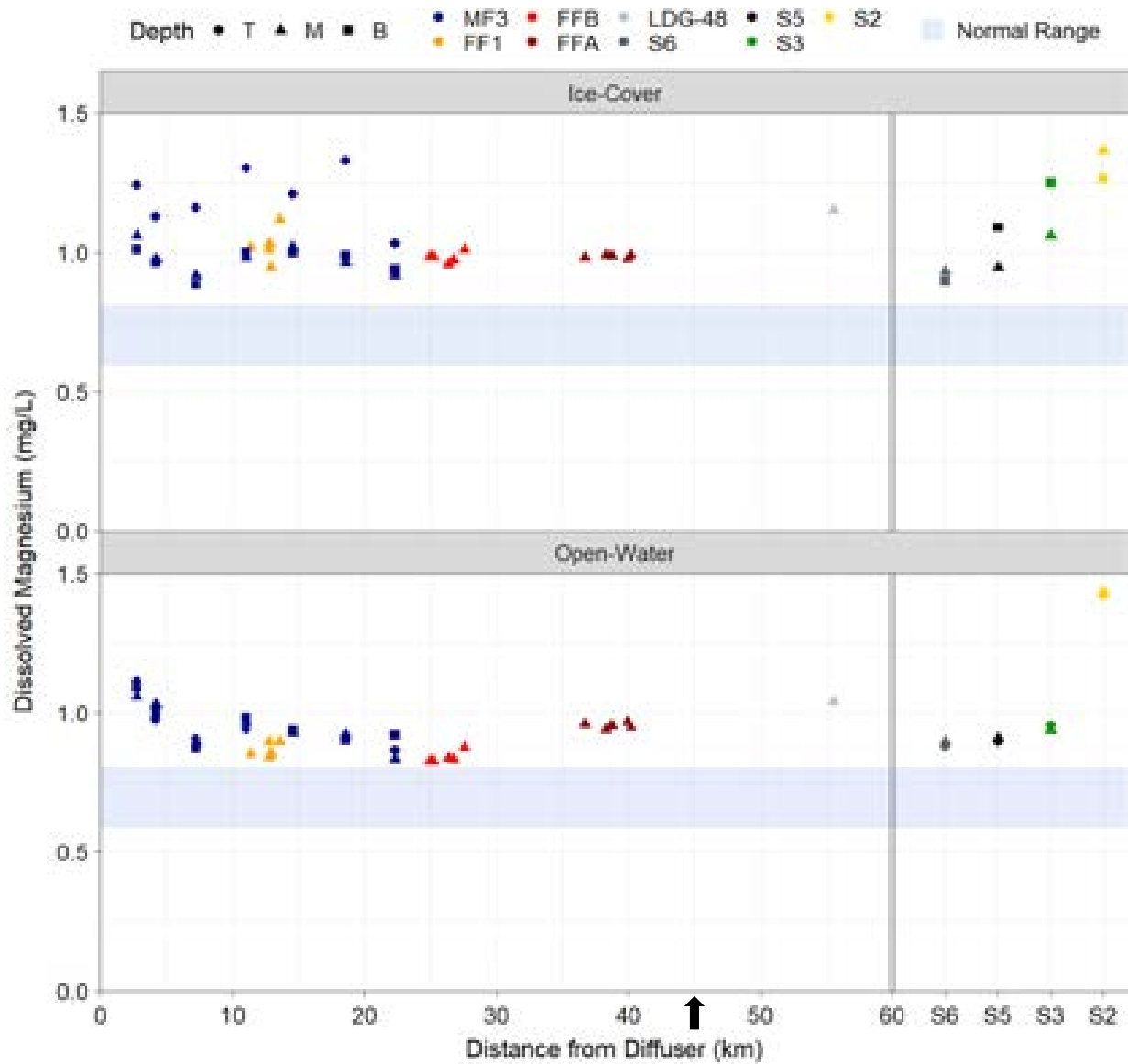
Figure 3-53 Spatial Variation in Chloride at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

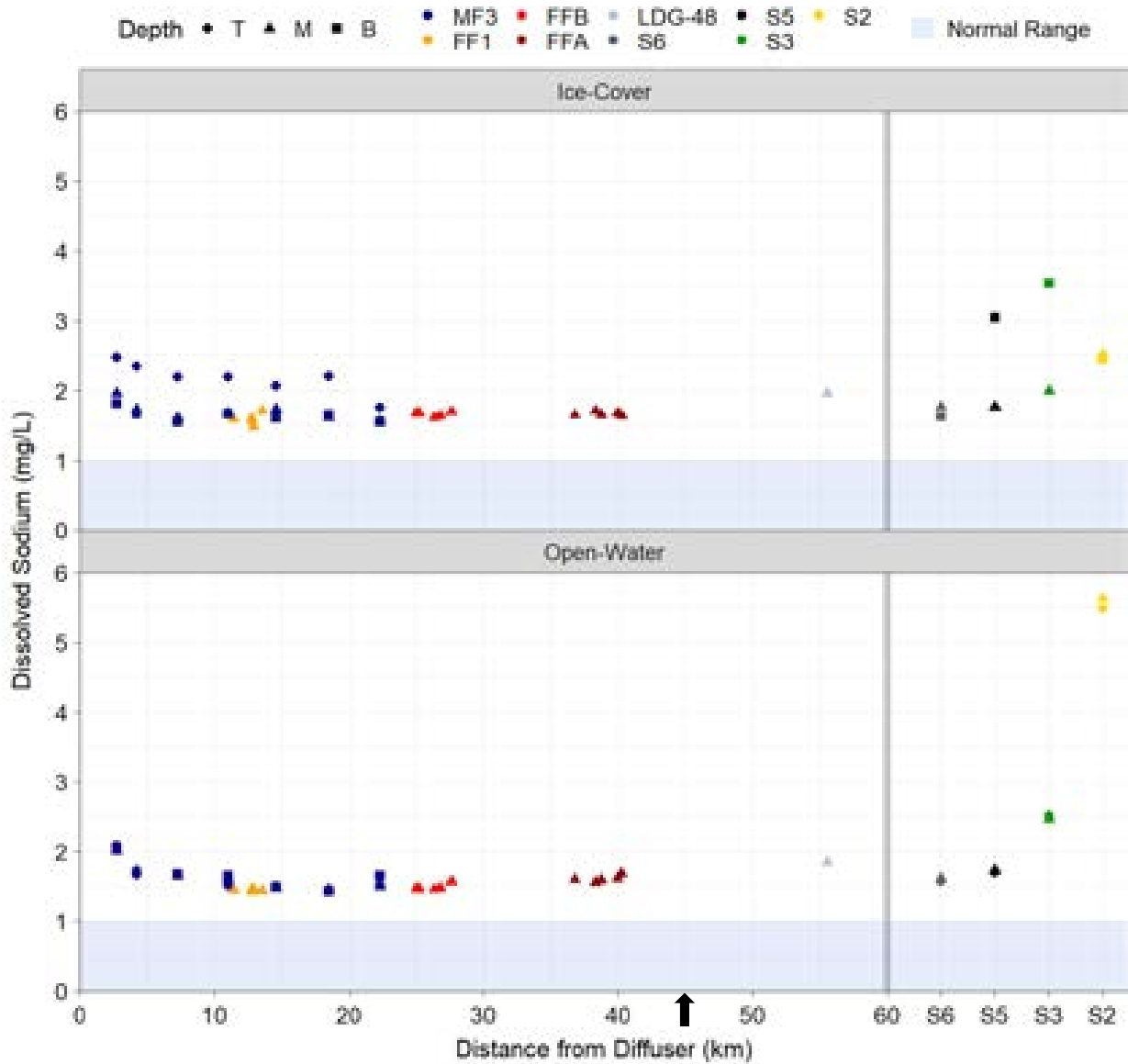
Figure 3-54 Spatial Variation in Dissolved Magnesium at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

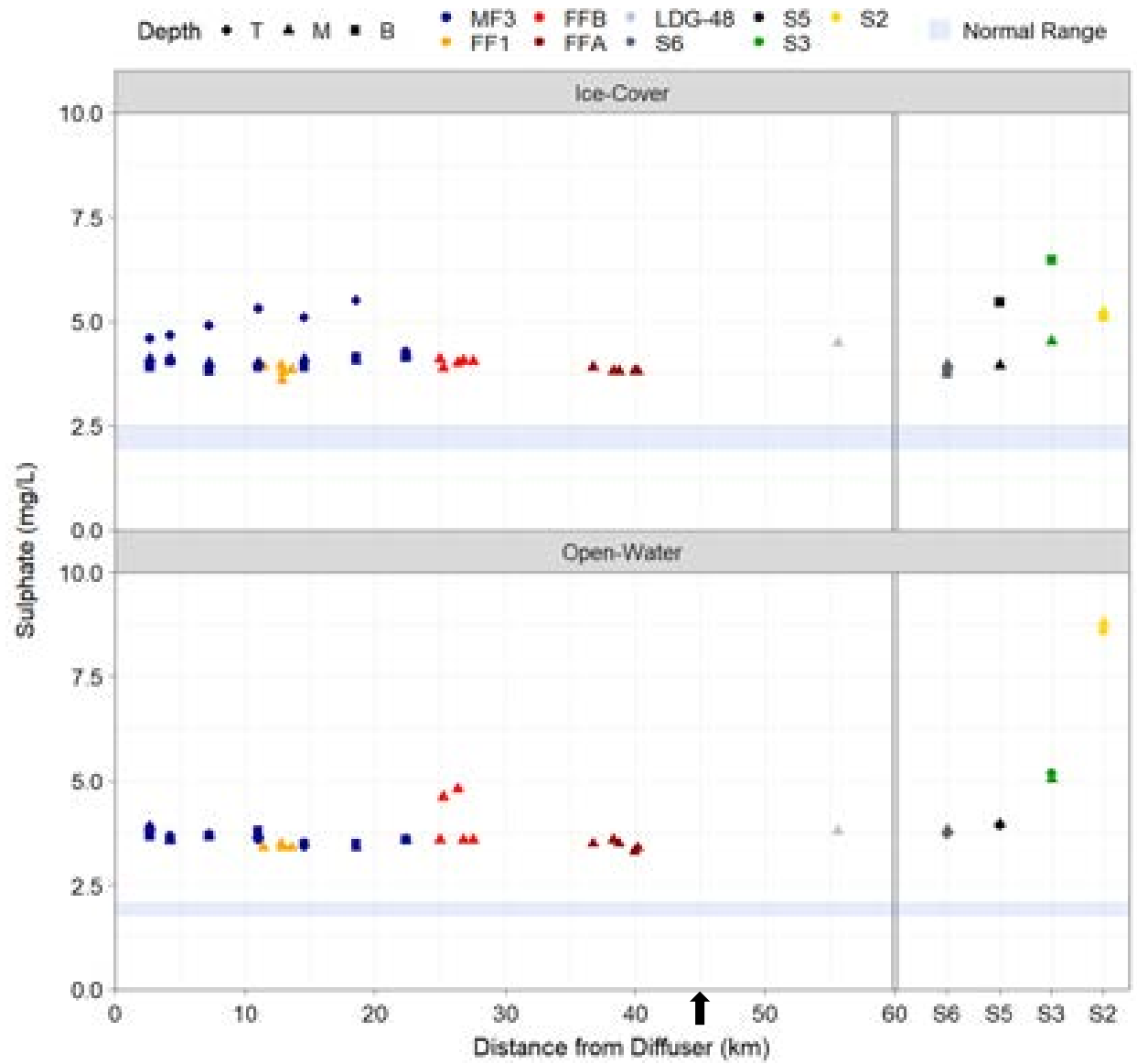
Figure 3-55 Spatial Variation in Dissolved Sodium at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

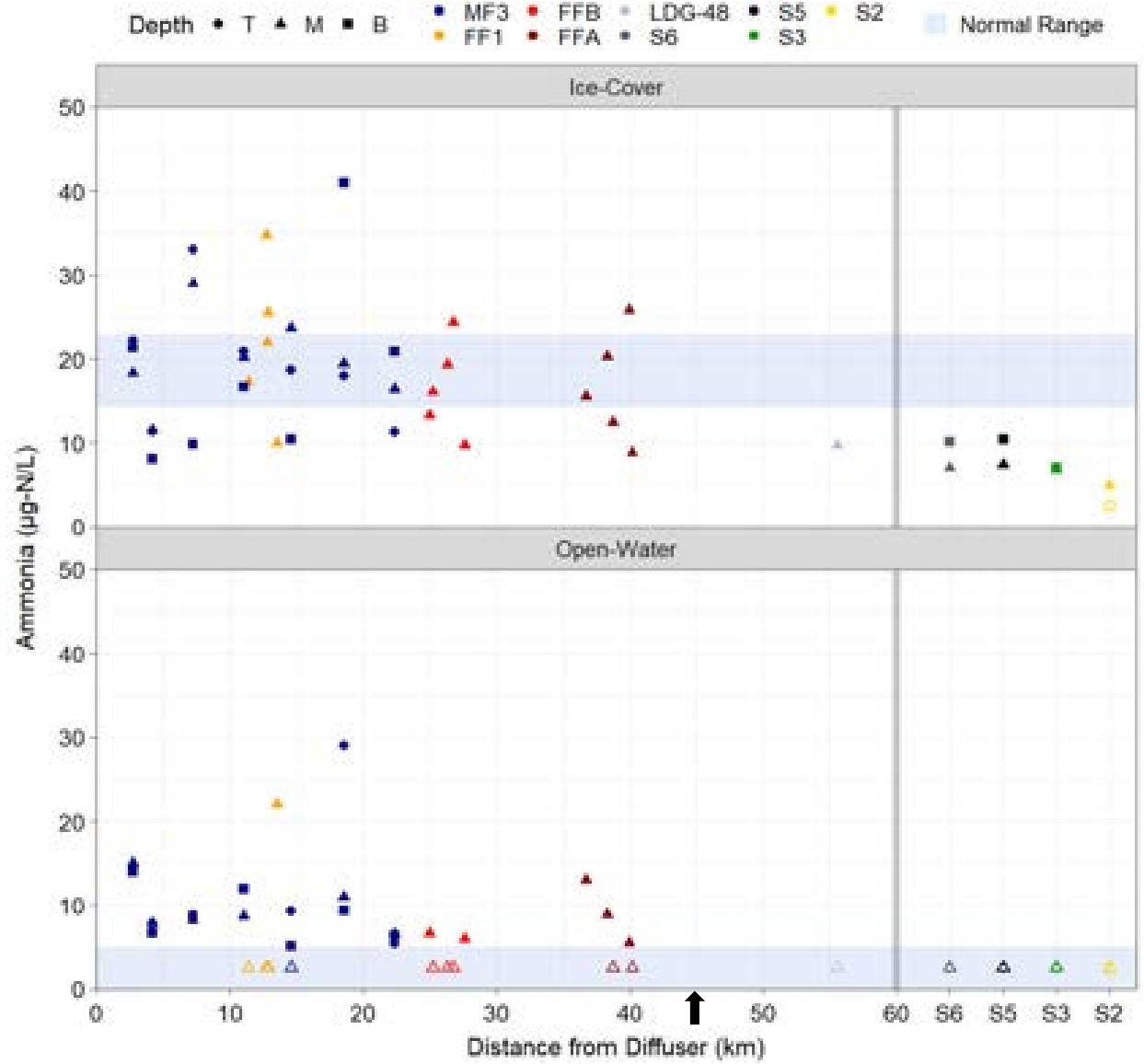
Figure 3-56 Spatial Variation in Sulphate at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

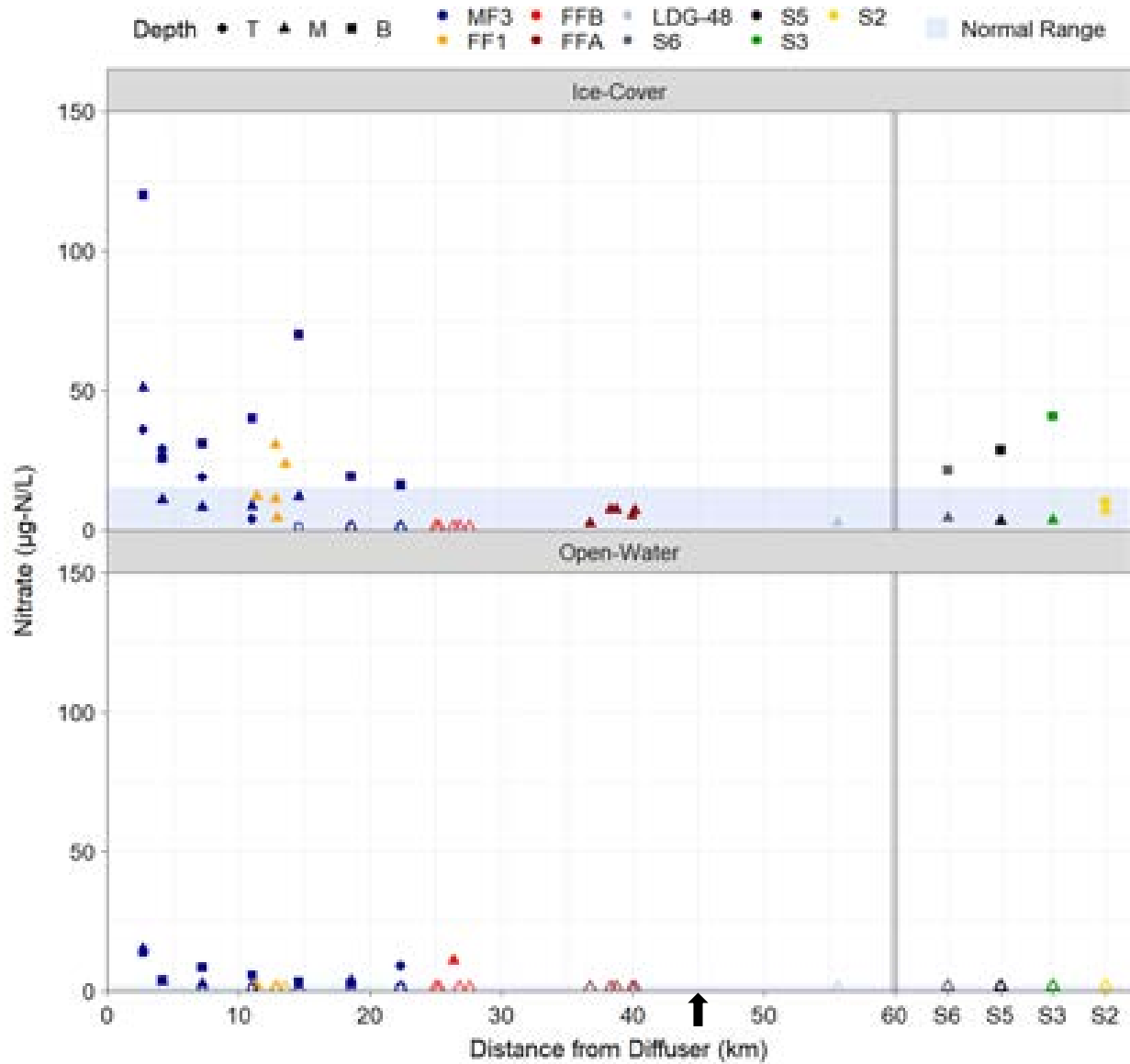
Figure 3-57 Spatial Variation in Ammonia at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

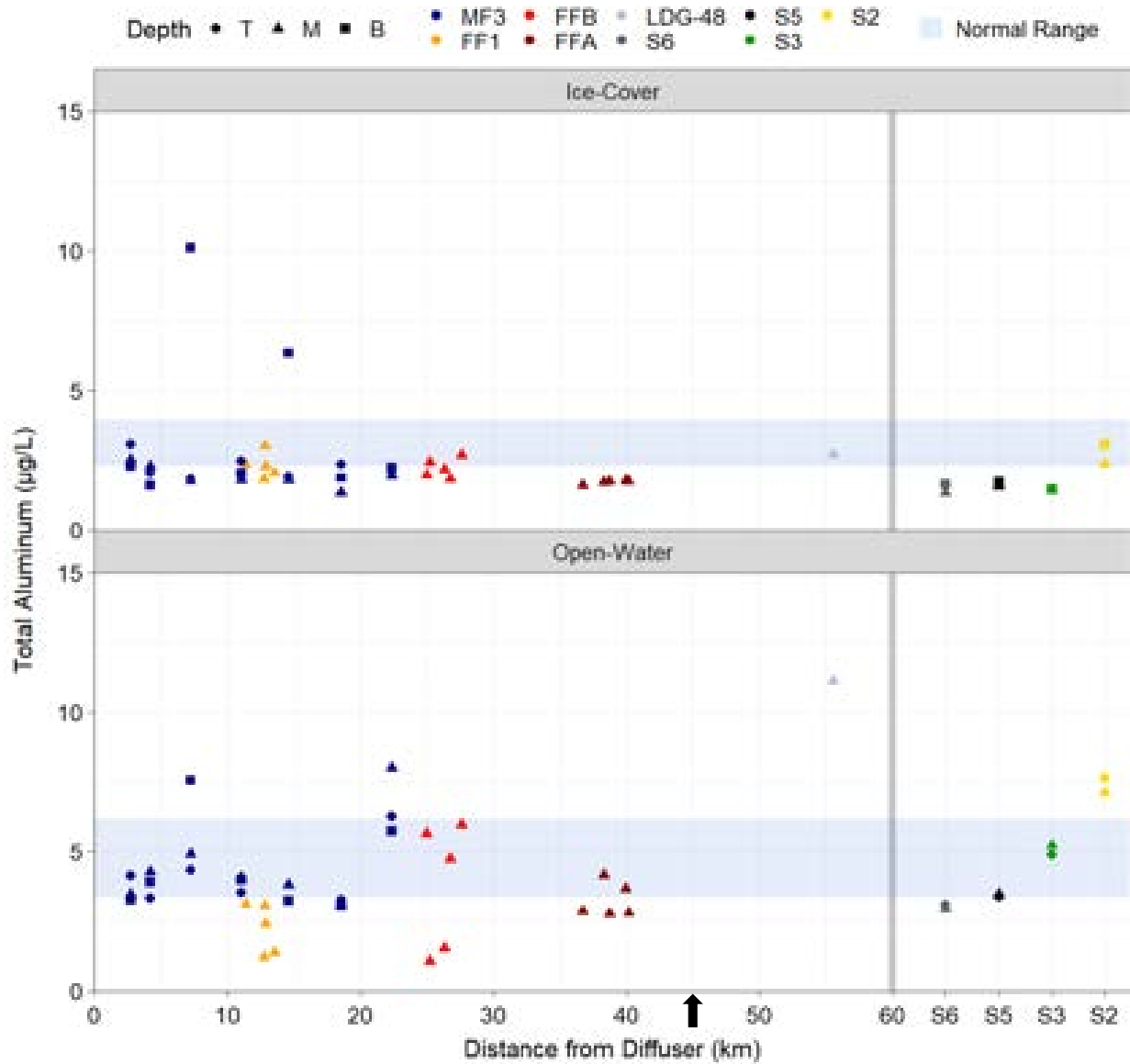
Figure 3-58 Spatial Variation in Nitrate at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

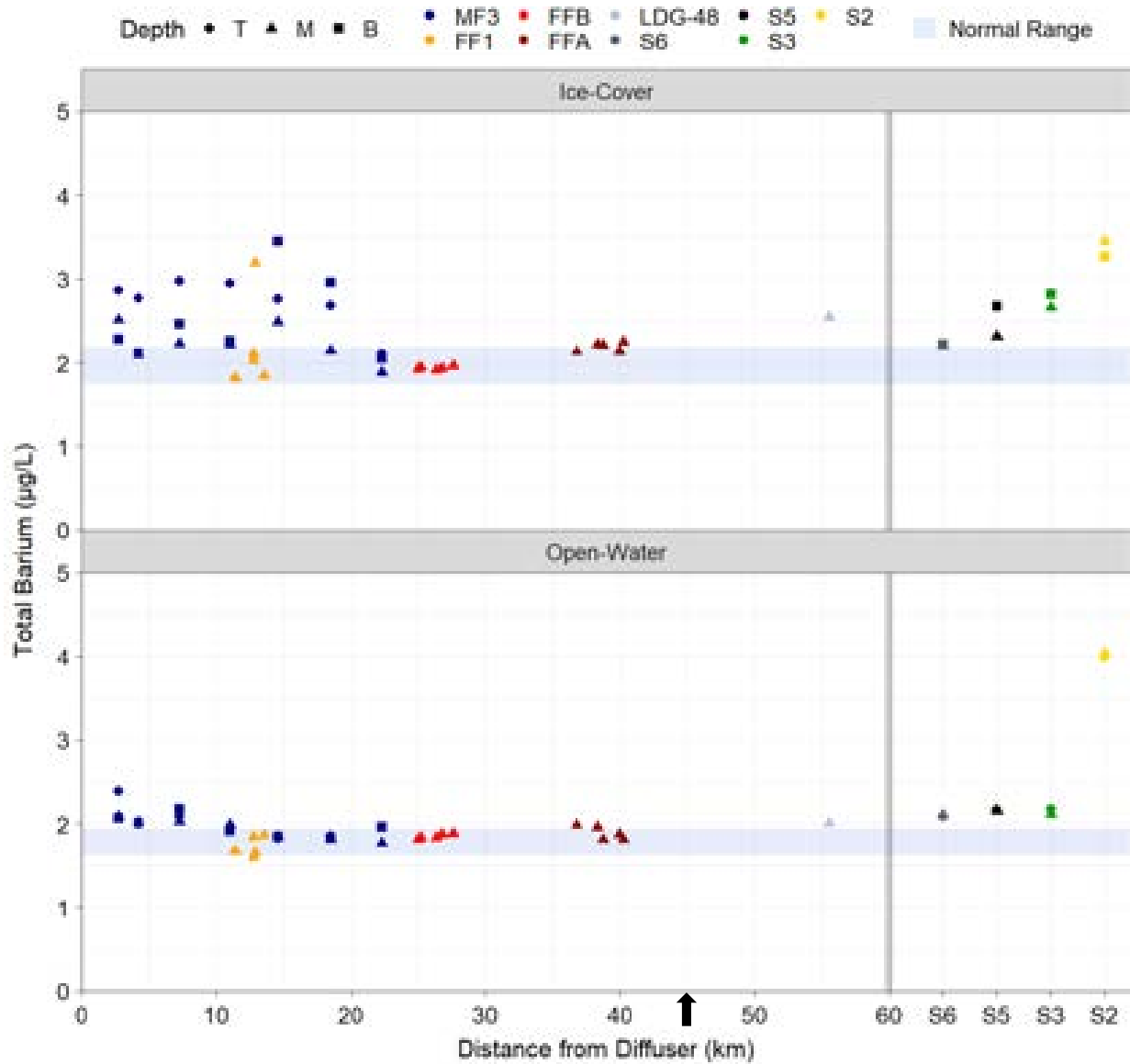
Figure 3-59 Spatial Variation in Total Aluminum at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

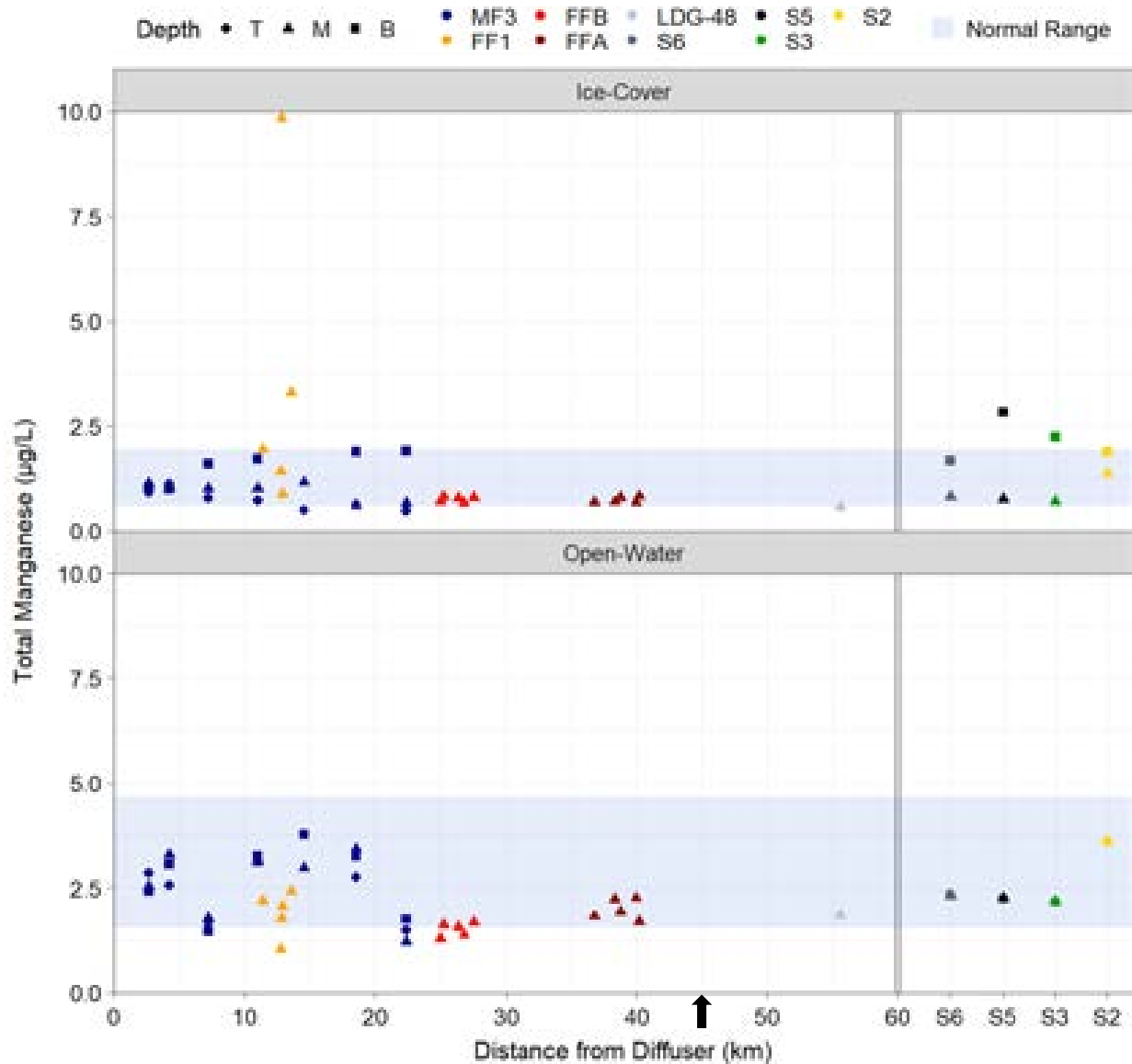
Figure 3-60 Spatial Variation in Total Barium at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

Figure 3-61 Spatial Variation in Total Manganese at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras

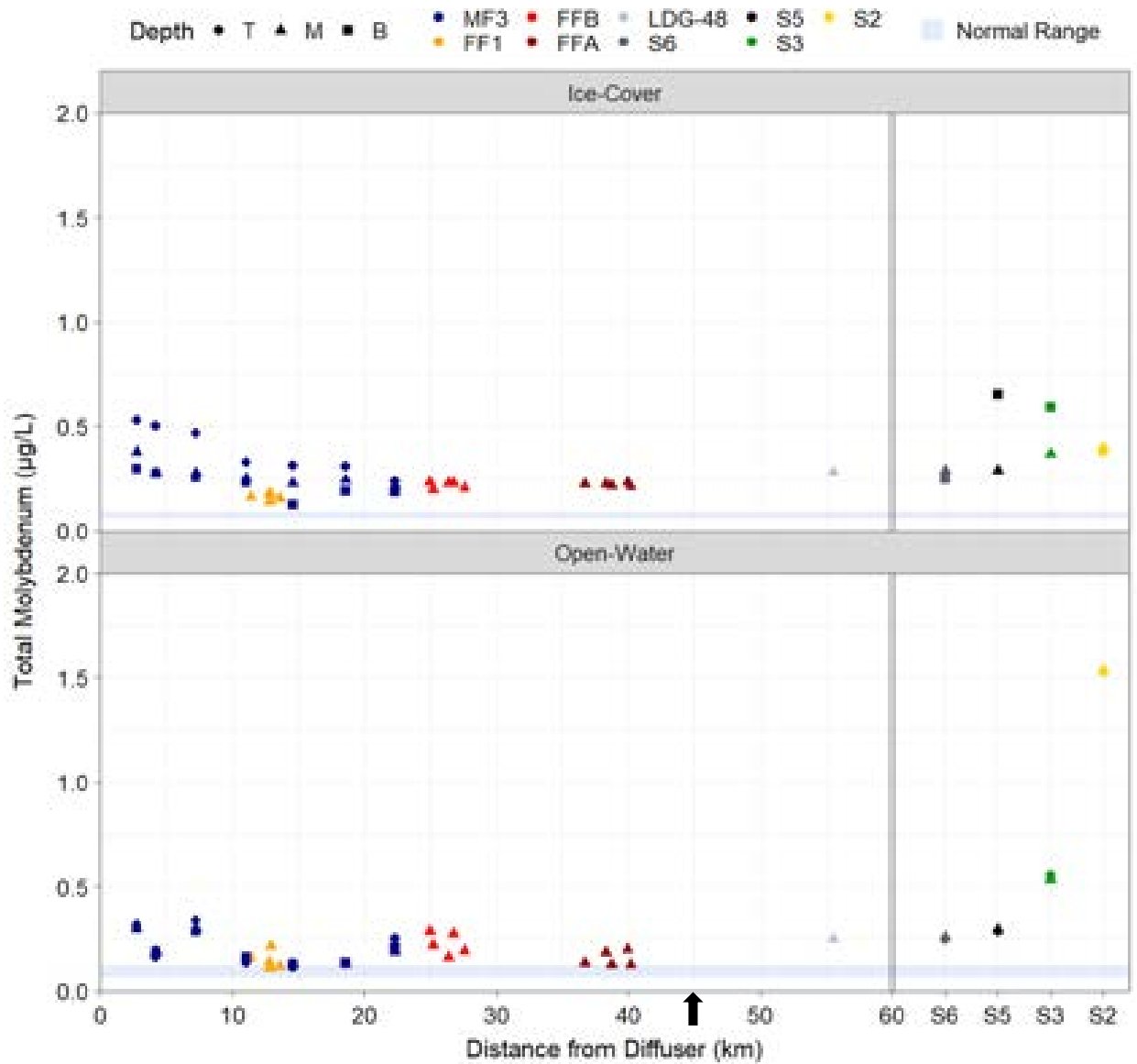


Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

An elevated manganese value (159 µg/L) on the ice-cover plot was removed to allow for appropriate scaling of the graph and to improve readability.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

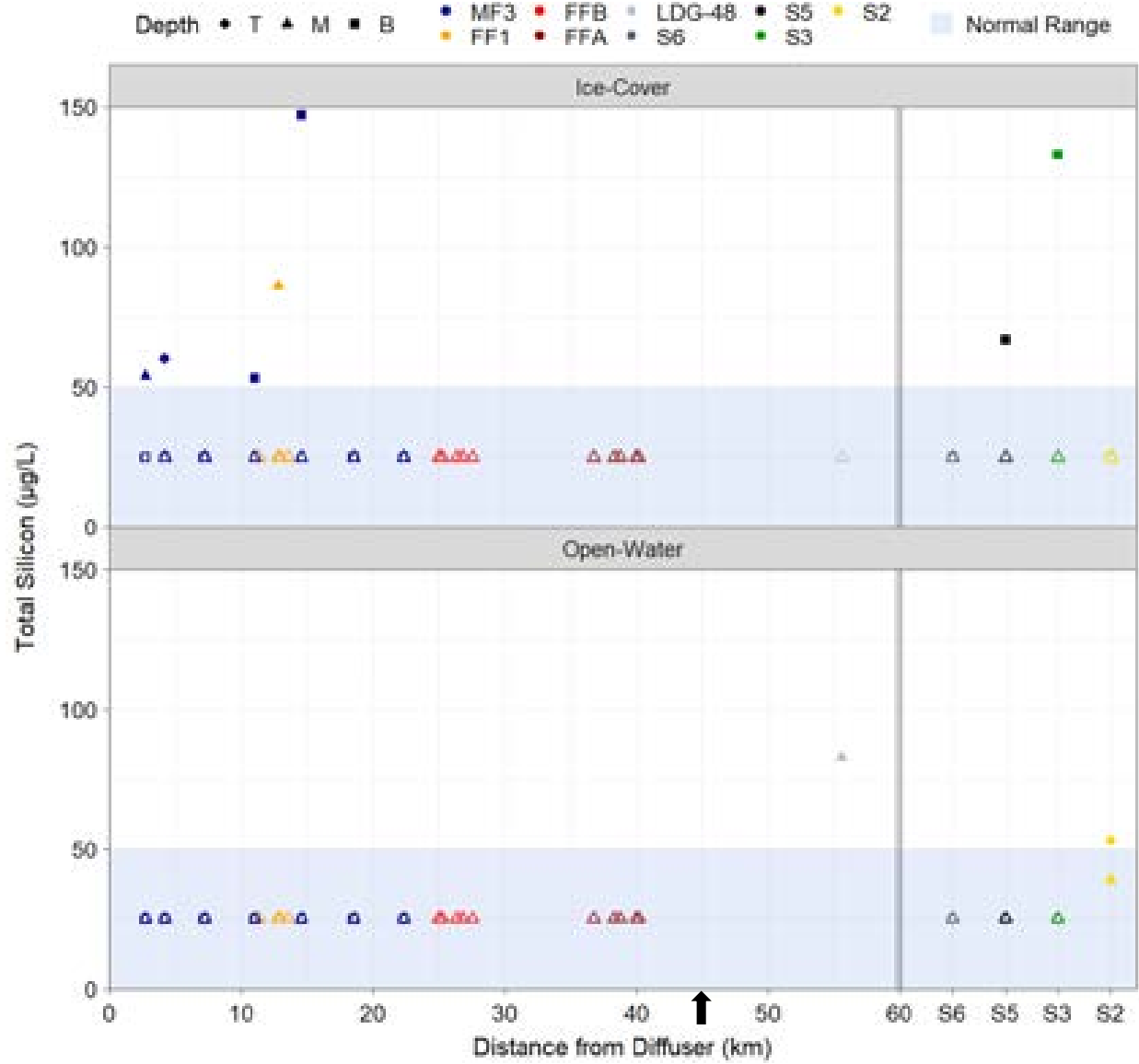
Figure 3-62 Spatial Variation in Total Molybdenum at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

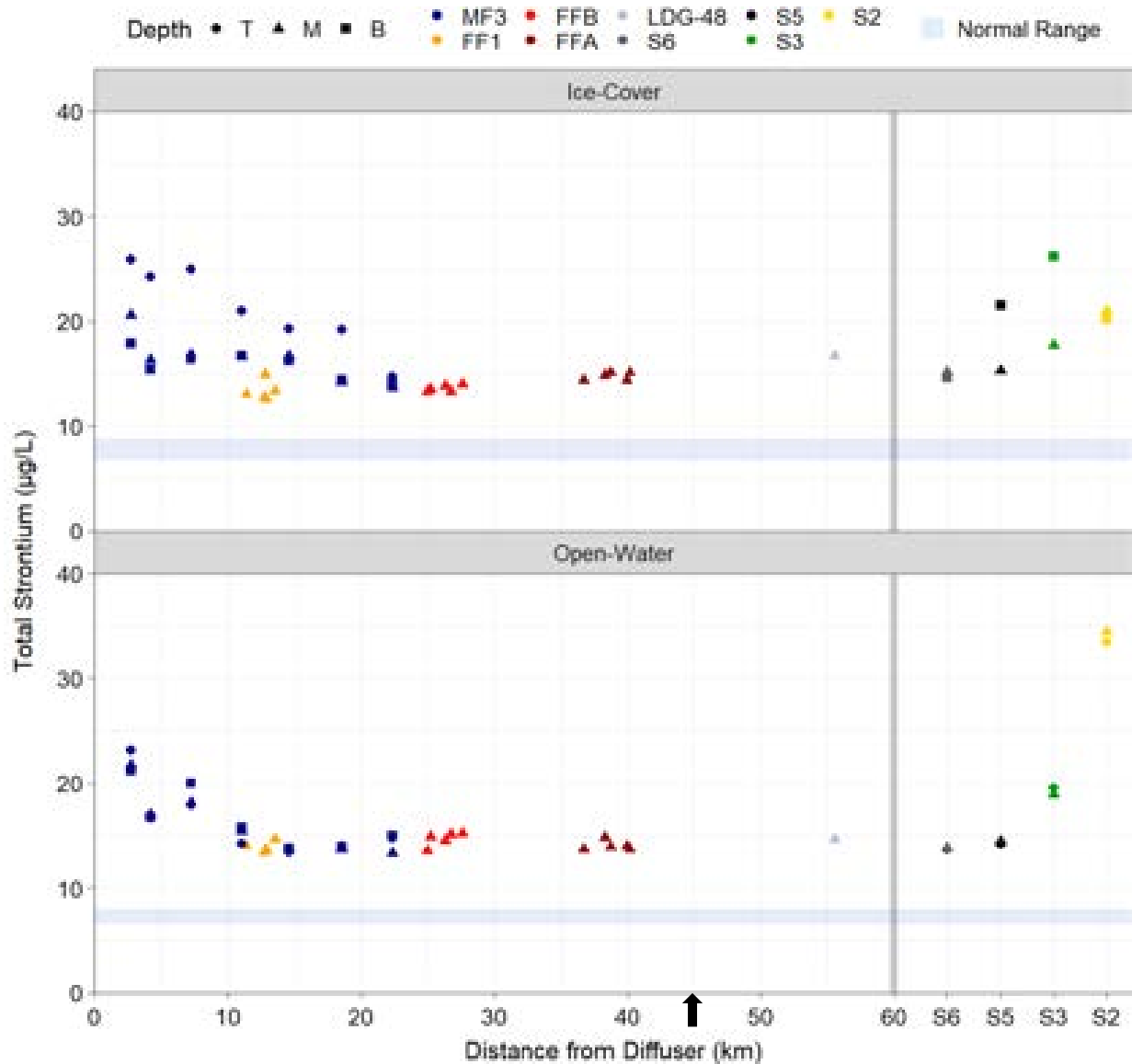
Figure 3-63 Spatial Variation in Total Silicon at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

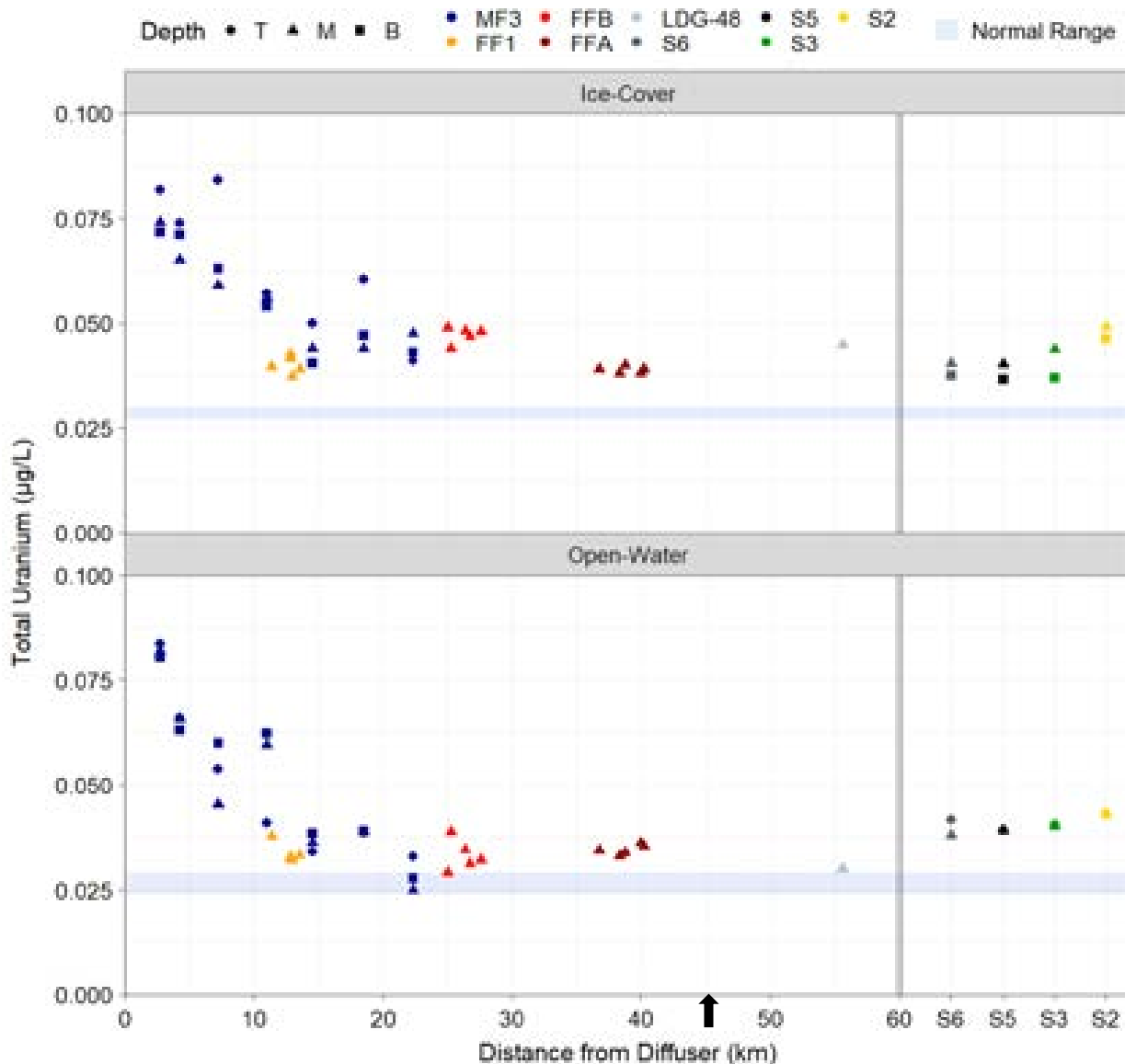
Figure 3-64 Spatial Variation in Total Strontium at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

Figure 3-65 Spatial Variation in Total Uranium at Diavik (FFB, FFA, LDG-48) and Ekati Stations (S2, S3, S5, S6) near the Northwest End of Lac de Gras



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data. The most recent publicly available Ekati data from the 2018 AEMP is included on the plot for reference. The approximate location of S6 relative to the Diavik AEMP stations is indicated by an arrow.

T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac de Gras; S2 to S6 = Ekati AEMP stations.

3.11 Weight-of-Evidence Input

The results described in the preceding sections feed into the WOE approach described in the *Weight-of-Evidence Report* (Appendix XV). The results of the weight-of-evidence relevant to water quality and related components are described in Section 3.1.1 of the Weight-of-Evidence Report (Appendix XV).

4 SUMMARY AND DISCUSSION

Concentrations of variables with EQC were within applicable limits in samples collected in 2019 and no variables were added to the SOI list based on effluent screening (Criterion 1 in Table 3-1). Toxicity testing results in 2019 indicated that effluent samples were generally not toxic to aquatic test organisms. None of the mixing zone chemistry variables with Effects Benchmarks were added to the SOI list because concentrations in all samples analyzed during the 2019 reporting period were below the relevant Effects Benchmarks (Criterion 2 in Table 3-1).

Water quality variables measured in Lac de Gras as part of the 2019 AEMP were assessed for a Mine-related effect according to Action Levels. Sixteen variables triggered Action Level 1, which is an early-warning indicator of effects in Lac de Gras. These 16 variables were retained as SOIs in 2019 (Criterion 3 in Table 3-1). These variables had NF area median concentrations that were greater than two times the median concentrations in reference datasets. Each of the SOIs that triggered Action Level 1 was detected in the NIWTP effluent and/or identified in dust associated with the Mine, indicating that the increase observed in the NF area could be linked to the Mine. Of the 16 variables that triggered Action Level 1 and were retained as SOIs, nine also triggered Action Level 2. None of the SOIs evaluated triggered Action Level 3 in 2019.

Spatial trends of decreasing concentrations with distance from the Mine effluent discharge were evident for all of the 16 SOIs that triggered Action Level 1 or greater in 2019, based on a graphical and statistical evaluation of the data. In addition, most of the SOIs had NF mean concentrations significantly greater than FF area mean concentrations. The results of these analyses provided confirmation that the changes for these variables observed in the NF area (i.e., at Action Levels 1 and 2) were related to the Mine effluent discharge.

In 2019, 11 variables exceeded two times the median of the reference dataset at one or more of the four MF area stations located within the estimated ZOI from dust deposition (i.e., MF1-1, MF2-1, MF3-1 and MF3-2; Criterion 4 in Table 3-1). These 11 SOIs also triggered Action Level 1 in the NF area, indicating that the exceedances at the MF stations were at least partly caused by dispersion of Mine effluent into the lake. Although some variables (i.e., turbidity, sodium, ammonia, strontium, and uranium) had slightly greater concentrations at one or two MF area stations within the ZOI compared to the NF median, increases relative to the NF median were very slight, and nearly all MF station medians were less than the greatest NF station median, as expected when the source of a parameter is the Mine effluent. Overall, analysis of the 2019 AEMP water quality data did not provide clear evidence to suggest an effect of dust deposition from the Mine site on the water quality of Lac de Gras.

In 2019, potential cumulative effects of the Diavik and Ekati mines were identified in 13 SOIs (i.e., calcium, chloride, magnesium, sodium, barium, molybdenum, strontium, uranium). These SOIs either had a pattern of increasing concentration extending from the FFB area to the FFA area, with a further increase at the

outlet of Lac de gras at Station LDG-48; or they had greater concentrations at the outflow of Lac de Gras compared to one of either FFA or FFB. These responses may indicate a cumulative effect on water quality in Lac de Gras, resulting from the combined influence of the Diavik and Ekati mine effluent discharge at the northwest end of Lac de Gras.

5 RESPONSE FRAMEWORK

Water quality variables were assessed for a Mine-related effect according to Action Levels in the Response Framework. Sixteen variables triggered Action Level 1 (i.e., TDS [calculated], turbidity, calcium, chloride, magnesium, sodium, sulphate, ammonia, nitrate, aluminum, barium, manganese, molybdenum, silicon, strontium, and uranium). No management action is required under the Response Framework when a variable triggers Action Level 1. Of the 16 variables that triggered Action Level 1, nine also triggered Action Level 2 (i.e., TDS [calculated], chloride, sodium, sulphate, ammonia, nitrate, molybdenum, strontium, and uranium). The required management action when a water quality variable triggers Action Level 2 is to establish an AEMP Effects Benchmark for that variable if one does not already exist. All nine variables that triggered Action Level 2 have existing Effects Benchmarks; therefore, no action was required. No water quality variables triggered Action Level 3 in 2019.

6 CONCLUSIONS

Based on the analysis of water quality data collected during the 2019 AEMP program, the following conclusions can be drawn:

- The 2019 effluent toxicity results indicated that the effluent discharged to Lac de Gras in 2019 was non-toxic; all effluent samples submitted for lethal and sublethal toxicity testing passed test criteria.
- The concentrations of all regulated effluent variables were below applicable EQC values.
- Nearly all concentrations (>99%) measured in samples collected at the mixing zone boundary were within the relevant AEMP water quality Effects Benchmarks for the protection of aquatic life and drinking water.
- In the ice-cover season, elevated conductivity was measured in the bottom two-thirds of the water column in the NF area, indicating the depth range where the effluent plume was located. During the open-water season, *in situ* water quality measurements were typically uniform throughout the water column.
- Concentrations of the majority of variables in samples collected during the 2019 AEMP were below the relevant Effects Benchmarks for the protection of aquatic life and drinking water.
- In 2019, 16 water quality variables demonstrated an effect equivalent to Action Level 1 (i.e., TDS [calculated], turbidity, calcium, chloride, magnesium, sodium, sulphate, ammonia, nitrate, aluminum, barium, manganese, molybdenum, silicon, strontium, and uranium), and were included in the list of SOIs in 2019 (Table 6-1).
- Of the 16 SOIs that triggered Action Level 1, nine also triggered Action Level 2 (i.e., TDS [calculated], chloride, sodium, sulphate, ammonia, nitrate, molybdenum, strontium, and uranium; Table 6-1); these nine variables already have existing Effects Benchmarks.
- None of the SOIs triggered Action Level 3 (Table 6-1).

- Spatial trends of decreasing concentrations with distance from the Mine effluent discharge were evident for most SOIs based on a graphical and statistical evaluation of the data. An exception was turbidity, which had a significant decreasing trend along only one of three MF area transects (i.e., MF1) during the open-water season.
- Most of the SOIs had NF mean concentrations significantly greater than the 2019 FF area mean concentrations, indicating that the increases observed in the NF area for these variables were related to the Mine effluent discharge.
- Eleven variables triggered an effect equivalent to Action Level 1 at one or more of the four MF area stations located within the estimated ZOI from dust deposition from the Mine site (Section 3.9); however, all of these SOIs also triggered Action Level 1 in the Response Framework for water quality, as a result of the effluent discharge. Analysis of the 2019 AEMP water quality data did not provide clear evidence to suggest an effect of dust deposition from the Mine site on the water quality of Lac de Gras. A special study evaluating the effects of dust deposition on water quality in Lac de Gras is presented in Appendix XII. The results of the special study are consistent with Mine effluent, rather than dust deposition, being the primary cause of effects on water quality in Lac de Gras.
- Some water quality variables in 2019 exhibited a spatial trend with distance from the Diavik diffusers that reversed as one moves west from the MF3 or FFB areas, indicating the potential for cumulative effects from Diavik and Ekati mines on these variables.

Table 6-1 Action Level Summary for Water Quality Substances of Interest, 2019

2019 SOIs	Action Level Classification
Conventional Parameters	
Total dissolved solids, calculated	2
Turbidity – lab	1
Major Ions	
Calcium (dissolved)	1
Chloride	2
Magnesium (dissolved)	1
Sodium (dissolved)	2
Sulphate	2
Nutrients	
Ammonia	2
Nitrate	2
Total Metals	
Aluminum	1
Barium	1
Manganese	1
Molybdenum	2
Silicon	1
Strontium	2
Uranium	2

1 = Action Level 1 triggered; 2 = Action Level 2 triggered.

7 REFERENCES

- Alaska DEC (Alaska Department of Environmental Conservation). 2012. Water Quality Standards. Amended as of April 8, 2012.
- Arnold TW. 2010. Uninformative parameters and model selection using Akaike's information criterion. *The Journal of Wildlife Management* 74: 1175-1178.
- BC MOE (British Columbia Ministry of Environment). 2001. Water Quality Criteria for Aluminum – Overview Report. <https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/waterquality/water-quality-guidelines/approved-wqgs/aluminum-or.pdf>
- BC MOE. 2013. A Compendium of Working Water Quality Guidelines for British Columbia. Retrieved on 13 May 2013.
- BC MOE. 2017. British Columbia Approved Water Quality Guidelines: Aquatic Life, Wildlife & Agriculture Summary Report.
- Box GEP, Cox DR. 1964. An analysis of transformations (with discussion). *Journal of the Royal Statistical Society B*, 26, 211–252.
- Burnham KP, Anderson DR. 2002. *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach*. New York: Springer Science+Business Media, Inc.
- CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Water Quality Guidelines. Prepared by the Task Force on Water Quality Guidelines of the Canadian Council of Ministers of the Environment. With updates to 2017. Ottawa, ON.
- Daniel WW. 1990. *Applied Nonparametric Statistics*. 2nd ed. PWS-Kent, Boston, MA, USA. 635 p.
- Davies RB. 1987. Hypothesis testing when a nuisance parameter is present only under the alternative. *Biometrika* 74, 33--43.
- Davies RB. 2002. Hypothesis testing when a nuisance parameter is present only under the alternative: linear model case. *Biometrika* 89, 484--489.
- Day RW, Quinn GP. 1989. Comparisons of treatments after an analysis of variance in ecology. *Ecol Monog* 59: 433-463.
- DDMI (Diavik Diamond Mines (2012) Inc.). 2000. Winter Dissolved Oxygen Survey. Yellowknife, NT, Canada.
- DDMI. 2007. Diavik Diamond Mine – Aquatic Effects Monitoring Program – AEMP Design Document, Version 2.0. Yellowknife, NT. December 2007.
- DDMI. 2019. Water License W2015L2-0001 Monthly SNP Report – December 2018. Yellowknife, NT. January 2019.
- Dunn OJ. 1964. Multiple comparisons using rank sums. *Technometrics* 6: 241-252.

- Environment Canada. 2007. Biological Test Method: Growth Inhibition Test using a Freshwater Alga. Environmental Protection Series, Report EPS/1/RM/25 Second Edition. Method Development and Application Centre, Ottawa ON, Canada.
- Gibbons JD. 1976. Nonparametric Methods for Quantitative Analysis. Holt, Rinehart and Winston, New York, NY, USA. 463 p.
- Golder. 2016a. Diavik Diamond Mines Inc. – Aquatic Effects Monitoring Program – Study Design Version 4.0. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT. June 2016.
- Golder. 2016b. 2011 to 2013 Aquatic Effects Re-evaluation Report. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT. June 2016.
- Golder. 2017a. Diavik Diamond Mine Inc. – Aquatic Effects Monitoring Program Design Plan Version 4.1. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. June 2017.
- Golder. 2017b. Diavik Diamond Mine - Aquatic Effects Monitoring Program – Quality Assurance Project Plan (QAPP). Version 3.1. Prepared for Diavik Diamond Mines (2012) Inc., Yellowknife, NT. June 2017.
- Golder. 2018b. AEMP 2017 Annual Report. Submitted to Diavik Diamond Mines (2012) Inc., Yellowknife, Northwest Territories. April, 2018.
- Golder. 2019a. Aquatic Effects Monitoring Program Design Plan Version 5.1, Prepared for Diavik Diamond Mines (2012) Inc., Yellowknife, NT. October 2019.
- Golder. 2019b. AEMP Reference Conditions Report Version 1.4. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. July 2019.
- Golder. 2019c. 2014 to 2016 Aquatic Effects Re-evaluation Report. Version 1.1. Prepared for Diavik Diamond Mines (2012) Inc. (DDMI). Yellowknife, NT. June 2019.
- Golder. 2019d. AEMP 2018 Annual Report. Submitted to Diavik Diamond Mines (2012) Inc., Yellowknife, Northwest Territories. March 2019.
- Government of Canada. 1999. The Canadian Environmental Assessment Act Comprehensive Study Report. Diavik Diamonds Project. June 1999.
- Health Canada. 1996. Guidelines for Canadian Drinking Water Quality, Sixth Edition.
- Health Canada. 2006. Guidelines for Canadian Drinking Water Quality Summary Table. Prepared by the Federal-Provincial-Territorial Committee on Drinking Water of the Federal-Provincial-Territorial Committee on Health and the Environment. www.healthcanada.gc.ca/waterquality.
- Health Canada. 2015. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document – Manganese. <https://www.canada.ca/en/health-canada/services/publications/healthy-living/guidelines-canadian-drinking-water-quality-guideline-technical-document-manganese.html>. Accessed February 2019.

- HydroQual (HydroQual Laboratories Ltd.). 2009. Aquatic Toxicity Assessment on Strontium. Reported prepared for Golder Associates Ltd., Calgary, AB, by HydroQual Laboratories Ltd., Calgary, AB. May 8, 2009.
- Muggeo VMR. 2008. Segmented: an R package to fit regression models with broken-line relationships. R News, 8/1, 20-25. URL <https://cran.r-project.org/doc/Rnews/>.
- Pacholski L. 2009. Toxicity of Stable Strontium in Surface Freshwaters of the Oil Sands Region in Alberta, Canada – Deriving an Aquatic Guideline and Refined Chronic Effects Benchmark. University of Ulster, Londonderry, Northern Ireland.
- Racher KN, Hutchinson D, Hart G, Fraser B, Clark R, Fequet R, Ewaschuk P, Cliffe-Phillips M. 2011. Linking environmental assessment to environmental regulation through adaptive management. Integr Environ Assess Manag 7:301-302.
- R Core Team. 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.
- Sokal RR, Rohlf FJ. 2012. Biometry, Fourth Edition. W.H. Freeman and Co., New York, NY, USA.
- US EPA (United States Environmental Protection Agency). 1998. Guidelines for Ecological Risk Assessment. Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC, USA. EPA/630/R-95/002F. April 1998.
- US EPA. 2000. Guidelines for Data Quality Assessment. Practical Methods for Data Analysis. U.S. Environmental Protection Agency, Washington, DC, USA. EPA/600/R-96/084. July 2000.
- WLWB. 2010. Guidelines for Adaptive Management- a Response Framework for Aquatic Effects Monitoring. Wek'èezhì Land and Water Board, Yellowknife, NWT, Canada. October 17, 2010. Draft document.
- WLWB. 2013. Decision from Wek'èezhì Land and Water Board Meeting of August 12, 2013: Diavik Diamond Mines Inc. (DDMI), AEMP – Version 3.1 – Response Framework. Wek'èezhì Land and Water Board, File W2009L2-0001 (Type “A”).
- WLWB. 2015. Diavik Diamond Mines Inc. Water Licence W2015L2-0001. Updated October 2017. Wek'èezhì Land and Water Board, Yellowknife, NT. October 19, 2015.

8 CLOSURE

We trust the information in this report meets your requirements at this time. If you have any questions relating to the information contained in this report, please do not hesitate to contact the undersigned.

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