Hope Bay Mining Limited

DORIS NORTH GOLD MINE PROJECT
2011 Aquatic Effects Monitoring Program Report

NEWMONT NORTH AMERICA

Rescan™ Environmental Services Ltd.
Rescan Building, Sixth Floor - 1111 West Hastings Street
Vancouver, BC Canada V6E 2J3
Tel: (604) 689-9460 Fax: (604) 687-4277

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DORIS NORTH GOLD MINE PROJECT
2011 AQUATIC EFFECTS MONITORING PROGRAM REPORT

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Hope Bay Mining Limited

Prepared by:

Rescan™
Engineers and Scientists

Rescan™ Environmental Services Ltd.
Vancouver, British Columbia

Executive Summary

Engineers and Scientists

Executive Summary

The Doris North Gold Mine Project (the Project) is located approximately 125 km southwest of Cambridge Bay, Nunavut, on the south shore of Melville Sound. The nearest communities are Omingmaktok (75 km to the southwest of the property), Cambridge Bay, and Kingaok (Bathurst Inlet; 160 km to the southwest of the property).

Having received all necessary permits, licences, and authorizations for development, Hope Bay Mining Ltd. (HBML) started major construction on the Project site in 2010. As of January 2012, HBML announced that it will be transitioning the Project into care and maintenance.

The purpose of this document is to comply with the requirement outlined in the Type A Water Licence to conduct and report on an Aquatic Effects Monitoring Program (AEMP). The following text outlines the requirements in the Doris North Project Type A Water Licence (issued September 19, 2007; NWB Licence #2AM-DOH0713):

- Part K, Item 7. *The Licensee shall submit to the Board for approval..., a proposal for the development of an Aquatic Effects Monitoring Plan (AEMP) in consultation with Environment Canada. The proposal for an AEMP shall consider modifications and advances in schedule which are consistent with the objectives and requirements of the Metal Mining Effluent Regulations (MMER);*
- Part K, Item 8. *The Licensee and Environment Canada shall coordinate with the NWB to ensure that the advanced submission of the AEMP meets the requirements of MMER.*

In compliance with Part K, Item 7, HBML along with Rescan Environmental Services Ltd. (Rescan) developed an AEMP Plan in consultation with Environment Canada between December 2009 and February 2010. The final AEMP Plan, *Doris North Gold Mine Project: Aquatics Effects Monitoring Plan* (Rescan 2010c), was submitted to the Nunavut Water Board (NWB) on February 24, 2010, and the document was approved on March 25, 2010, under Motion 2009-23-L04. This document conformed to the methodologies and practices laid out in the MMER (2002), thus complying with Part K, Item 8 of the Type A Water Licence.

This report presents the results from the second year of the AEMP. As outlined in the Plan, three streams, three lakes, and two marine exposure sites were monitored along with two reference streams, two reference lakes, and one marine reference site. Aquatic components evaluated in 2011 included: lake and marine under-ice dissolved oxygen levels; lake Secchi depth; stream, lake, and marine water and sediment quality; stream periphyton biomass; lake and marine phytoplankton biomass; and stream, lake, and marine benthic invertebrate community descriptors (total density, taxa richness, evenness, diversity, and the Bray-Curtis Index). Lake and marine fish communities were surveyed in 2010 (Rescan 2011) and were not scheduled to be resurveyed in 2011.

Streams

There were no apparent Project-related effects in 2011 on water or sediment quality parameters, periphyton biomass levels, or benthic invertebrate communities in the AEMP streams. There were increases in the concentrations of total suspended solids (TSS) in Little Roberts Outflow and total molybdenum in Doris Outflow in 2011 compared to baseline concentrations; however, parallel increases from baseline means also occurred at the reference streams. Thus, there was no evidence that these increases were due to Project activities. The total organic carbon (TOC) content of sediments from Little Roberts Outflow decreased slightly in 2011 compared to the baseline mean; however, a parallel trend occurred at the reference streams, suggesting that this was a natural occurrence that was unrelated to

Project activities. Total lead and mercury concentrations in sediments from Little Roberts Outflow also decreased in 2011 compared to baseline levels, but decreases in concentrations of these heavy metals are not of environmental concern. There were differences in 2010 to 2011 trends for some benthic community descriptors between exposure and reference streams; however, these differences in trends are unlikely Project-related, and probably reflect natural annual variability or patchiness in the composition and distribution of the benthos community within streams.

Lakes

There were no apparent Project-related effects on under-ice dissolved oxygen concentrations, Secchi depths, water or sediment quality parameters, phytoplankton biomass levels, or benthic invertebrate communities in the AEMP lakes. There was evidence of a decrease in the mean arsenic concentration in Doris Lake North in 2011 compared to baseline years; however, a decrease is not of environmental concern. In sediments collected from Doris Lake North, total copper, lead, and zinc concentrations decreased in 2011 compared to baseline levels, but decreases in concentrations of these metals are also not of environmental concern. There were differences in 2010 to 2011 trends for some benthic community descriptors between exposure and reference lakes; however, these differences in trends are unlikely Project-related, and probably reflect natural annual variability or patchiness in the composition and distribution of the benthos community within lakes.

In several AEMP streams and lakes, total cyanide concentrations measured in 2011 were similar to concentrations measured in 2010, but were elevated compared to pre-2010 baseline levels. However, concentrations of free cyanide measured in the exposure streams and lakes in 2011 were near or below analytical detection limits and were always below the CCME guideline of 0.005 mg/L as free cyanide. The similarity of 2011 mean total cyanide concentrations between exposure and reference waterbodies suggests that the recent increase in cyanide at the exposure streams and lakes is an analytical anomaly or a natural phenomenon that also occurred in lakes outside of the Project area. It is highly unlikely that there was an anthropogenic cause for the elevated cyanide concentrations measured in 2011, as no cyanide was used on site or brought to site in either 2010 or 2011. Cyanide concentrations will continue to be closely monitored in AEMP streams and lakes.

Marine

There were no apparent Project-related effects on winter dissolved oxygen levels, water and sediment quality parameters, phytoplankton biomass levels, or benthic invertebrate communities in AEMP marine sites. All dissolved oxygen concentrations and water quality parameters measured at the marine exposure sites during 2011 remained similar to baseline conditions, indicating that 2011 Project activities had no effects on the water chemistry in the surrounding marine habitat. Several metals increased in sediments at a monitoring site in Roberts Bay (RBW) between 2002 and 2011. However, greater increases occurred at the marine reference site between 2009 and 2011, indicating that this variability was likely natural. Similar to stream and lake benthos communities, there were differences in 2010 to 2011 trends for some benthic community descriptors between marine exposure and reference sites; however, these differences in trends are unlikely Project-related, and probably reflect natural annual variability or patchiness in the composition and distribution of the benthos community within marine sites.

Mitigation measures to reduce the potential for adverse effects to stream, lake, and marine habitats in the Doris North area included surface water runoff management, dust abatement measures, site water compliance monitoring, tailings and site geotechnical monitoring, quarry and waste rock monitoring and management, and waste management. 2011 results indicate that these mitigation measures were successful in preventing adverse effects to dissolved oxygen levels, Secchi depths, water and sediment quality parameters, periphyton and phytoplankton biomass levels, and benthic invertebrate communities in Project area waterbodies.

Acknowledgements

Engineers and Scientists

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Extensive support was provided by the HBML Environment and Social Responsibility (ESR) Department, the Health, Safety and Loss Prevention (HSLP) Department, and camp management, as well as Great Slave Helicopters, Braden Burry Expediting, and Nuna Logistics.

This report was prepared for HBML by Rescan Environmental Services Limited (Rescan). The 2011 aquatic fieldwork was conducted by Rescan scientists Mike Henry (Ph.D.), Soleil Switzer (M.Sc., R.P.Bio.), Kerry Marchinko (Ph.D.), Katsky Venter (M.Sc.), and Craig Hatt (Dip. Eng. Tech.). The report was written by Carol Adly (M.Sc.) and Mike Henry and reviewed by Deborah Muggli (Ph.D., M.Sc., R.P.Bio.). The Project was managed by Deborah Muggli.

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Glossary and Abbreviations

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Glossary and Abbreviations

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

Abbreviation/Acronym	Definition
AEMP	Aquatic Effects Monitoring Program
ALS	ALS Laboratory Group
ANOVA	Analysis of Variance
BA	Before-after
BACI	Before-after-control-impact
BC	Bray-Curtis Dissimilarity Index (also known as Bray-Curtis Similarity Index) or British Columbia
Benthos	Benthic invertebrates
CCME	Canadian Council of Ministers of the Environment
Censored value	A value that is only partially known, e.g., a parameter concentration that is reported as being below a specified detection limit, although the actual concentration is not known.
Chl *a*	Chlorophyll *a*
Chlorophyll *a*	An essential light-harvesting pigment for photosynthetic organisms including phytoplankton. Because of the difficulty involved in the direct measurement of plant carbon, chlorophyll *a* is routinely used as a ‘proxy’ estimate for plant biomass in aquatic studies.
CTD	Conductivity, temperature, depth probe
D	Simpson’s Diversity Index
DO	Dissolved oxygen
D_s	Secchi depth
E	Simpson’s Evenness Index
EEM	Environmental Effects Monitoring
Epontic	Occurring in or on the bottom of the ice layer.
ESR	Environment and Social Responsibility Department
Exposure areas	Areas anticipated to be potentially influenced by mining-related activities as part of the Doris North Project.
F	Family richness
GA	Graphical analysis
HBML	Hope Bay Mining Limited

Abbreviation/Acronym	**Definition**
HSLP	Health, Safety and Loss Prevention Department
ILBT	Impact level-by-time
ISQG	Interim sediment quality guideline
k	Light extinction coefficient
MMER	Metal Mining Effluent Regulations
NA	Not applicable
NC	Not collected
NTU	Nephelometric Turbidity Units
NWB	Nunavut Water Board
OF	Outflow
PEL	Probable effects level
QA/QC	Quality assurance/quality control
RBE	Roberts Bay East
RBW	Roberts Bay West
RDL	Realized detection limit
Reference areas	Areas located beyond any Project influence.
Rescan	Rescan Environmental Services Limited
Salinity	No units, dimensionless. Historically, many units have been assigned to salinity, for example, parts per thousand (ppt or ‰), Practical Salinity Units (PSU), and Practical Salinity Scale (PSS 78). Salinity is defined on the Practical Salinity Scale (PSS) as the conductivity ratio of a sea water sample to a standard KCl solution. As PSS is a ratio, it has no units.
SD	Standard deviation
SE	Standard error of the mean
TIA	Tailings Impoundment Area
TOC	Total organic carbon
TSS	Total suspended solids
$Z_{1\%}$	The 1% euphotic depth, i.e., the depth of the water column at which 1% of the surface irradiance reaches.

1. Introduction

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The Doris North Gold Mine Project (the Project) is located approximately 125 km southwest of Cambridge Bay, Nunavut, on the south shore of Melville Sound (Figure 1-1). The nearest communities are Omingmaktok (75 km to the southwest of the property), Cambridge Bay, and Kingaok (Bathurst Inlet; 160 km to the southwest of the property).

Having received all necessary permits, licences, and authorizations for development, Hope Bay Mining Ltd. (HBML) started major construction on the Project site in 2010. As of January 2012, HBML announced that it will be transitioning the Project into care and maintenance.

The purpose of this document is to comply with the requirement outlined in the Type A Water Licence to conduct and report on an Aquatic Effects Monitoring Program (AEMP). The following text outlines the requirements in the Doris North Project Type A Water Licence (issued September 19, 2007; Nunavut Water Board (NWB) Licence #2AM-DOH0713):

- Part K, Item 7. *The Licensee shall submit to the Board for approval..., a proposal for the development of an Aquatic Effects Monitoring Plan (AEMP) in consultation with Environment Canada. The proposal for an AEMP shall consider modifications and advances in schedule which are consistent with the objectives and requirements of the Metal Mining Effluent Regulations (MMER);*
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This report presents the results from the second year of the AEMP. 2011 is considered the second year of construction of the Doris North Project.

1.1 2011 CONSTRUCTION ACTIVITIES

2010 was the first year of official Project construction, and construction continued into 2011. Some construction activities also occurred in 2008 and 2009. Figure 1.1-1 presents the existing and future infrastructure for the Doris North Project.

The main Project activities in 2011 that could have affected the Doris North aquatic environment include the following:

- Construction of Roberts Bay tank farm and laydown expansion;
- Construction of sewage discharge line and relocation;
- Construction of fuel offload road (from the overburden dump east of the Roberts Bay 5,000,000 L tank down to the high water mark of the bay);

Figure 1-1

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Regional Location of the Doris North Project

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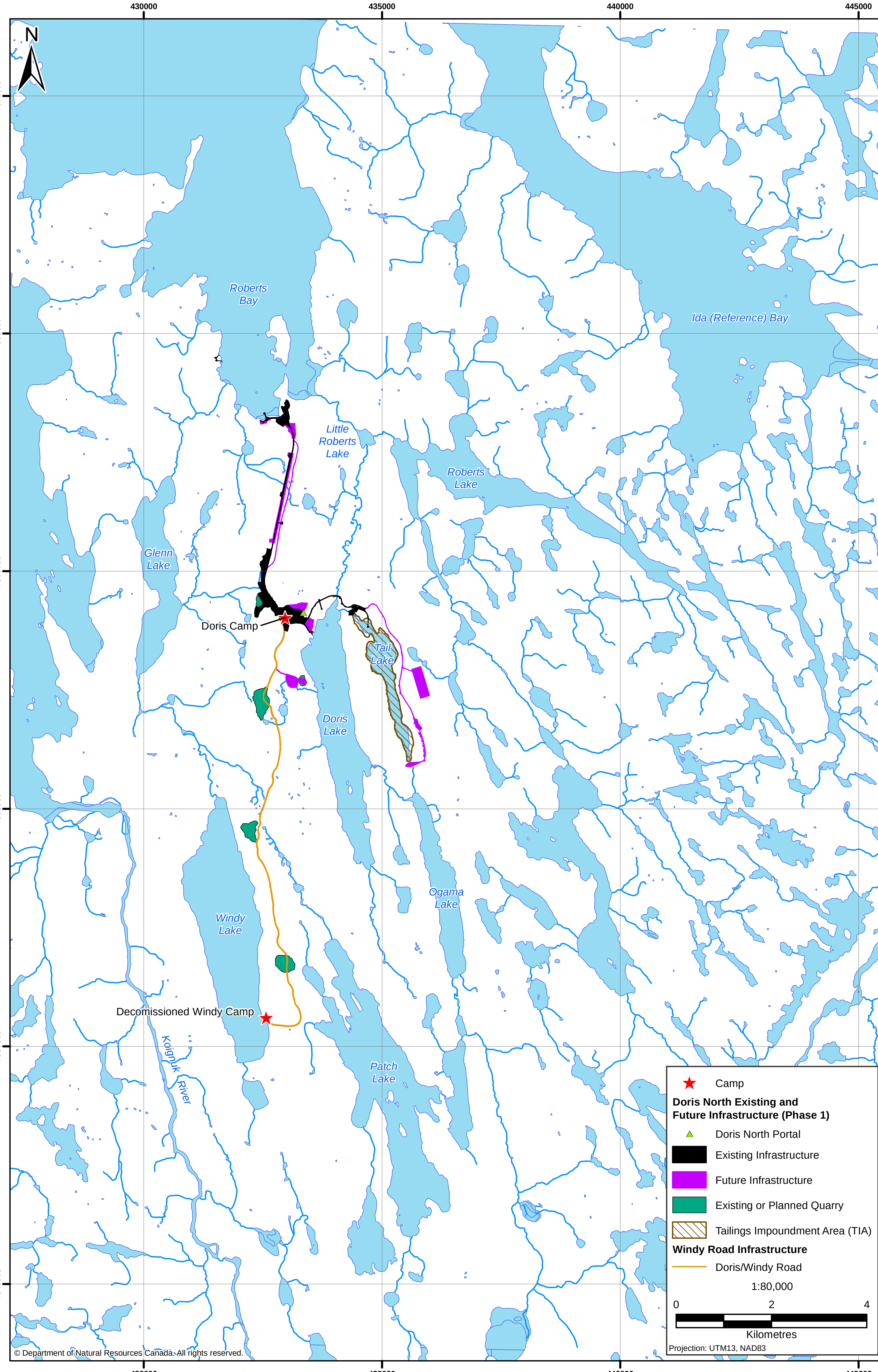

Figure 1.1-1

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Existing and Future Infrastructure, Doris North Project

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- Construction of a sedimentation pond and a pollution control pond;
- Construction of a pollution pond water treatment plant;
- Construction of a landfarm;
- Construction of secondary road from the Doris Lake road to the Tail Lake dam and continuing south to the Tail Lake reclaim barge access road;
- Airstrip expansion;
- Construction of mine vent raise;
- Partial completion of the North Dam at Tail Lake that blocked the outflow of Tail Lake, and removed the influence of Tail Lake and Tail Outflow water quality and volume on downstream waterbodies; and
- Barge traffic in Roberts Bay.

Infrastructure that already existed in 2011 included the following: the Roberts Bay jetty, the accommodation barges in Roberts Bay, the 5,000,000 L tank farm, the Roberts Bay pad, the road and associated airstrip between Roberts Bay and Doris Camp, the access road to the Doris Lake pump house, Doris Camp Pads X and Y (including the camp, generator, and sewage and water treatment system), Doris Camp Pads B, C, E/P, F, G, H/J, I, Q, the helipad, and the lower reagent pad.

The main potential interactions between the Project and the aquatic freshwater and marine environment over the lifetime of the Project are anticipated to be:

- The operation of the Tailings Impoundment Area (TIA, formerly Tail Lake). Under the current Type A water licence and Mine Certificate, treated effluent from this facility is expected to be released into Doris Outflow where it would flow successively through Little Roberts Lake and into Little Roberts Outflow before entering Roberts Bay;
- Shipping activity at the marine jetty in southern Roberts Bay;
- Construction of roads and infrastructure;
- Runoff from site infrastructure, roads, waste rock, explosives facility; and
- Accidental spills.

Mitigation measures in place to reduce the potential for adverse effects to the aquatic environment include surface water runoff management, dust abatement measures, site water compliance monitoring, tailings and site geotechnical monitoring, quarry and waste rock monitoring and management, and waste management. Updated versions of these plans are available from 2010 or 2011, and a summary of current environmental plans can be found in the *Doris North Monitoring and Follow Up Plan* (HBML 2011).

1.2 REPORT STRUCTURE

This document presents the methods, evaluation of effects, and conclusions of the 2011 AEMP. Raw data and results from the 2011 AEMP (including water column structure, water quality, sediment quality, primary producers, and benthic invertebrates) are provided in Appendix A, and supplemental information relevant to the 2011 evaluation of effects is provided in Appendix B.

2. Methods

2. Methods

2.1 SUMMARY OF AEMP STUDY DESIGN

The 2011 AEMP was conducted in accordance with the *Doris North Gold Mine Project: Aquatic Effects Monitoring Plan* (Rescan 2010c), which is a requirement of the Doris North Project Type A Water Licence (NWB No. 2AM-DOH0713).

2.1.1 Objectives of the AEMP

The AEMP study design was driven by the requirements of the MMER and the anticipated location of Project activities during the construction, operation, and closure phase of the mine. The MMER stipulate that mines are required to conduct Environmental Effects Monitoring (EEM) if effluent discharge rates exceed 50 m^3 per day and/or deleterious substances are discharged into any water body as per subsection 36(3) of the *Fisheries Act*. The primary objective of the mining EEM program is to evaluate the effects of mining effluents on fish, fish habitat, and the use of fisheries resources. Thus, the objectives of the Doris North AEMP are to monitor and evaluate potential effects of Project activities on the following parameters in waterbodies within the Doris North Project area:

- water quality and water column structure;
- sediment quality;
- primary producers (phytoplankton and periphyton);
- benthic invertebrate community (abundance and taxonomy); and
- fish.

Fish were last sampled in 2010 (Rescan 2011) and were not scheduled to be resampled in 2011.

2.1.2 Study Area and Sampling Locations

The AEMP study area included those areas anticipated to be potentially influenced by mining-related activities as part of the Doris North Project (exposure areas) and those areas beyond any Project influence (reference areas). Three lake and three stream sites were sampled in the exposure areas and two lakes and two streams were sampled as reference sites. In addition, two marine exposure sites and one marine reference site were also sampled. Figure 2.1-1 shows the sampling sites, the parameters collected, and the Doris North Project infrastructure. It also shows the projected flow path of the treated TIA effluent to be released into Doris Outflow. The approved AEMP Plan (Rescan 2010c) includes a description of the site selections. A summary table (Table 2.1-1) and text are provided below.

2.1.2.1 Exposure Sites

The principal exposure sites in the AEMP study area are those waterbodies that will be downstream of the future discharge from the TIA. From upstream to downstream, these locations include: Doris Outflow, Little Roberts Lake, Little Roberts Outflow, and Roberts Bay East (RBE; Figure 2.1-1). The Doris Outflow sampling site is situated within 100 m of the projected discharge location to best measure the potential effects of the TIA discharge. Little Roberts Lake, a small, shallow lake (0.1 km^2, < 5 m depth) receiving outflow from Doris Lake and Roberts Lake, is the only lake along the projected TIA discharge path. A receiving environment site is located in eastern Roberts Bay where Little Roberts Outflow enters the marine habitat (Roberts Bay East).

Table 2.1-1. AEMP Sampling Locations, Descriptions, and Purpose, Doris North Project, 2011

Sampling Location	Coordinates (13W)	Description	Purpose
Doris Outflow	434177E 7559910N	Immediately downstream of discharge point from the Tailings Impoundment Facility	First exposure site downstream of TIA discharge location
Little Roberts Lake	434624E 7562747N	Small lake downstream of Doris Outflow	First and only lake exposed to upstream TIA discharge
Little Roberts Outflow	434367E 7563094N	Stream downstream of Little Roberts Lake	Second exposure stream downstream of TIA discharge location
Roberts Bay East (RBE)	433430E 7563850N	Marine bay where Little Roberts Lake drains into	Marine receiving environment for freshwater system downstream of TIA discharge location
Roberts Outflow	435129E 7562881N	Stream upstream of Little Roberts Lake, which drains the much larger Roberts Lake	To characterize any influence of the abandoned silver mine and current neighbouring exploration activity (North Arrow Minerals Inc.) on Roberts Outflow and potentially downstream in Little Roberts Lake and Little Roberts Outflow, and to be able to differentiate this from potential effects of TIA discharge upstream
Doris Lake North	433815E 7558222N	Large lake located south of main Project site. North part of lake is adjacent to Project infrastructure.	Potential exposure site due to close proximity of Project infrastructure and explosives storage
Doris Lake South	434288E 7555935N	Large lake located south of main Project site. South part of lake is 4 km away from Project infrastructure.	South site can be used to characterize any potential changes to the lake (whether local or lake-wide)
Roberts Bay West (Jetty; RBW)	432479E 7563346N	Small marine bay where jetty is located	Potential exposure marine area due to marine activities and infrastructure
Reference Lake D	447566E 7561201N	Small reference lake located west of the Project	Reference lake meant to closely resemble the morphology, habitat, and fish community of Little Roberts Lake
Reference D Outflow	448109E 7562830N	Reference outflow located west of the Project	Reference stream meant to closely resemble the morphology, habitat, and fish community of Little Roberts Outflow
Reference Lake B	424050E 7532000N	Large reference lake located southwest of the Project	Reference lake meant to closely resemble the morphology, habitat, and fish community of Doris Lake
Reference B Outflow	427150E 7530515N	Reference outflow located southwest of the Project	Reference stream meant to closely resemble the morphology, habitat, and fish community of Doris Outflow
Ida (Reference) Bay (REF-Marine 1)	441152E 7563018N	Marine bay located west of the Project	Marine reference area meant to provide a reference for the two potential marine exposure sites (Roberts Bay East, Roberts Bay West (Jetty))

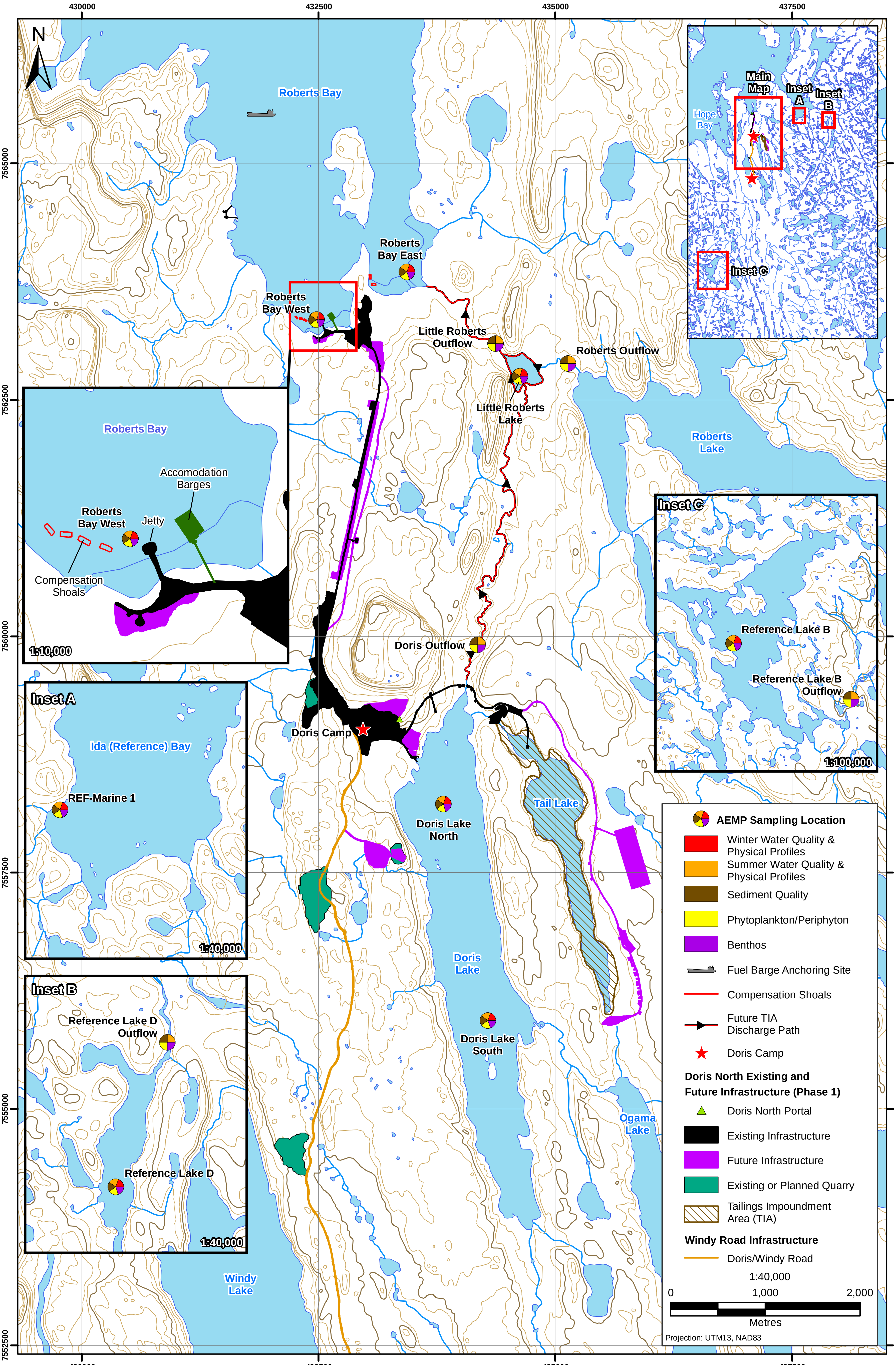

Figure 2.1-1

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2011 AEMP Sampling Locations, Doris North Project

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Because there is both historical mining activity (an abandoned silver mine) and current exploration activity (North Arrow Minerals Inc.) occurring in the Roberts Watershed and lake area, a sampling site at Roberts Outflow is also included. This station will help to identify any potential confounding influence of non-HBML activities.

In addition to the sampling sites that could potentially be affected by future TIA discharge, sites also exist to capture other potential effects of the Doris North Project. These sites include two sampling locations in Doris Lake (adjacent to site infrastructure and roads), and a single site in western Roberts Bay (Roberts Bay West; RBW) near the marine jetty (roads, site infrastructure, marine loading/unloading activities). In all, there are three stream exposure sites, three lake exposure sites, and two marine exposure sites. Note that the 2010 Doris South sampling location was moved approximately 800 m to the north to a deeper basin (> 10 m deep) for 2011 sampling for improved comparability with the Doris North sampling location, which is also in a deep basin (> 10 m deep) (Figure 2.1-1).

2.1.2.2 Reference Sites

Three reference areas have been approved for the AEMP: two lake/stream outflow systems (Reference Lakes/Outflows B and D) and one marine site (Ida Bay; Figure 2.1-1). The two lake/stream outflow areas (Reference Lake B/Reference B Outflow and Reference Lake D/Reference D Outflow) are used as reference sites for comparability with exposure freshwater sites. Reference Lake D (area: 0.6 km^2) was selected as a suitable reference analogue for Little Roberts Lake (area: 0.1 km^2) based on its size and a direct linkage to the marine environment. Reference Lake B (7.7 km^2) was selected as a comparable lake to Doris Lake (3.4 km^2). A marine reference site located in south Ida Bay (REF-Marine 1) was selected for comparability with the two marine exposure sites in Roberts Bay. These reference areas were chosen with two features in mind:

- the reference areas are located sufficiently far away from the influence of Project activity; and
- the reference areas resemble, as much as possible, the hydrological and habitat features of the exposure areas.

There will be no Project activities near the selected reference sites. The major consideration was to place the reference locations beyond any potential wind-borne particulates from mine sources. Reference Lake D is located 15 km from Doris North infrastructure, Reference Lake B is located 25 km away, and the marine reference site in Ida Bay is 10 km away.

2.1.3 Overall Schedule

The AEMP schedule is outlined in the current Plan. However, HBML recently announced that it will be transitioning the Project into care and maintenance. Consequently, the AEMP Plan will be revised and a new monitoring schedule will be developed.

2.1.4 2011 Sampling Schedule

For 2011, AEMP sampling commenced in April with the under-ice, physical limnology/oceanography and water quality collection, and ended in late September. Physical characteristics (e.g., temperature, dissolved oxygen (DO), salinity) and water quality (e.g., nutrients and metals) were collected in streams, lakes, and the marine environment four times during the sampling period, at least one month apart (whenever possible), thereby complying with MMER guidelines (Schedule 5, s.7 (1-2)). Phytoplankton and periphyton biomass (as chlorophyll *a*) were also collected during these surveys. Sediment quality and benthos samples were collected once in August. A summary of the 2011 sampling schedule is provided in Table 2.1-2.

Table 2.1-2. Summary of the 2011 AEMP Sampling Dates, Doris North Project

Waterbody	Parameter	Sampling Dates
Streams	Water Quality	June 26
		July 23
		August 20-23
		September 18-23
	Sediment Quality	August 20-28
	Periphyton Biomass	July 23*
		August 20-28*
		September 18-23*
	Benthos	August 20-28
Lakes	Physical Limnology	April 21-24
		July 18-20
		August 15-28
		September 18-26
	Water Quality	April 22-24
		July 18-20
		August 16-23
		September 18-26
	Sediment Quality	August 16-28
	Phytoplankton Biomass	April 21-24
		July 18-20
		August 15-28
		September 18-26
	Benthos	August 16-28
Marine	Physical Oceanography	April 23-24
		July 22-26
		August 14-19
		September 20-25
	Water Quality	April 23-24
		July 22-23
		August 14-19
		September 20-25
	Sediment Quality	August 19
	Phytoplankton Biomass	April 23-24
		July 23
		August 14-19
		September 20-25
	Benthos	August 19

** Periphyton biomass sampling dates indicate the dates of sampler retrieval. Samplers were installed in streams for approximately one month.*

2.2 DETAILED 2011 AEMP METHODS

Table 2.2-1 presents a summary of the AEMP components and methods, including the parameters assessed, the within-year sampling frequency, sampling replication, sampling dates, and the sampling devices used.

Table 2.2-1. Summary of the 2011 AEMP Environmental Sampling Program, Doris North Project

Monitoring Parameter	Sampling Frequency	Sample Replication and Depths	Sampling Dates/Timing	Sampling Device
Lake and Marine Water Quality				
Physical, nutrients, total metals, dissolved oxygen/temperature profile, Secchi depth	4 x	Lakes: n = 1/site @ 1 m below the surface and 2 m above water-sediment interface + 20% replication; Marine: n = 2/site @ 1 m	April, July, August, September	GO-FLO sampling bottle; Conductivity-Temperature-Depth (CTD) probe; DO meter
Lake and Marine Phytoplankton				
Biomass (chlorophyll *a*)	4 x	n = 3/site @ 1 m below the surface	April, July, August, September; coincident with lake and marine water quality	GO-FLO sampling bottle
Lake and Marine Benthos				
Abundance and taxonomy	1 x	n = 5/site (3 composite subsamples/replicate)	August; coincident with August lake and marine survey	Ekman grab (lake); Petite Ponar grab (marine); 500 µm sieve
Lake and Marine Sediment Quality				
Physical, particle size, nutrients, metals, total organic carbon	1 x	n = 3/site	August; coincident with August lake and marine survey	Ekman grab (lake); Petite Ponar grab (marine)
Stream Water Quality				
Physical, nutrients, total metals, temperature	4 x	n = 2/site	June, July, August, September	Clean water sampling bottles; Temperature meter
Stream Periphyton				
Biomass (chlorophyll *a*)	3 x	n = 3/site	June-July, July-August, August-September; coincident with stream water quality	Artificial Samplers (Plexiglas plates) installed for ~1 month
Stream Benthos				
Abundance and taxonomy	1 x	n = 5/site (3 composite subsamples/replicate)	August; coincident with August stream survey	Hess sampler; 500 µm sieve

2.2.1 Physical Limnology and Oceanography

Physical limnological (e.g., temperature and dissolved oxygen) and oceanographic (e.g., salinity, temperature, and dissolved oxygen) profiles were collected once during the under-ice season (April) and three times during the open-water season (July, August, and September) in 2011. The under-ice sampling was designed to collect water during a period when dissolved oxygen concentrations are expected to be lowest due to reduced photosynthesis and the absence of oxygen diffusion from the atmosphere, and concentrations of nutrients and metals are expected to be highest due to limited biological uptake and solute extrusion from the formation of the ice cover.

2.2.1.1 Lakes

Under-ice

The underlying lake water at the April sampling sites was accessed by drilling a 25-cm diameter hole through the ice. The ice thickness was then recorded and the lake bottom depth measured using a weighted, metred line, with care taken to minimize any disturbance to lake sediments. Water column profiling and water quality sampling depths were calculated based on bottom depth.

Measurements of water column structure (including temperature and dissolved oxygen) were collected using a YSI dissolved oxygen/temperature meter. Temperature and dissolved oxygen values were recorded at 0.5 or 1 m intervals. The probe was gently agitated as it was held at a particular depth to ensure a continual flushing of 'new' water. The profiles extended from the surface to approximately 1 m above the sediment surface to reduce suspension of bottom sediments.

Open Water

Summer temperature and dissolved oxygen profiles were measured at the same locations using the same equipment as in winter, and were collected from an aluminum boat. In addition, light attenuation was estimated in each lake using a Secchi disk. Measurements were collected at each site by lowering the 20-cm black and white disk on a metred line through the water column on the shaded side of the boat until it disappeared from sight. The depth of disappearance was recorded as the Secchi depth (D_s). The 1% euphotic zone depth ($Z_{1\%}$) was computed by first calculating the light extinction coefficient (k) from D_s, and then calculating the euphotic zone depth based on the appropriate light extinction coefficient. The 1% euphotic depth is the depth of the water column at which 1% of the surface irradiance reaches. It represents the depth at which the integrated gross water column photosynthetic production is equivalent to the integrated gross water column respiration; thus, there is net photosynthesis above this depth. The 1% euphotic depth is often referred to as the compensation depth, and is calculated as follows (Parsons, Takahashi, and Hargrave 1984):

Light extinction coefficient:

$$k\ (m^{-1}) = 1.7/D_s$$

Euphotic Depth (1%):

$$Z_{1\%}\ (m) = 4.6/k$$

2.2.1.2 Marine

Under-ice

Marine under-ice water was accessed by drilling a 25-cm diameter hole through the ice. Ice thickness was recorded and the bottom depth measured using a weighted, metred line. A vertical profile of temperature, salinity, and conductivity was collected using an *in situ* conductivity, temperature, and depth probe (CTD; model RBR-420). The probe was lowered through the water column on a cable at approximately 0.5 m/s to within 1 m of the sea floor. The data logged during this process were immediately transferred to a computer in the field. Data from the downcast were used to derive physical profiles. Following the CTD casts, vertical profiles of dissolved oxygen concentration and percent saturation were collected using a YSI dissolved oxygen meter lowered at 0.5 m intervals to within 1 m of the sediments.

Open Water

CTD and dissolved oxygen profiles were collected from the side of an aluminum boat. The logged and recorded data were processed using the same methodology in April. Light penetration at each site was measured by lowering a 30-cm white Secchi disk over the shaded side of the boat until it disappeared from sight. This was recorded as the Secchi depth. The 1% euphotic zone depth was calculated from the Secchi depth as described above for lakes.

2.2.2 Water Quality

Water quality samples were collected at the lake and marine sites during the under-ice season in April, and the open-water season in July, August, and September 2011. Stream water quality samples were collected during the June freshet in addition to the three open water months listed above. Whenever possible, samples at a specific site were collected at least one month apart to conform to EEM recommendations. The sampling dates and depths for all sites are presented in Table 2.2-2 and the analyzed parameters are summarized in Table 2.2-3. All sampling locations are presented in Figure 2.1-1. The sampling procedures used for each aquatic habitat are described below.

Table 2.2-2. AEMP Stream, Lake, and Marine Water Quality Sampling Dates and Depths, Doris North Project, 2011

Habitat	Site	Sampling Date	Depth(s) (m)
Stream	Doris Outflow	26-Jun-11	Surface
		23-Jul-11	Surface
		23-Aug-11	Surface
		23-Sep-11	Surface
	Roberts Outflow	26-Jun-11	Surface
		23-Jul-11	Surface
		23-Aug-11	Surface
		23-Sep-11	Surface
	Little Roberts Outflow	26-Jun-11	Surface
		23-Jul-11	Surface
		23-Aug-11	Surface
		23-Sep-11	Surface
	Reference B Outflow	26-Jun-11	Surface
		23-Jul-11	Surface
		20-Aug-11	Surface
		18-Sep-11	Surface
	Reference D Outflow	26-Jun-11	Surface
		23-Jul-11	Surface
		21-Aug-11	Surface
		23-Sep-11	Surface
Lake	Doris Lake North	24-Apr-11	2.4, 11.3
		19-Jul-11	1.0, 11.0
		16-Aug-11	1.0, 12.0
		19-Sep-11	1.0, 9.0
	Doris Lake South	24-Apr-11	2.7, 5.0
		19-Jul-11	1.0
		16-Aug-11	1.0, 7.0
		19-Sep-11	1.0

(continued)

Table 2.2-2. AEMP Stream, Lake, and Marine Water Quality Sampling Dates and Depths, Doris North Project, 2011 (completed)

Habitat	Site	Sampling Date	Depth (m)
	Little Roberts Lake	22-Apr-11	2.0
		20-Jul-11	1.0
		23-Aug-11	1.0
		24-Sep-11	1.0
	Reference Lake B	22-Apr-11	2.5, 8.4
		18-Jul-11	1.0, 9.0
		20-Aug-11	1.0, 9.0
		18-Sep-11	1.0, 8.0
	Reference Lake D	22-Apr-11	2.0
		20-Jul-11	1.0
		17-Aug-11	1.0
		26-Sep-11	1.0
Marine	RBE (Roberts Bay)	23-Apr-11	2.5
		22-Jul-11	0.5
		14-Aug-11	0.5
		20-Sep-10	0.5
	RBW (Roberts Bay)	24-Apr-11	2.8
		23-Jul-11	1.0
		14-Aug-11	1.0
		20-Sep-11	1.0
	REF-Marine 1 (Ida Bay)	23-Apr-11	2.6
		22-Jul-11	1.0
		19-Aug-11	1.0
		25-Sep-11	1.0

2.2.2.1 Streams

During the open-water season, water quality samples were collected from three streams within the Doris Watershed (Doris, Roberts, and Little Roberts outflows), and two reference streams outside of the Project area (Reference B and Reference D outflows). Samples were collected on four separate occasions (June, July, August, and September) at each sampling site between June 26 and September 23, 2011. Locations of the 2011 AEMP study streams and sampling sites are presented in Figure 2.1-1.

Water quality samples from streams were collected at one midstream point in the cross section of the flow, with care being taken to prevent sampling artifacts by disturbing bottom sediments and collecting particulate material. Sampling personnel stood facing upstream to minimize sample contamination from resuspended sediments, and capped bottles were plunged just below the water surface and opened underwater to avoid the collection of surface material. Samples were collected using appropriate plastic bottles provided by ALS Laboratory Group, Burnaby, BC (ALS), and were rinsed three times with site-specific water prior to filling. All samples were collected in duplicate and the appropriate preservatives provided by ALS were added in the field after sample collection.

All samples were kept cold and in the dark while in the field, and were refrigerated at Doris camp prior to transport. Samples were transported in coolers with freezer packs to ALS in Burnaby, BC for all analyses. The analyzed parameters and their detection limits are presented in Table 2.2-3.

Table 2.2-3. AEMP Water Quality Parameters and Realized Detection Limits, Doris North Project, 2011

		Realized Detection Limits				Realized Detection Limits	
Parameter	**Units**	**Freshwater**	**Marine**	**Parameter**	**Units**	**Freshwater**	**Marine**
Physical Tests				**Total Metals (cont'd)**			
pH	pH	0.1	0.1	Chromium (Cr)	mg/L	0.0005	0.0001 to 0.0006
Alkalinity, Total (as $CaCO_3$)	mg/L	2	2	Cobalt (Co)	mg/L	0.00005	0.00005
Hardness (as $CaCO_3$)	mg/L	0.5	1.3 or 4.3	Copper (Cu)	mg/L	0.0005	0.00005
Conductivity	μS/cm	2	-	Gallium (Ga)	mg/L	0.00005	0.0005
Total Suspended Solids	mg/L	1	2	Iron (Fe)	mg/L	0.03	0.01
Turbidity	NTU	0.1	0.1	Lead (Pb)	mg/L	0.00005	0.00005
Salinity		-	1	Lithium (Li)	mg/L	0.0002	0.02
				Magnesium (Mg)	mg/L	0.1	0.3 or 1
Anions				Manganese (Mn)	mg/L	0.0002	0.00005
Bromide (Br)	mg/L	0.05 or 0.1	2.5 or 5.0	Mercury (Hg)	mg/L	0.0000005 or 0.00001	0.0000005 or 0.00001
Chloride (Cl)	mg/L	0.5	25 or 50	Molybdenum (Mo)	mg/L	0.00005	0.002
Fluoride (F)	mg/L	0.02	0.75 or 1.0	Nickel (Ni)	mg/L	0.0002	0.00005
Sulphate (SO_4)	mg/L	0.5	25 or 50	Phosphorus (P)	mg/L	0.30	1
				Potassium (K)	mg/L	2	6 or 20
Nutrients				Rhenium (Re)	mg/L	0.000005	0.0005
Ammonia (as N)	mg/L	0.005	0.005	Rubidium (Rb)	mg/L	0.00002	0.005
Nitrate (as N)	mg/L	0.005 or 0.025	0.006	Selenium (Se)	mg/L	0.00020	0.0004
Nitrite (as N)	mg/L	0.001	0.002	Silicon (Si)	mg/L	0.05	0.15 or 0.5
Total Phosphorus	mg/L	0.002	0.002	Silver (Ag)	mg/L	0.000005	0.0001 or 0.0004
				Sodium (Na)	mg/L	2	6 or 20
Cyanides				Strontium (Sr)	mg/L	0.00005	0.01 to 0.05
Cyanide, Total	mg/L	0.001 to 0.0013	0.001 or 0.0011	Tellurium (Te)	mg/L	0.00001	0.0005
Cyanide, Free	mg/L	0.001 or 0.005	0.001 or 0.005	Thallium (Tl)	mg/L	0.000002	0.00005
Organic Carbon				Thorium (Th)	mg/L	0.000005 to 0.000035	0.0005
Total Organic Carbon	mg/L	0.5	0.5	Tin (Sn)	mg/L	0.0002	0.001
				Titanium (Ti)	mg/L	0.0002	0.005
Total Metals				Tungsten (W)	mg/L	0.00001 to 0.00006	0.001
Aluminum (Al)	mg/L	0.003 or 0.015	0.005	Uranium (U)	mg/L	0.000002	0.00005
Antimony (Sb)	mg/L	0.00001	0.0005	Vanadium (V)	mg/L	0.00005	0.0005
Arsenic (As)	mg/L	0.00005	0.0004	Yttrium (Y)	mg/L	0.000005	0.0005
Barium (Ba)	mg/L	0.0001	0.001	Zinc (Zn)	mg/L	0.003	0.0008
Beryllium (Be)	mg/L	0.000005	0.0005	Zirconium (Zr)	mg/L	0.00005 or 0.0002	0.0005
Bismuth (Bi)	mg/L	0.00005	0.0005				
Boron (B)	mg/L	0.005 to 0.03	0.1	**Speciated Metals**			
Cadmium (Cd)	mg/L	0.000005	0.00002	Methylmercury	μg/L	-	0.00005
Calcium (Ca)	mg/L	0.05	0.15 or 0.5				
Cesium (Cs)	mg/L	0.000005	0.0005	**Radiochemistry**			
				Radium-226	Bq/L	0.005	0.005

2.2.2.2 *Lakes and Marine*

Water quality samples were collected in both lakes and the marine environment during the 2011 AEMP program. Lake samples were collected from three sites in two lakes within the Doris Watershed (Doris Lake South, Doris Lake North, Little Roberts Lake), and from two reference lakes (Reference Lake B and Reference Lake D). Marine water quality samples were collected from two sites in Roberts Bay (RBE, RBW) and at one reference site in the adjacent inlet, Ida (Reference) Bay (REF-Marine 1). Locations of the 2011 AEMP lake and marine sampling sites are presented in Figure 2.1-1.

Samples were collected once during the ice-covered season (April), and three times during the open water season (July, August, September) between April 22 and September 26, 2011. Within each lake, samples were collected at ~1 m depth over the deepest part of the lake. In the deepest lake sites (Doris Lake North and South and Reference Lake B), samples were collected both at ~1 m below the surface and ~2 m above the sediment.

In April, the underlying water was accessed through a hole following the temperature, CTD, and dissolved oxygen profiles. An adapted 2.5 L 'skinny' Niskin bottle was used to collect water during winter sampling. This bottle is designed to 'trip' and collect discrete samples during freezing temperatures. To avoid metal contamination, the tripping mechanism used acid-cleaned silicone tubing within the interior of the bottle. A dual rope system was used to achieve bottle closure and to ensure the collection of discrete samples. During summer and fall sampling, all water samples were collected using an acid-washed 5 L GO-FLO sampling device. The GO-FLO was securely attached to a metred cable line and was lowered to the appropriate sampling depth and allowed to equilibrate for one minute. It was then triggered closed using a brass messenger and brought aboard the boat for subsampling. Each GO-FLO cast represented one replicate.

Subsamples for the various water quality components (e.g., physical parameters/major ions, nutrients, and total metals) were drawn from the GO-FLO/Niskin bottles. All sample bottles were rinsed three times prior to filling with care being taken not to bring the bottle or cap into contact with the plastic spigot or other possible sources of contamination. The appropriate preservatives provided by ALS were added in the field after sample collection.

All samples were kept cold and in the dark while in the field and were refrigerated at camp prior to transport. Samples were transported in coolers with freezer packs to ALS, Burnaby for all analyses as described for stream water quality samples. The parameters analyzed and applicable detection limits are summarized in Table 2.2-3. Realized detection limits were occasionally higher than the theoretical detection limits in freshwater samples due to interference from other parameters. Marine samples were consistently diluted to reduce matrix effects from the high concentrations of cations (e.g., sodium).

2.2.2.3 *Quality Assurance and Quality Control*

The quality assurance and quality control (QA/QC) program for water quality sampling included the collection of replicates to account for within-site variability and the use of chain of custody forms to track all samples. A set of travel, field, and equipment blanks (~20% of total samples) was also processed and submitted with the water samples as part of the QA/QC program. These blanks were used to identify potential sources of contamination to the field samples. Results for all water quality QA/QC blanks are provided in Appendix A.

2.2.3 Sediment Quality

Sediment quality samples were collected at the stream, lake, and marine sites during the open-water season in August, 2011. This sampling coincided with benthic invertebrate sampling. Sampling dates and depths for all sites are presented in Table 2.2-4 and the analyzed parameters are summarized in Table 2.2-5. All sampling locations are presented in Figure 2.1-1. Sampling procedures for each aquatic habitat are described below.

Table 2.2-4. AEMP Stream, Lake, and Marine Sediment Quality and Benthic Invertebrate Sampling Dates and Depths, Doris North Project, 2011

Habitat	Site	Sampling Date	Depth (m)
Stream	Doris Outflow	27-Aug-11	NA
	Roberts Outflow	27-Aug-11	NA
	Little Roberts Outflow	28-Aug-11	NA
	Reference B Outflow	20-Aug-11	NA
	Reference D Outflow	21-Aug-11	NA
Lake	Doris Lake North	16-Aug-11	13.7
	Doris Lake South	16-Aug-11	11.5
	Little Roberts Lake	28-Aug-11	3.6
	Reference Lake B	20-Aug-11	10.5
	Reference Lake D	16-Aug-11	3.5
Marine	RBE (Roberts Bay)	19-Aug-11	1.2
	RBW (Roberts Bay)	19-Aug-11	3.7
	REF-Marine-1 (Ida Bay)	19-Aug-11	4.5

NA - not applicable

Table 2.2-5. AEMP Sediment Quality Parameters and Realized Detection Limits, Doris North Project, August 2011

		Realized Detection Limit				Realized Detection Limit	
Parameter	Units	Freshwater	Marine	Parameter	Units	Freshwater	Marine
Physical Tests				**Total Metals (continued)**			
Moisture	%	0.25	0.25	Bismuth (Bi)	mg/kg	0.2	0.2
pH	pH	0.1	0.1	Cadmium (Cd)	mg/kg	0.05	0.05
				Calcium (Ca)	mg/kg	50	50
Particle Size				Chromium (Cr)	mg/kg	0.5	0.5
% Gravel (>2 mm)	%	0.1	0.1	Cobalt (Co)	mg/kg	0.1	0.1
% Sand (2.0 - 0.063 mm)	%	0.1	0.1	Copper (Cu)	mg/kg	0.5	0.5
% Silt (0.063 mm - 4 µm)	%	0.1	0.1	Iron (Fe)	mg/kg	50	50
% Clay (<4 µm)	%	0.1	0.1	Lead (Pb)	mg/kg	0.5	0.5
				Lithium (Li)	mg/kg	1	1
Organic / Inorganic Carbon				Magnesium (Mg)	mg/kg	20	20
Total Organic Carbon	%	0.1	0.1	Manganese (Mn)	mg/kg	1	1
				Mercury (Hg)	mg/kg	0.005	0.005
Leachable Nutrients				Molybdenum (Mo)	mg/kg	0.5	0.5
Total Nitrogen	%	0.02	0.02	Nickel (Ni)	mg/kg	0.5	0.5
				Phosphorus (P)	mg/kg	50	50
Plant Available Nutrients				Potassium (K)	mg/kg	100	100
Available Ammonium-N	mg/kg	1.0 to 8.8	1.0 to 2.4	Selenium (Se)	mg/kg	0.2	0.2

(continued)

Table 2.2-5. AEMP Sediment Quality Parameters and Realized Detection Limits, Doris North Project, August 2011 (completed)

		Realized Detection Limit				Realized Detection Limit	
Parameter	**Units**	**Freshwater**	**Marine**	**Parameter**	**Units**	**Freshwater**	**Marine**
Available Nitrate-N	mg/kg	2.0 to 20	2.0 or 4.0	Silver (Ag)	mg/kg	0.1	0.1
Available Nitrite-N	mg/kg	0.4 to 1.2	0.4 or 0.8	Sodium (Na)	mg/kg	100	100
Available Phosphate-P	mg/kg	2.0 to 8.0	2.0	Strontium (Sr)	mg/kg	0.5	0.5
				Sulphur (S)	mg/kg	500	500
Total Metals				Thallium (Tl)	mg/kg	0.05	0.05
Aluminum (Al)	mg/kg	50	50	Tin (Sn)	mg/kg	2	2
Antimony (Sb)	mg/kg	0.1	0.1	Titanium (Ti)	mg/kg	1	1
Arsenic (As)	mg/kg	0.05	0.05	Uranium (U)	mg/kg	0.05	0.05
Barium (Ba)	mg/kg	0.5	0.5	Vanadium (V)	mg/kg	0.2	0.2
Beryllium (Be)	mg/kg	0.2	0.2	Zinc (Zn)	mg/kg	1	1

2.2.3.1 Streams

Three replicate sediment samples were collected at each stream site. Replicate samples were collected by plunging an Ekman grab sampler (surface sampling area of 0.0225 m^2) into the sediment bed, with each replicate spaced approximately three times the channel width apart. The sample was carefully raised and inspected to ensure the collection of an intact, undisturbed sample.

After the water was allowed to drain slowly, the sediment material was emptied onto a clean, plastic tray, and photographed. The surface 2 to 3 cm was subsequently removed with a clean plastic spoon and homogenized in a plastic bowl. Subsamples of this homogenous surface material were then transferred into separate pre-labelled Whirl-Pak bags: one for particle size analysis, and one for sediment chemistry analysis. Each bag was then placed into another Whirl-Pak bag as a protective measure. All samples were refrigerated (in darkness) until they were shipped to ALS (Burnaby, BC) for analysis on the first available flight out of camp. Table 2.2-5 presents the sediment quality parameters that were analyzed and their corresponding detection limits.

2.2.3.2 Lakes

Lake sediments were obtained in the deepest section of the lake (except Doris Lake South) using an Ekman grab sampler with the replicates collected 5 to 20 m apart. Sampling depths are provided in Table 2.2-4. The Ekman was carefully set open, lowered gradually onto the sediment using a metred cable line, and triggered closed with a messenger. The sample was carefully raised and inspected to ensure the collection of an intact, undisturbed sample. All processing, shipping, and analytical procedures were identical to those described for stream sediment quality.

2.2.3.3 Marine

Marine sediment quality samples were collected in triplicate using a Petite Ponar grab sampler (surface sampling area of 0.023 m^2), with replicates spaced 5 to 20 m apart. The sampling depths are provided in Table 2.2-4. Each sediment sample was carefully transferred onto a tray, and the top 2 to 3 cm of sediment was scraped into two Whirl-Pak bags: one for particle size, and one for sediment chemistry. All samples were refrigerated (in darkness) until they were shipped to ALS (Burnaby, BC) on the first available flight out of camp. Table 2.2-5 presents the sediment quality parameters that were analyzed and their corresponding detection limits.

2.2.3.4 Quality Assurance and Quality Control

The QA/QC program for sediment quality sampling included the collection of replicates to account for within-site variability and the use of chain of custody forms to track all samples.

2.2.4 Primary Producers

Primary producer biomass (as chlorophyll *a*) samples were collected in streams, lakes, and the marine habitat to assess potential changes in their standing stocks due to eutrophication (i.e., excess nutrients) or toxicity (i.e., presence of deleterious substances). Periphyton biomass samples were collected in streams during the open-water season in July, August, and September. Phytoplankton biomass samples were collected in lakes and the marine environment under-ice in April, and during the open-water season in July, August, and September.

2.2.4.1 Stream Periphyton

Stream periphyton samples were collected using artificial substrate samplers. These samplers were installed in each study stream for approximately one month before sample collection and processing, i.e., those plates collected in July, August, and September, were installed in June, July, and August, respectively. The complete installation and retrieval schedule is outlined in Table 2.2-6.

Table 2.2-6. Periphyton Sampling Dates, Doris North Project, 2011

Stream Site	Installation Date	Retrieval Date
Doris Outflow	26-Jun-11	23-Jul-11
	23-Jul-11	27-Aug-11
	27-Aug-11	23-Sep-11
Roberts Outflow	26-Jun-11	23-Jul-11
	23-Jul-11	27-Aug-11
	27-Aug-11	23-Sep-11
Little Roberts Outflow	26-Jun-11	23-Jul-11
	23-Jul-11	28-Aug-11
	28-Aug-11	23-Sep-11
Reference B Outflow	26-Jun-11	23-Jul-11
	23-Jul-11	20-Aug-11
	20-Aug-11	18-Sep-11
Reference D Outflow	26-Jun-11	23-Jul-11
	23-Jul-11	21-Aug-11
	21-Aug-11	23-Sep-11

The samplers used were 10 cm × 10 cm Plexiglas® plates, which were affixed to rocks with fishing line and placed in the stream such that they remained submerged until retrieval. Overall, five plates were submerged per site, but only three plates were processed. These extra plates were used to increase the likelihood that at least three plates were available to process after a month's time. The plates were installed a minimum distance of three times the channel width apart from each other.

Upon collection, the sample plates were scraped using a razor blade, and rinsed into a 250 mL wide-mouth plastic jar. The samples were then filtered at Doris camp onto 47 mm diameter, 0.45 μm pore-size membrane filters, folded carefully in half, and wrapped in aluminum foil. A label was then attached to the foil indicating all sampling information. The filters were kept frozen until they were sent to ALS Burnaby for analysis.

2.2.4.2 Lake and Marine Phytoplankton

Lake and marine phytoplankton biomass samples were collected in triplicate at ~1 m depth using a 5 L GO-FLO water sampler during July, August, and September. In April, a 2.5 L Niskin bottle was used to collect a sample from ~1 m beneath the ice layer. For each sample, the water sampler was lowered to the appropriate depth using a metred cable line and triggered closed with a messenger. Once in the boat, a subsample was drawn for a chlorophyll *a* sample. The GO-FLO/Niskin was set, lowered, and triggered three times; once for each replicate.

Subsamples for chlorophyll *a* were obtained by rinsing and filling a clean 1 L bottle. The samples were kept cold and dark and transported to Doris camp, where the samples were filtered using gentle vacuum filtration (hand pump). The samples were filtered onto 47 mm diameter, 0.45 µm pore size nitrocellulose membrane filters, folded carefully in half, and wrapped in aluminum foil. A label was then attached to the foil indicating all sampling information and the volume of water filtered. The filters were kept frozen until they were sent to ALS Burnaby for analysis.

2.2.4.3 Quality Assurance and Quality Control

The QA/QC program for phytoplankton and periphyton biomass sampling included the collection of replicates to account for within-site variability and the use of chain of custody forms to track all samples.

2.2.5 Benthos

Benthic invertebrate (benthos) samples were collected at the stream, lake, and marine sites during the open-water season in August 2011. This coincided with the sediment quality sampling. Sampling dates and depths for all sites are presented in Table 2.2-4 and all sampling locations are indicated in Figure 2.1-1.

All field sampling devices and methods for the AEMP benthos sampling were designed to comply with EEM guidance documents (Environment Canada 2011). Sampling procedures for each aquatic habitat are described below.

2.2.5.1 Streams

Benthos samples were collected at all AEMP streams from August 16 to August 28, 2011. To comply with EEM requirements, three separate subsamples were collected and pooled for each replicate sample, and five replicates were collected at each site. All samples were collected in riffle habitats using a Hess sampler (surface sampling area of 0.096 m^2) fitted with a 500 µm mesh size net and terminal cod-end. Replicate samples were collected a minimum distance of three times the channel width apart from each other.

For each subsample, the bottom of the Hess sampler was placed firmly on the sediment bottom making sure sediment contact was continuous along the bottom rim. The encircled sediment was then swept by hand and all rocks lifted and scrubbed to make sure the entire sediment surface was agitated. After sweeping, the collected debris was transferred from the cod-end into a 500 mL wide-mouthed plastic jar. Three subsamples were combined to make one sample and this was preserved with buffered formalin to a final concentration of 10%. All benthos samples were sent to Dr. Jack Zloty (Summerland, BC) for enumeration and identification.

Several community descriptors were calculated from the taxonomic results, including benthos density, family richness, Simpson's Diversity and Evenness indices, and the Bray-Curtis Index. Cladocerans and cyclopoid and calanoid copepods were not included in the community metrics as these groups are generally planktonic. Nematodes and harpacticoid copepods were excluded as they are typically considered to be meiofauna (invertebrates ranging in size between 63 µm and 500 µm) and are not adequately sampled using a 500 µm sieve bucket. Organisms that could not be identified to the family level and made up a minor proportion (< 2%) of the benthos counts in each replicate were excluded from the community analysis. Any terrestrial organisms or fish that were identified in the benthos samples were also excluded from the calculations of community descriptors.

Benthos counts were normalized to three times the surface area of the of the Hess sampler (i.e., 3 x 0.096 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of three pooled Hess samples).

Family richness was calculated as the total number of benthic invertebrate families present in each replicate sample. The Simpson's Diversity Index (D) was calculated as:

$$\textit{Simpson Diversity Index } (D) = 1 - \sum_{i=1}^{F} p_i^2$$

where F is the number of families present (i.e., family richness), and p_i is the relative abundance of each family calculated as n_i/N, where n_i is the number of individuals in family i, and N is the total number of all individuals. Simpson's Evenness Index (E) was calculated as:

$$\textit{Simpson Evenness Index } (E) = 1/\sum_{i=1}^{F} p_i^2/F$$

A complete dissimilarity matrix was also generated that included pairwise comparisons of all samples using the Bray-Curtis Index. The Bray-Curtis Index compares the community composition within a benthos sample to the median reference community composition (Environment Canada 2011). This reference composition is generated from the median abundance of each represented family from all of the reference site replicates. Since the median reference composition is generated from the combined reference site replicates, the comparison of a single reference site replicate community to the median reference community composition will produce a dissimilarity value (although generally a much lower value than exposure sites). Because the Bray-Curtis Index measures the percent difference between sites, the greater the dissimilarity value between a site and the median reference community, the more dissimilar those benthos communities are. The Bray-Curtis Index ranges from 0 to 1, with 1 representing completely dissimilar communities, and 0 representing identical communities. This index is calculated as:

$$\textit{Bray-Curtis Index } (BC) = \sum_{i=1}^{n} |y_{i1} - y_{i2}| \ / \ \sum_{i=1}^{n} (y_{i1} + y_{i2})$$

where BC is the Bray-Curtis distance between sites 1 and 2, n is the total number of families present at the two sites, y_{i1} is the count for family i at site 1, and y_{i2} is the count for family i at site 2.

A separate analysis was completed for stream, lake, and marine benthos. For the stream benthos, all replicate data from the two reference locations (Reference B and D outflows) were combined for the determination of the 'median reference composition'. Because lakes can have dramatically different physico-chemical and biological function based on their morphologies, median reference compositions were created for each reference lake (large lake: Reference Lake B; small lake: Reference Lake D). Bray-Curtis distances were then calculated by comparing the Reference Lake B median community to the large lake sites, Doris Lake North and South, and the Reference Lake D median community to Little Roberts Lake. For the marine sites, the REF-Marine 1 median community composition was compared to the RBW and RBE benthos communities.

Standard summary statistics (minimum, maximum, median, mean, standard deviation, and standard error) were calculated for all 2011 benthic invertebrate endpoints described above. These summary statistics are presented in Appendix A.

2.2.5.2 Lakes

Benthos samples were collected during the summer season at all AEMP lakes from August 16 to August 28, 2011. Like streams, all lake benthos sampling was designed to meet EEM criteria (i.e., three subsamples/replicate; five replicates/site). With the exception of Doris Lake South, lake benthos samples were obtained in the deepest section of the lake using an Ekman grab sampler (surface sampling area of 0.0225 m^2), with replicates collected 5 to 20 m apart. The Ekman was carefully set open, lowered gradually onto soft sediment using a metred cable line, and triggered closed with a messenger. All sampling depths are provided in Table 2.2-4.

Once at the surface, each sediment sample was transferred into a 500 µm sieve bucket and rinsed with site-specific water until free of sediments. The material retained within the sieve was then placed into a labelled plastic jar and preserved with buffered formalin to a final concentration of 10%. All benthos samples were sent to Dr. Jack Zloty (Summerland, BC) for enumeration and identification. Benthos counts were normalized to the surface area of three times the surface area of the of the Ekman sampler (i.e., 3 x 0.0225 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of three pooled Ekman samples). Community descriptors and summary statistics were calculated as described for stream benthos.

2.2.5.3 Marine

Benthos samples were collected during the summer season at the two sites in Roberts Bay (RBW and RBE; August 18, 2011) and at the reference site in Ida Bay (REF-Marine 1; August 19, 2011). Samples were collected with a Petite Ponar grab sampler (surface sampling area of 0.023 m^2). Five replicates were collected approximately 20 to 50 m apart at each site, with each replicate consisting of three pooled grab samples. Each sediment sample was transferred into a 500 µm sieve bucket and rinsed with site-specific water until free of sediments. The material retained within the sieve was then placed into a labelled plastic jar and preserved with saline, buffered formalin to a final concentration of 10%. All benthos samples were sent to Columbia Science (Courtney, BC) for enumeration and identification. Benthos counts were normalized to the surface area of three times the surface area of the of the Petite Ponar sampler (i.e., 3 x 0.023 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of three pooled Petite Ponar grab samples). Community descriptors and summary statistics were calculated as described for stream benthos.

2.2.5.4 Quality Assurance and Quality Control

The QA/QC program for benthos sampling included the collection of replicates to account for within-site variability and the use of chain of custody forms to track all samples.

A re-sorting of randomly selected sample residues was conducted by taxonomists on a minimum of 10% of the benthos samples to determine the level of sorting efficiency. The criterion for an acceptable sorting was that more than 90% of the total number of organisms was recovered during the initial sort. The number of organisms initially recovered from the sample was expressed as a percentage of the total number after the re-sort (total of initial and re-sort count). Any sample not meeting the 90% removal criterion was re-sorted a third time. The 90% minimum efficiency was always attained. Results for all benthos QA/QC are provided in Appendix A.

2.3 EVALUATION OF EFFECTS

Select baseline data collected between 1995 and 2009 in the Doris North Project area were compared against 2011 data to determine whether there were adverse changes to the aquatic environment that could be directly attributed to 2011 Project activities. 2010 was not included in the baseline years of the evaluation of effects as it was Year 1 of construction.

2.3.1 Parameters Subjected to Evaluation

Table 2.3-1 presents the physical, chemical, and biological parameters that were evaluated for 2011. All water quality parameters associated with the various components of the MMER (e.g., Schedule 4 Deleterious Substances, Effluent Monitoring Conditions (Division 2), EEM's Effluent Characterization) were assessed for potential effects. Canadian Council of Ministers of the Environment (CCME) water quality guidelines for the protection of aquatic life exist for many of the assessed parameters. As per the MMER and EEM requirements, the benthic invertebrate community and associated sediment parameters (sediment particle size and total organic carbon content) were evaluated. Additional sediment parameters for which there are CCME sediment quality guidelines for the protection of aquatic life were included in the assessment. Periphyton and phytoplankton biomass were also evaluated.

Table 2.3-1. Parameters Subjected to Effects Analysis, Doris North Project, 2011

Category	Parameter
Water Quality	
Deleterious Substances[a]	Total Suspended Solids[d]
	Cyanide, Total[d]
	Arsenic, Total[d]
	Copper, Total[d]
	Lead, Total[d]
	Nickel, Total[d]
	Zinc, Total[d]
	Radium-226
Effluent Characterization and Water Quality Parameters[b]	pH[d]
	Alkalinity, Total
	Hardness
	Ammonia (as N)[d]
	Nitrate (as N)[d]
	Aluminum, Total[d]
	Cadmium, Total[d]
	Iron, Total[d]
	Mercury, Total[d]
	Molybdenum, Total[d]
Physical Limnology	
Effluent Characterization and Water Quality Parameters[b]	Dissolved Oxygen[d]
	Secchi Depth
Sediment Quality	
	Particle Size[c]
	Total Organic Carbon[c]
	Arsenic[d]
	Cadmium[d]

(completed)

Table 2.3-1. Parameters Subjected to Effects Analysis, Doris North Project, 2011 (completed)

Category	Parameter
Sediment Quality *(continued)*	Chromium[d]
	Copper[d]
	Lead[d]
	Mercury[d]
	Zinc[d]
Biology	
	Phytoplankton and Periphyton Biomass
	Benthic Invertebrate Density[c], Taxa Richness[c], Evenness Index[c], Similarity Index[c]

Notes:
[a] Parameters regulated as deleterious substances as per Schedule 4 of the MMER
[b] Parameters required for effluent characterization and water quality monitoring as per Schedule 5 of the MMER
[c] Parameters required as part of the benthic invertebrate surveys as per Schedule 5 of the MMER
[d] Parameters that have CCME water or sediment quality guidelines for the protection of aquatic life
2010 was Year 1 of fish data collection. Fish sampling was not undertaken in 2011.

2.3.2 Baseline Data and Effects Analysis

Baseline physical, chemical, and biological data have been collected in the Doris North Project area since 1995. Historical samples have been collected from a variety of locations and depths within each of the AEMP stream, lake, and marine environments. The frequency and seasonal timing of sampling has also varied since 1995, as have sampling methodologies. For these reasons, professional judgment was used in the selection of baseline data that could be used for comparison with the 2011 data.

The approaches used to assemble the appropriate baseline datasets and to determine whether there were any effects on evaluated parameters in 2011 are discussed below. Key determining factors for the inclusion of baseline data included the proximity of baseline sampling sites to 2011 sampling sites, the depth of sampling (for sediment quality and benthos), and sampling methodology (for sediment quality, periphyton, phytoplankton, and benthos). Historical data used for the effects analyses were from the following reports: Klohn-Crippen Consultants Ltd. (1995), Rescan (1997, 1998, 1999, 2001, 2010a, 2010b, 2011), RL&L Environmental Services Ltd. and Golder Associates Ltd. (2003a, 2003b), and Golder Associates Ltd. (2005, 2006, 2007, 2008, 2009).

Full descriptions of statistical methods and results are provided in Appendix B.

2.3.2.1 Under-ice Dissolved Oxygen

<u>Data Selection</u>

Potential effects on physical limnology and oceanography were evaluated using April, May, or early June under-ice dissolved oxygen since concentrations are lowest during this period, and therefore pose the greatest concern for aquatic life. Although temperature and salinity (marine) were also measured, they were not evaluated for effects since they are largely determined by climatic variability, and no TIA effluent was discharged into the aquatic environment in 2011.

Baseline (pre-2010) under-ice dissolved oxygen measurements have been collected several times at the AEMP exposure lake sites since 1998. Under-ice dissolved oxygen data are available from 2009 and 2010 for Reference Lake B, and from 2010 for Reference Lake D. 2010 data collected from the reference lakes were considered in the evaluation of effects because these lakes would not have been influenced by Project activities.

In the marine environment, baseline under-ice dissolved oxygen profiles were collected at RBE in May 2006 and at RBW in April 2009. No baseline or 2010 under-ice dissolved oxygen data exist for REF-Marine 1.

Effects Analysis

The potential for effects on under-ice dissolved oxygen levels was assessed by graphical analysis. For winter dissolved oxygen levels to warrant concern and be considered an effect, concentrations from 2011 had to be noticeably different from all available baseline years (pre-2010). For example, if 2011 dissolved oxygen levels were different from 2005, but similar to 2007, it was concluded that there were no 2011 construction effects at that exposure site. Dissolved oxygen concentrations were also compared against CCME guidelines for the protection of aquatic life (CCME 2011b) to determine if baseline or 2011 concentrations dropped below recommended levels.

Ice cover usually forms in October and November in the Doris North region, and under-ice oxygen profiles were collected in April 2011. The formation of the ice cover in November 2010 isolated lakes, streams, and Roberts Bay from any atmospheric inputs such as dust that could have been generated by Project activities between November 2010 and June/July 2011. Therefore, the water column that was profiled in April 2011 reflects activities from 2010 rather than 2011.

2.3.2.2 Secchi Depth

Data Selection

Secchi depths have been measured at lake sites in the Doris North Project area since 1995. The selection of historical lake data to include in the effects evaluation was based on similarity of baseline sampling locations to 2011 sampling locations. At least three years of baseline (pre-2010) Secchi depth data are available for Doris Lake South, Doris Lake North, and Little Roberts Lake. Baseline Secchi depth was recorded once in August 2009 at Reference Lake B, and no pre-2010 data are available for Reference Lake D.

Marine sites RBE and RBW are shallow (< 5 m) and typically contain low levels of phytoplankton biomass. Secchi depths measured at these sites in 2011 always reached the bottom (Appendix A), indicating that water clarity was high and that the euphotic zone extended throughout the entire water column. The purpose of evaluating Secchi depth is to determine whether there is any evidence of reduced water clarity caused by either an increase in phytoplankton biomass as a result of eutrophication or an increase in suspended sediments. As water clarity at marine sites was high in 2011, Secchi depth was not evaluated for the Roberts Bay sites RBE and RBW.

Effects Analysis

Graphs showing annual mean Secchi depth and comparing before (pre-2010)-after (2011) trends at the exposure sites to before-after trends at the reference sites were used to identify trends and to supplement the results of the statistical analyses.

For each lake site, a before-after comparison between the mean baseline Secchi depth and the mean Secchi depth for 2011 was conducted. A mixed model ANOVA using the Proc Mixed procedure in SAS 9.2 was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and *season*, and a random effect of *year* to account for variability in the Secchi depth data. For the *period* effect, data were grouped into one of two periods: *before* the start of construction (1995 to 2009) or *after* the start of construction (2011). For the *season* effect, data were grouped into one of three seasons depending on the timing of Secchi depth measurement: 1) July, 2) August, 3) September, since Secchi depth can vary over the open-water season depending on sediment and nutrient inputs and phytoplankton growth. To reduce the number of false positives (Type I error) due to the large number of statistical tests that were conducted, a reduced significance level (0.01) was used when reviewing the results. If the results of the before-after analysis indicated that the mean Secchi depth in 2011 was not significantly different from the baseline mean, no further statistical analysis results are discussed, and it was concluded that there was no effect of 2011 construction activities on Secchi depth.

If the before-after comparison revealed that the mean Secchi depth in 2011 was different from the baseline mean, the next step of the analysis was to conduct a before-after-control-impact (BACI) analysis, which is a standard method used to assess an environmental impact. The BACI analysis compares a before-after trend apparent at the exposure site with that at the corresponding reference site, to see if the trends are parallel and thus attributable to a natural process. A BACI analysis could only be performed if both baseline and 2011 data were available for both the exposure site and the reference site. Because there was no baseline data available for Secchi depth in Reference Lake D, it was not possible to conduct a BACI analysis for Secchi depth in Little Roberts Lake.

The BACI analysis introduces a *class* effect to the mixed model ANOVA, which is the classification of the waterbody as an exposure or a reference site. The interaction between the *period* and *class* effects reveals whether any before-after change in the mean Secchi depth that occurred in the exposure site also occurred in the reference site. To reduce the number of false positives (Type I error) due to the large number of statistical tests that were conducted, a reduced significance level (0.01) was used when reviewing the results. If a change in the mean was detected by the before-after comparison, but the BACI analysis revealed that a parallel change also occurred at the reference site, it is reasonable to assume that this change was likely a natural phenomenon and was unrelated to the 2011 construction activities. Note that BACI results are only discussed in the text if a difference is detected by the before-after analysis, but all BACI results are included in Appendix B. A complete description of the statistical methodology and results used to assess the Project effects on Secchi depth is included in Appendix B.

2.3.2.3 Water Quality

<u>Data Selection</u>

Water quality samples have been collected in the Doris North Project area since 1995 (Figure 2.3-1). The selection of historical data to include in the effects evaluation was based on the similarity of baseline sampling locations to 2011 sampling locations, methodology (e.g., shoreline grabs were excluded from dataset), sampling depth (e.g., for marine data, baseline samples collected from just above the sediment were excluded because all 2011 samples were collected from the surface zone), and professional judgement. Note that for Doris Lake South, historical water quality data collected between 1996 and 2000 were excluded from the evaluation of effects presented in the 2010 AEMP because the 1996-2000 sampling site was more than 1 km away to the north of the 2010 Doris Lake South sampling site (Figure 2.3-1). However, the Doris Lake South sampling site was moved slightly further to the north in 2011, and approximately 500 m away from the 1996-2000 sampling site. Therefore, these historical data were considered comparable to the 2011 water quality data and were included in the 2011 evaluation of effects for Doris Lake South. A summary of available data and the rationale for the exclusion of some historical data is provided in Appendix B.

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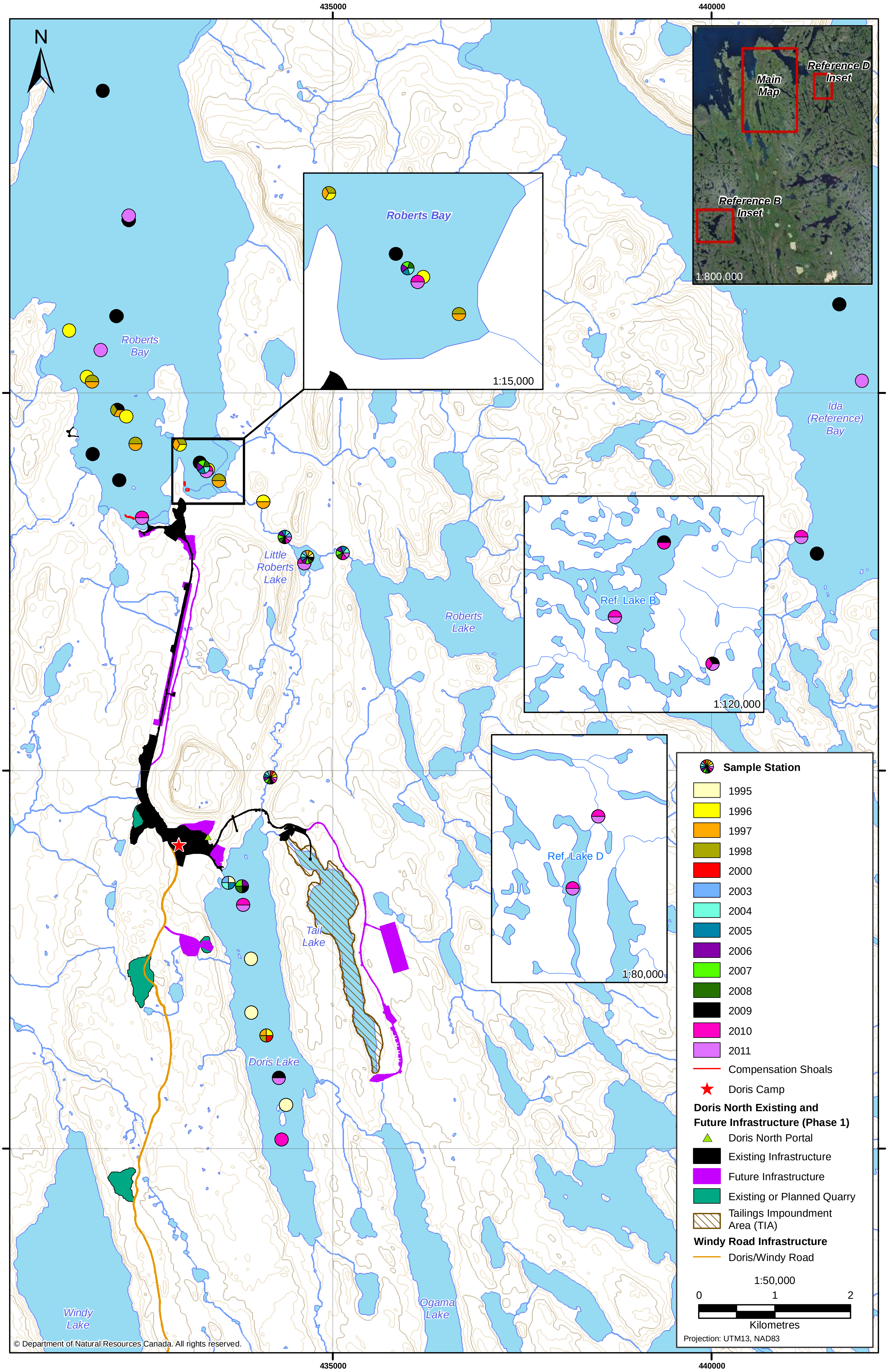

Figure 2.3-1

NEWMONT NORTH AMERICA

Historical Water Quality Sampling Stations in AEMP Waterbodies, Doris North Project, 1995-2011

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Effects Analysis

All 18 evaluated water quality parameters presented in Table 2.3-1 were screened against relevant CCME guidelines for the protection of freshwater and marine aquatic life (CCME 2011b). For each parameter, a graph showing annual mean parameter concentrations for all available years is presented alongside a graph comparing before-after trends at the exposure sites to before-after trends at the reference sites. This graphical analysis was used to identify trends and to supplement the results of the statistical analyses. Relevant CCME guidelines are included on these graphs, as well as in Appendix A.

For each waterbody, a before-after comparison between the baseline mean and the 2011 mean was conducted for each of the 18 evaluated parameters (provided that baseline data were available). A mixed model ANOVA using the Proc Mixed procedure in SAS 9.2 was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and *season* (early vs. late), and a random effect of *year* to account for variability in water quality data. For the *period* effect, data were grouped into one of two periods: *before* the start of construction (1995 to 2009) or *after* the start of construction (2011). For the *season* effect, samples were grouped into one of two seasons depending on the timing of sampling: *early* (i.e., June or earlier, which included all freshet or under-ice sampling) or *late* (i.e., July or later, which included all open-water season sampling). To reduce the number of false positives (Type I error) due to the large number of statistical tests that were conducted, a reduced significance level (0.01) was used when reviewing the results. If the results of the before-after analysis indicated that a 2011 parameter mean was not significantly different from the baseline mean, no further statistical analysis results are discussed, and it was concluded that there was no effect of 2011 construction activities on this parameter.

If the before-after comparison revealed that a 2011 parameter mean was different from the baseline mean, the next step of the analysis was to conduct a BACI analysis to determine if the observed difference in the before-after parameter mean was also seen at the reference site (which would indicate that the difference is due to a natural process). A BACI analysis could only be performed if both baseline and 2011 data were available for both the exposure site and the reference site. The BACI analysis introduces a *class* effect to the mixed model ANOVA, which is the classification of the waterbody as an exposure or a reference site. The interaction between the *period* and *class* effects reveals whether any change in the mean of the water quality parameter that occurred at the exposure site also occurred at the reference site. To reduce the number of false positives (Type I error) due to the large number of statistical tests that were conducted, a reduced significance level (0.01) was used when reviewing the results. If a change in the mean was detected by the before-after analysis, but the BACI analysis revealed that a parallel change occurred at the reference site, it is reasonable to assume that this change was likely a natural phenomenon and was unrelated to the 2011 construction activities. Note that BACI results are only discussed in the text if a difference is detected by the before-after analysis, but all BACI results are included in Appendix B.

For lake and marine water quality parameters, the before-after trend for each exposure site was compared against the trend at the corresponding reference site for the BACI analysis. For stream water quality parameters, the before-after trend for each exposure site was compared against the trend obtained using data from both reference streams (Reference B Outflow and Reference D Outflow) for the BACI analysis. Although no baseline data was available for Reference D Outflow, data collected from this site in 2011 contributed some information on the year-effect, which improved the precision of the BACI estimate.

All sample replicates collected on the same date and from the same depth in the water quality dataset were treated as pseudo-replicates and were averaged prior to graphical and statistical analysis. In some large lake sites, the dataset included samples that were collected from multiple depths within the water column. Because there was little evidence of vertical chemical stratification, the data were pooled for the calculation of the parameter mean regardless of sampling depth. For all effects analyses, statistical results were considered unreliable if > 70% of the values in the dataset for a parameter were below analytical detection limits (i.e., censored data). These statistical results are not presented in this report (though statistical results for these data do appear in the raw outputs provided in Appendix B).

Half the detection limit was substituted for censored data that were included in the analyses. In general, similar results were obtained regardless of whether half the detection limit or the full detection limit was substituted for these censored values. Values determined to be outliers were excluded from the statistical analyses. In most cases, outliers were baseline values that were below very high detection limits. These and other anomalous historical values were removed to reduce artificial inflation of the variance, which would lead to reduced power to detect effects. The only 2011 data treated as outliers were censored values that were below relatively high detection limits (i.e., a single nitrate concentration of < 2.5 mg/L measured in July 2011 at REF-Marine 1).

A complete description of the statistical analyses used to assess the construction effects on water quality, including lists of outliers and detailed methodology and results, is presented in Appendix B.

2.3.2.4 Sediment Quality

Data Selection

Baseline sediment quality sampling has been conducted five times in the AEMP freshwater and marine habitats since 1996 (Figure 2.3-2). The most important criterion in the historical sediment quality data selection process was that pre-2010 samples had to be collected from the same depth strata as the 2011 samples, since higher metal concentrations are often associated with higher proportions of fine sediments (silts and clays; e.g., Lakhan, Cabana, and LaValle 2003), and this in turn is affected by the depth of sampling (i.e., deeper samples tend to contain higher proportions of fine sediments). Because the Doris Lake South sampling location was moved from a shallow site in 2010 (< 5 m deep) to a deep site in 2011 (> 10 m deep) for improved comparability with the Doris Lake North site (which is also a deep site), only baseline data collected from the deep depth strata were included in the comparison to 2011 Doris Lake South data.

The selection of historical data was also based on the proximity of baseline sampling sites to the 2011 sites and the similarity of sampling techniques. A summary of available data and the rationale for the exclusion of some historical data is provided in Appendix B.

Effects Analysis

The nine sediment quality parameters presented in Table 2.3-1 were evaluated using graphical analysis, before-after comparisons, and BACI analysis. All evaluated sediment quality parameters were screened against relevant CCME guidelines for the protection of freshwater and marine aquatic life (CCME 2011a). Relevant CCME guidelines are included on effects analysis graphs, as well as in Appendix A.

Before-after comparisons were used to determine if mean 2011 concentrations of sediment quality parameters differed from baseline means. A mixed model ANOVA using the Proc Mixed procedure in SAS 9.2 was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and a random effect of *year* to account for variability in water quality data. For the *period* effect, data were grouped into one of two periods: *before* the start of construction (1996 to 2009) or *after* the start of construction (2011). The potential for false positives (Type I errors) due to the large number of tested parameters was reduced by lowering the level of significance to 0.01. Each waterbody was treated independently and each parameter was treated separately. If the results of the before-after analysis indicated that a 2011 parameter mean was not significantly different from the baseline mean, no further statistical analysis results are discussed, and it was concluded that there was no effect of 2011 construction activities on this parameter.

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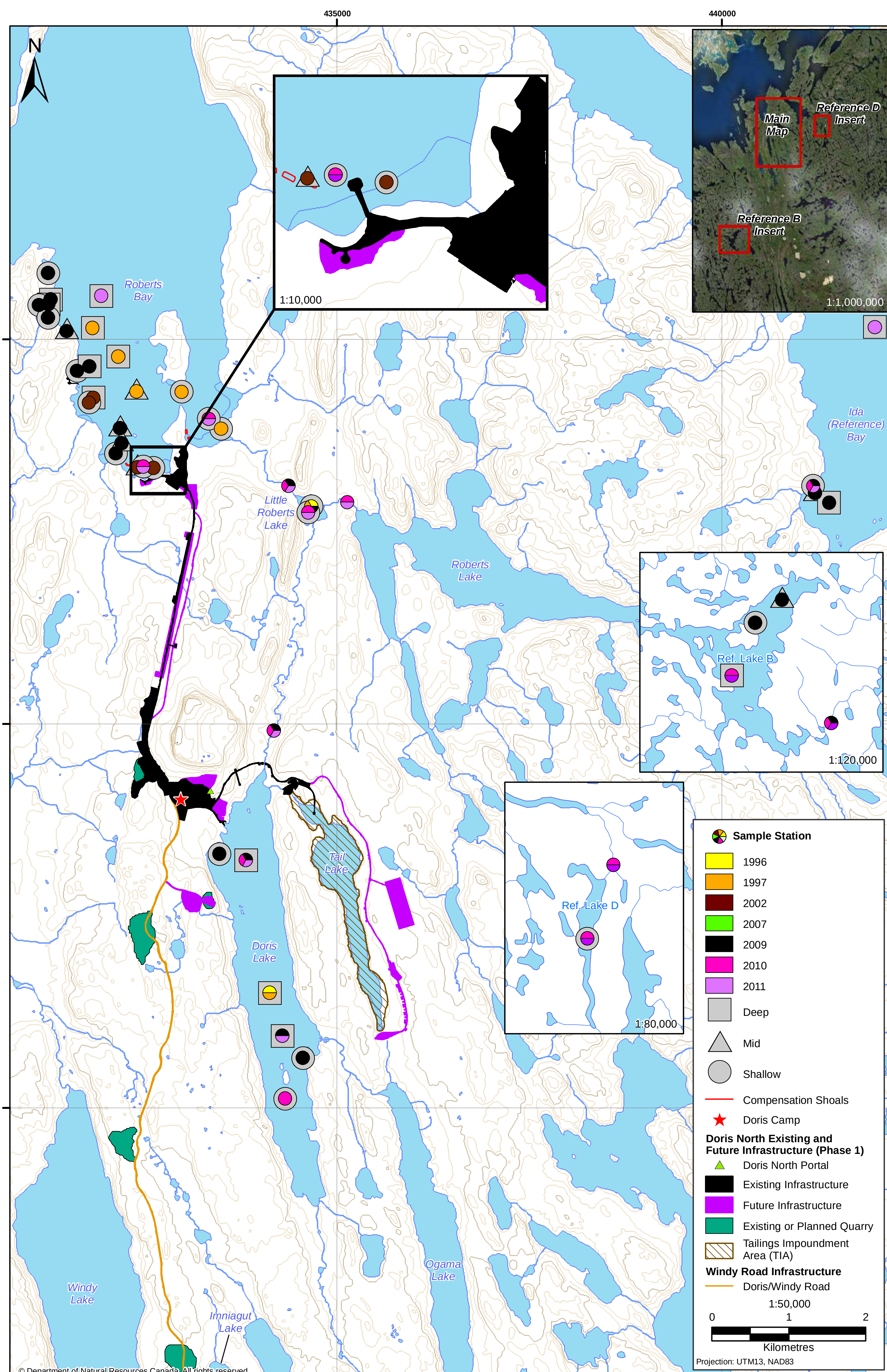

Figure 2.3-2

NEWMONT NORTH AMERICA

Historical Sediment Quality Sampling Stations in AEMP Waterbodies, Doris North Project, 1996-2011

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If before-after comparisons determined that there was evidence of a statistically significant difference in means, a BACI analysis was performed to determine if changes in exposure sites also occurred at reference sites. To test this, a mixed model ANOVA was run using the Proc Mixed procedure in SAS 9.2, where *period* was the effect of before or after construction, *class* was the effect of a Project or reference waterbody, and the interaction of *period* and *class* revealed whether any change in the mean of the sediment quality parameter that occurred in an exposure site also occurred in the reference site. For lakes sites, there was no appropriate baseline sediment data available for the reference lakes; therefore, BACI comparisons of lake sediment quality parameters were not possible, and only before-after comparisons were undertaken.

The key effect of interest in this BACI design is the interaction effect. If exposure site parameters increase or decrease over time relative to reference sites (i.e., a significant interaction effect), this may suggest that the Project is having an effect on the surrounding sediments (i.e., a non-parallel effect). However, the change over time at exposure sites could also be due to natural episodic events (e.g., higher than average stream flow) or slight differences in sampling locations (leading to differences in grain size composition). Thus, professional judgment was used to determine if a statistically significant interaction effect was likely attributable to Project activities. For the marine environment, the baseline data used for before-after comparisons of exposure and reference sites were from different years (2002 data were used for the exposure site, RBW, and 2009 data were used for the reference site, REF-Marine 1). Therefore, caution must be exercised when interpreting BACI comparisons between these sites.

For marine sediment quality parameters, the before-after trend for each exposure site was compared against the trend at the corresponding reference site (REF-Marine 1) for the BACI analysis. For stream sediment quality parameters, the before-after trend for each exposure site was compared against the trend obtained using data from both reference streams (Reference B Outflow and Reference D Outflow) for the BACI analysis. Although no baseline data was available for Reference D Outflow, data collected from this site in 2011 contributed some information on the year-effect, which improved the precision of the BACI estimate.

Like water quality, highly censored parameters (i.e., > 70% of data below detection limit) were considered unreliable and were not subjected to effects analysis. Censored data that were included in the analyses were substituted with one half the detection limit concentration. A complete description of the statistical effects analysis of sediment quality, including all methodology and results, is presented in Appendix B.

2.3.2.5 Primary Producers

Data Selection

Historical primary producer biomass (phytoplankton and periphyton) sampling has been conducted in the Doris North Project area since 1996 (Figure 2.3-3). The main criteria for the selection of historical periphyton and phytoplankton biomass data for inclusion in the evaluation of effects were the proximity of baseline sampling sites to 2011 AEMP sampling sites, and the comparability of sampling methodologies (e.g., phytoplankton biomass samples collected throughout the euphotic zone using an integrated sampler were excluded from the evaluation of effects as these were not comparable to the discrete surface samples collected in 2011). For Doris Lake South, historical phytoplankton biomass data collected in 1997 and 2000 were excluded from the evaluation of effects presented in the 2010 AEMP because the 1997 and 2000 sampling site was more than 1 km away to the north of the 2010 Doris Lake South sampling site (Figure 2.3-3). However, the Doris Lake South sampling site was moved slightly further to the north in 2011, and approximately 500 m away from the 1997 and 2000 sampling site. Therefore, these historical data were considered comparable to the 2011 phytoplankton biomass and were included in the 2011 evaluation of effects for Doris Lake South. A summary of available data and the rationale for the exclusion of some historical data is provided in Appendix B.

Effects Analysis

Graphs showing annual mean phytoplankton or periphyton biomass and comparing before-after trends at the exposure sites to before-after trends at the reference sites were used to identify trends and to supplement the results of the statistical analyses.

For each waterbody, a before-after comparison between the baseline biomass mean and the 2011 biomass mean was conducted (provided that baseline data were available). A mixed model ANOVA using the Proc Mixed procedure in SAS 9.2 was used for this before-after comparison. This model included fixed effects of *period* (before vs. after) and *season*, and random effect of *year* to account for variability in water quality data. For the *period* effect, data were grouped into one of two periods: *before* the start of construction (1996 to 2009) or *after* the start of construction (2011). For the *season* effect, samples were grouped into one of four seasons depending on the date of sample collection: 1) April or May (under ice), 2) July, 3) August, 4) September to account for within-year variability in biomass levels. To reduce the number of false positives (Type I error) due to the large number of statistical tests that were conducted, a reduced significance level (0.01) was used when reviewing the results. If the results of the before-after analysis indicated that the 2011 mean periphyton or phytoplankton biomass was not significantly different from the baseline mean, no further statistical analysis results were discussed, and it was concluded that there was no effect of construction activities on periphyton or phytoplankton biomass.

If the before-after comparison revealed that the 2011 biomass mean was different from the baseline mean, the next step of the analysis was to conduct a BACI analysis to determine if the observed change in the before-after mean was also seen at the reference site. A BACI analysis could only be performed if both baseline and 2011 data were available for both the exposure site and the reference site. The BACI analysis introduces a *class* effect to the mixed model ANOVA, which is the classification of the waterbody as an exposure or a reference site. The interaction between the *period* and *class* effects reveals whether any change in the mean biomass that occurred at the exposure site was paralleled at the reference site. To reduce the number of false positives (Type I error) due to the large number of statistical tests that were conducted, a reduced significance level (0.01) was used when reviewing the results. Note that BACI results are only discussed in the text if a difference is detected by the before-after analysis, but all BACI results are included in Appendix B.

For lake and marine phytoplankton biomass, the before-after trend for each exposure site was compared against the trend at the corresponding reference site for the BACI analysis. For stream periphyton biomass, the before-after trend for each exposure site was compared against the trend obtained using data from both reference streams (Reference B Outflow and Reference D Outflow) for the BACI analysis. Although no baseline data was available for Reference D Outflow, data collected from this site in 2011 contributed some information on the year-effect, which improved the precision of the BACI estimate.

All phytoplankton and periphyton biomass replicates collected on the same date were treated as pseudo-replicates and were averaged prior to graphical and statistical analysis. A complete description of the statistical analyses used to assess the construction effects on primary producer biomass, including methodology, results, and a list of outliers (only one outlier was identified: a periphyton chlorophyll *a* sample collected at Doris Outflow in 1997) is presented in Appendix B.

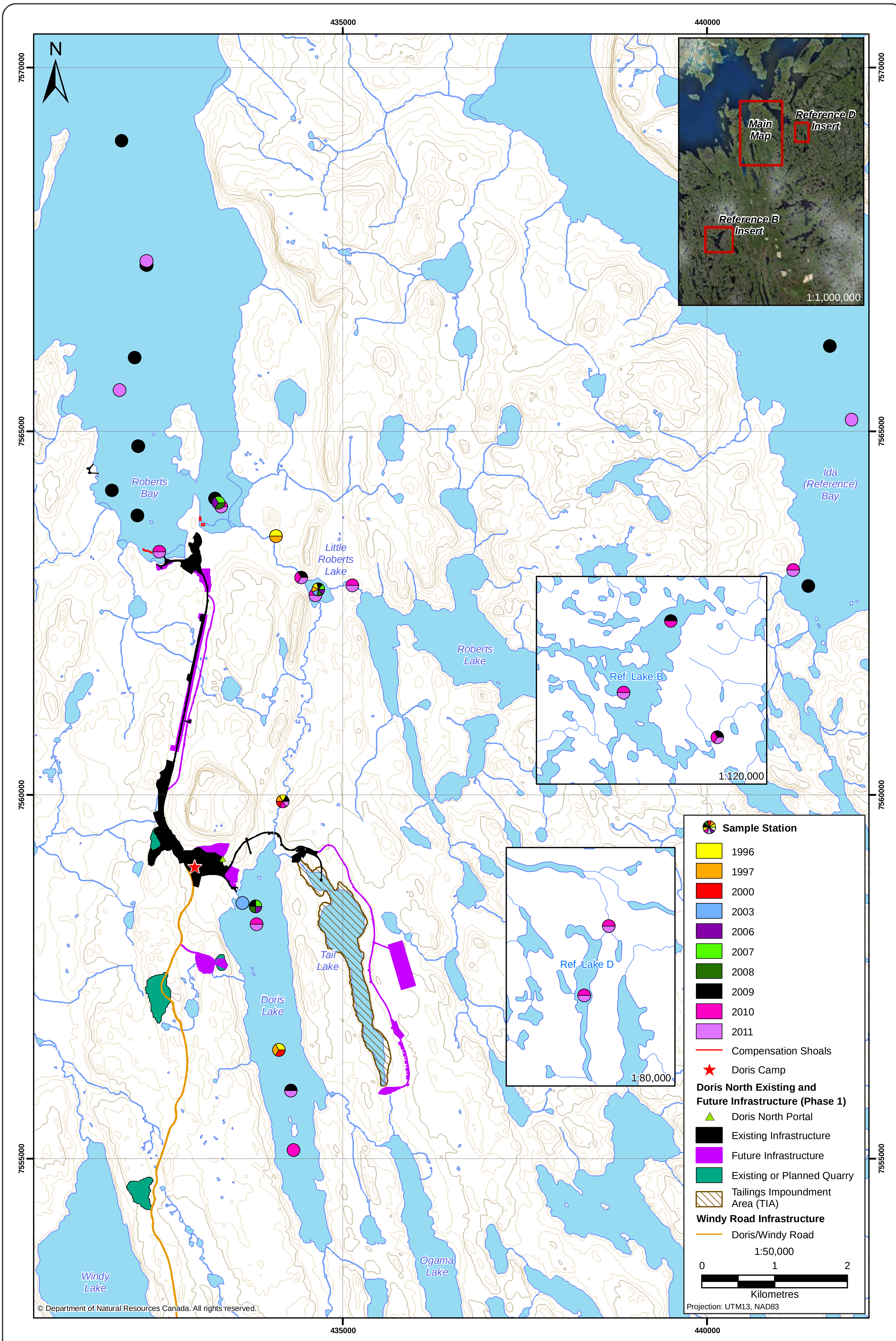

Figure 2.3-3

NEWMONT NORTH AMERICA

Historical Phytoplankton and Periphyton Sampling Stations in AEMP Waterbodies, Doris North Project, 1996-2011

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2.3.2.6 Benthos

Data Selection

Benthos data have been collected since 1996 in the Doris North Project area (Figure 2.3-4). Prior to 2010, historical benthos sampling consisted of collecting one to five replicates per site with no composite sampling. In 2010 and 2011, this technique was changed to accommodate the EEM methodologies as required under the Type A Water Licence for the Doris North Project. The 2010 and 2011 sampling procedure required the pooling of three subsamples per replicate, and the collection of five replicates per site. Because the pooling of subsamples for each replicate affects sample variability, as well as various diversity components (e.g., richness and evenness), baseline benthos community descriptors were not considered comparable to 2010 and 2011 data.

Effects Analysis

Because of methodological differences, no baseline benthos data are available for comparison against 2011 data; therefore, neither before-after nor BACI analyses were possible for benthos data. The absence of appropriate baseline data for benthos complicates the determination of potential effects of the Project on benthos community descriptors. Comparing reference site data to exposure site data is not an ideal approach because of the potential natural differences between sites that are unrelated to Project activities. A preferred approach recommended by Wiens and Parker (1995) is an impact level-by-time analysis, where the benthos trends at exposure sites are compared to the trends at reference sites to determine if there is evidence of non-parallelism over time (in this case, from 2010 to 2011). Because of the limited data available, evidence of non-parallelism between 2010 and 2011 may simply indicate patchiness in the environment or natural yearly variation and does not necessarily imply a Project-related effect. As more years of data become available, trends (if present) should become more apparent.

The impact level-by-time model included a *year* effect, a *class* effect (i.e., the classification of the waterbody as an exposure or a reference site), and a *year*class* interaction term, which is the effect of interest representing non-parallelism over time between the two classes of sites. This model was fit using Proc Mixed in SAS 9.2. As with the other analyses, a reduced significance level (0.01) was used when reviewing the results to reduce the number of false positives (Type I error) due to the large number of statistical tests that were conducted. The complete methodology and results of the level-by-time analysis are provided in Appendix B.

For lake and marine benthos data, the 2010 to 2011 trend for each exposure site was compared against the trend at the corresponding reference site for the impact level-by-time analysis. For stream benthos data, the 2010 to 2011 trend for each exposure site was compared against the 2010 to 2011 trend obtained using data from both reference streams (Reference B Outflow and Reference D Outflow) for the impact level-by-time analysis.

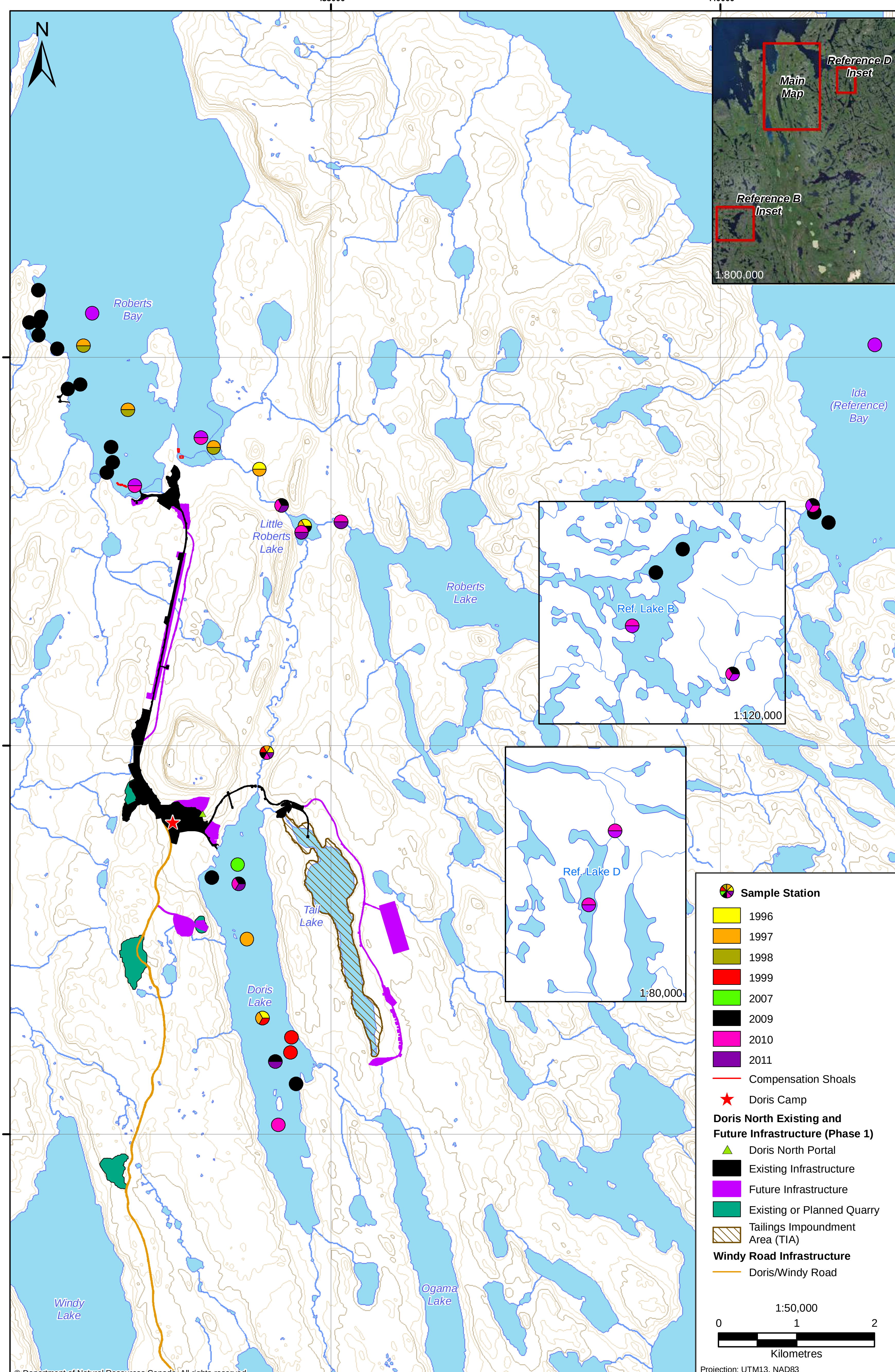

Figure 2.3-4

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Historical Benthic Invertebrate Sampling Stations in AEMP Waterbodies, 1996-2011

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Figure 2.3-4

3. Evaluation of Effects

3. Evaluation of Effects

3.1 UNDER-ICE DISSOLVED OXYGEN

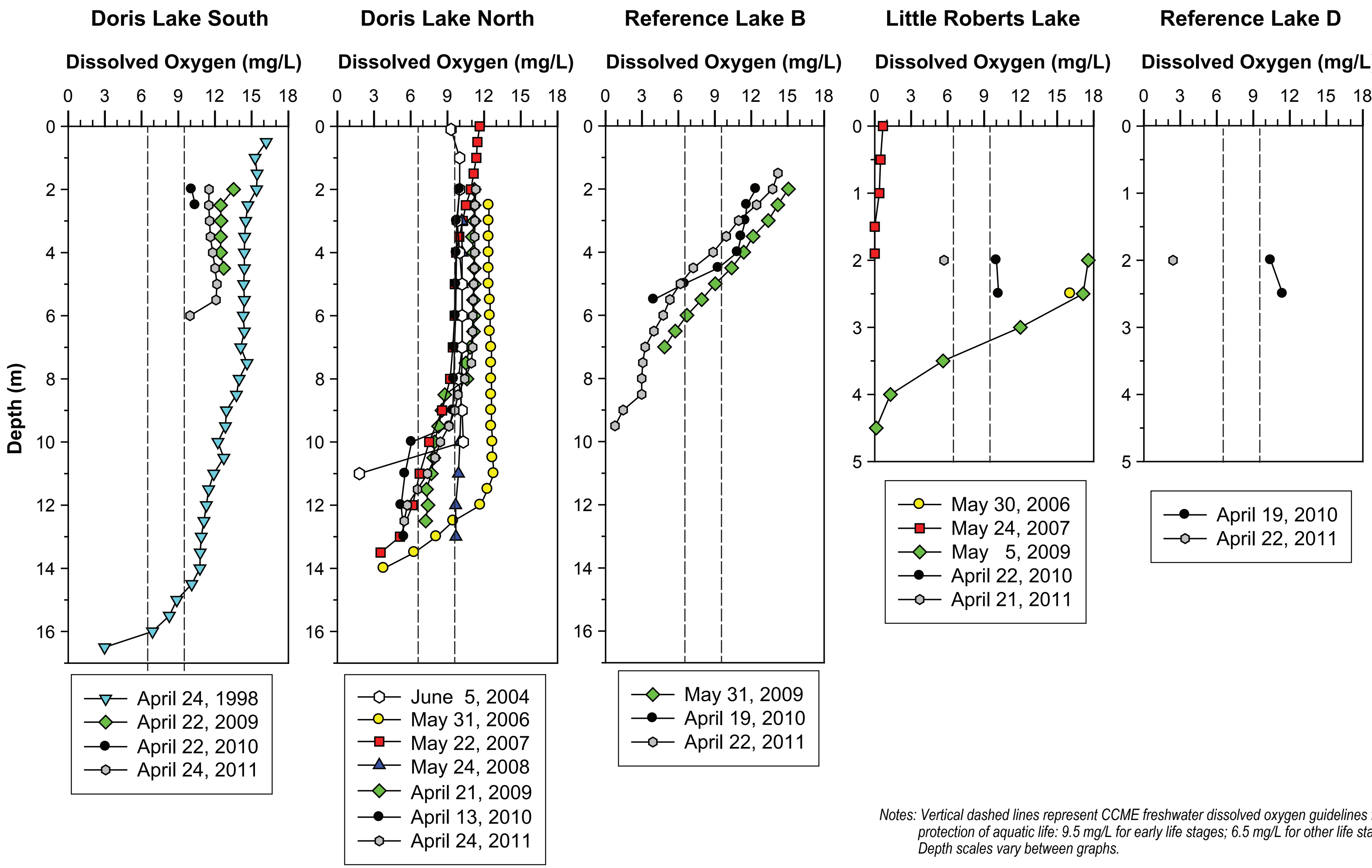
Potential effects on lake and ocean dissolved oxygen concentrations were evaluated using under-ice dissolved oxygen concentrations, since concentrations are lowest during this period and pose the greatest concern for aquatic life. Minimum oxygen levels are required for critical life stages of fish and other freshwater and marine organisms (CCME 2011b). Ice cover usually forms in October and November in the Doris North region, and under-ice oxygen profiles were collected in April 2011. The formation of the ice cover in November 2010 isolated lakes, streams, and Roberts Bay from any atmospheric inputs such as dust that could have been generated by Project activities between November 2010 and June/July 2011. Therefore, the water column that was profiled in April 2011 reflects activities from 2010 rather than 2011.

Figures 3.1-1 and 3.1-2 present the 2011 and historical under-ice dissolved oxygen profiles for the lake and marine AEMP sites. 2011 under-ice profiles were collected in late April, and historical under-ice profiles were collected between late April and early June.

3.1.1 Lakes

There was limited baseline winter dissolved oxygen data available for most lake sites, with the exception of Doris Lake North. At this site, winter dissolved oxygen profiles were largely consistent from 2004 to 2011, with uniform concentrations in the upper waters and decreasing concentrations below 10 m (Figure 3.1-1). Decreasing concentrations were also observed in the deeper waters of Reference Lake B. This dissolved oxygen decrease at depth is a common phenomenon in seasonally stratified lakes. The upper layer dissolved oxygen concentrations in Doris Lake North were usually near or above the CCME guideline for cold-water, early life stages (9.5 mg/L), and approached or dropped below the guideline for cold-water, other life stages (6.5 mg/L) in the bottom waters. The 2011 profiles fell within historical ranges. Although there are only two years of pre-2010 baseline data available for Doris Lake South, no obvious changes were apparent at this site, and all 2011 concentrations were above the CCME guideline for cold-water, early life stages (9.5 mg/L; Figure 3.1 1). Winter dissolved oxygen concentrations would not be expected to decline unless there was nutrient input to the lake, and there were no known sources of nutrient input to Doris Lake in 2011. April 2011 dissolved oxygen concentrations were within the expected range of natural variability; hence, no adverse changes were detected.

Winter dissolved oxygen concentrations varied widely in the shallow exposure site, Little Roberts Lake, between 2006 and 2009 (range: < 1 mg/L in May 2007 to 17.6 mg/L in May 2009; Figure 3.1-1). The 2011 concentration (5.7 mg/L) was slightly below the CCME guideline for non-early life stages (6.5 mg/L), but fell within the wide range of baseline measurements; therefore, no adverse changes to 2011 winter dissolved oxygen concentrations were apparent in Little Roberts Lake. In the shallow reference lake, Reference Lake D, the under-ice dissolved oxygen concentration measured in April 2011 (2.4 mg/L) was also below the CCME guideline for non-early life stages (6.5 mg/L). Ice-covered shallow lakes are prone to large fluctuations in dissolved oxygen concentrations, particularly late in the ice-covered season, because of increases in epontic and benthic photosynthesis and the respiratory consumption of organic material in the sediments.



Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg/L for early life stages; 6.5 mg/L for other life stages. Depth scales vary between graphs.

Figure 3.1-1

Winter Dissolved Oxygen Concentrations in AEMP Lake Sites, Doris North Project, 1998-2011

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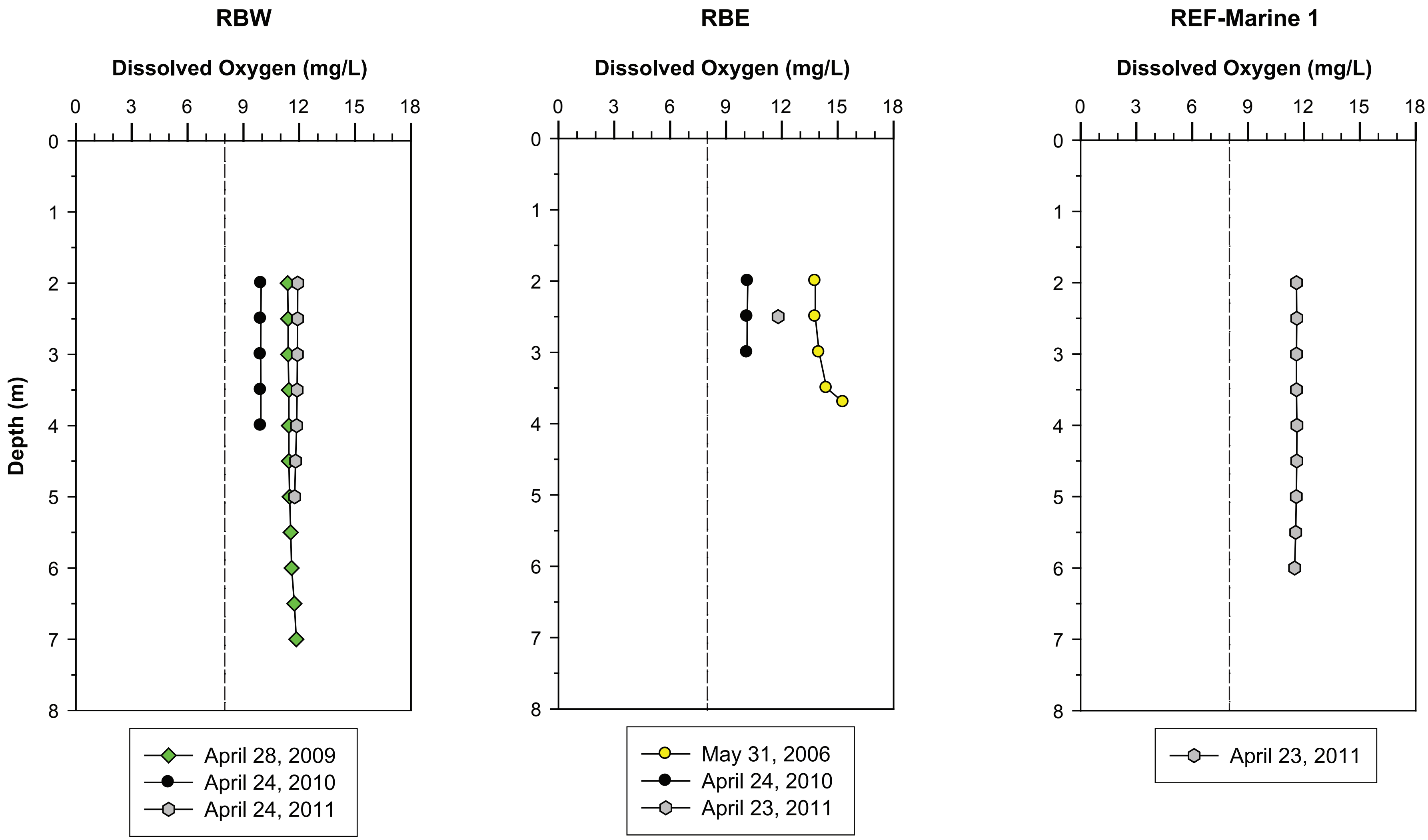

Note: Vertical dashed lines represent the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L).

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Winter Dissolved Oxygen Concentrations in AEMP Marine Sites, Doris North Project, 2006-2011

Figure 3.1-2

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3.1.2 Marine

In the marine sites, 2011 under-ice dissolved oxygen concentrations were similar at all marine exposure and references sites, approaching 12 mg/L (Figure 3.1-2). These concentrations were well above the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters for the protection of aquatic life (8.0 mg/L). Historical concentrations recorded in 2006 at RBE were slightly higher than 2011 concentrations, but concentrations recorded in 2009 at RBW were similar to 2011 levels. The 2006 profile at RBE was taken in late May, a month later than in 2011. The photoperiod is longer in May than in April, and under-ice photosynthesis is typically higher; therefore, the rate of oxygen evolution is likely higher in May than in April. There was no evidence of adverse effects on marine dissolved oxygen levels as a result of Project activities.

3.2 SECCHI DEPTH

Secchi depth, a measure of water transparency, was evaluated for lake sites to determine whether there was any evidence that 2011 Project activities negatively affected lake water clarity. The results of all statistical methods and analyses for the evaluation of effects for Secchi depth in lakes are provided in Appendix B.

The Secchi depth at the shallow marine sites RBE and RBW always reached the bottom in 2011, indicating that light was able to penetrate the entire water column. As water clarity at marine sites was high in 2011, Secchi depth was not evaluated for RBE and RBW.

3.2.1 Lakes

Figure 3.2-1 shows the average annual Secchi depth at lakes sites between 1995 and 2011. Average Secchi depth was similar among years and among exposure lakes, generally ranging between 1.1 and 2.1 m at Doris Lake North, Doris Lake South, and Little Roberts Lake. The Secchi depth recorded at Doris Lake South in August 2000 (4.2 m) was higher than other years. Secchi depths were generally higher at the reference lakes, ranging from 6.5 to 7.5 m at Reference Lake B, and from 2.1 to 2.6 m at Reference Lake D.

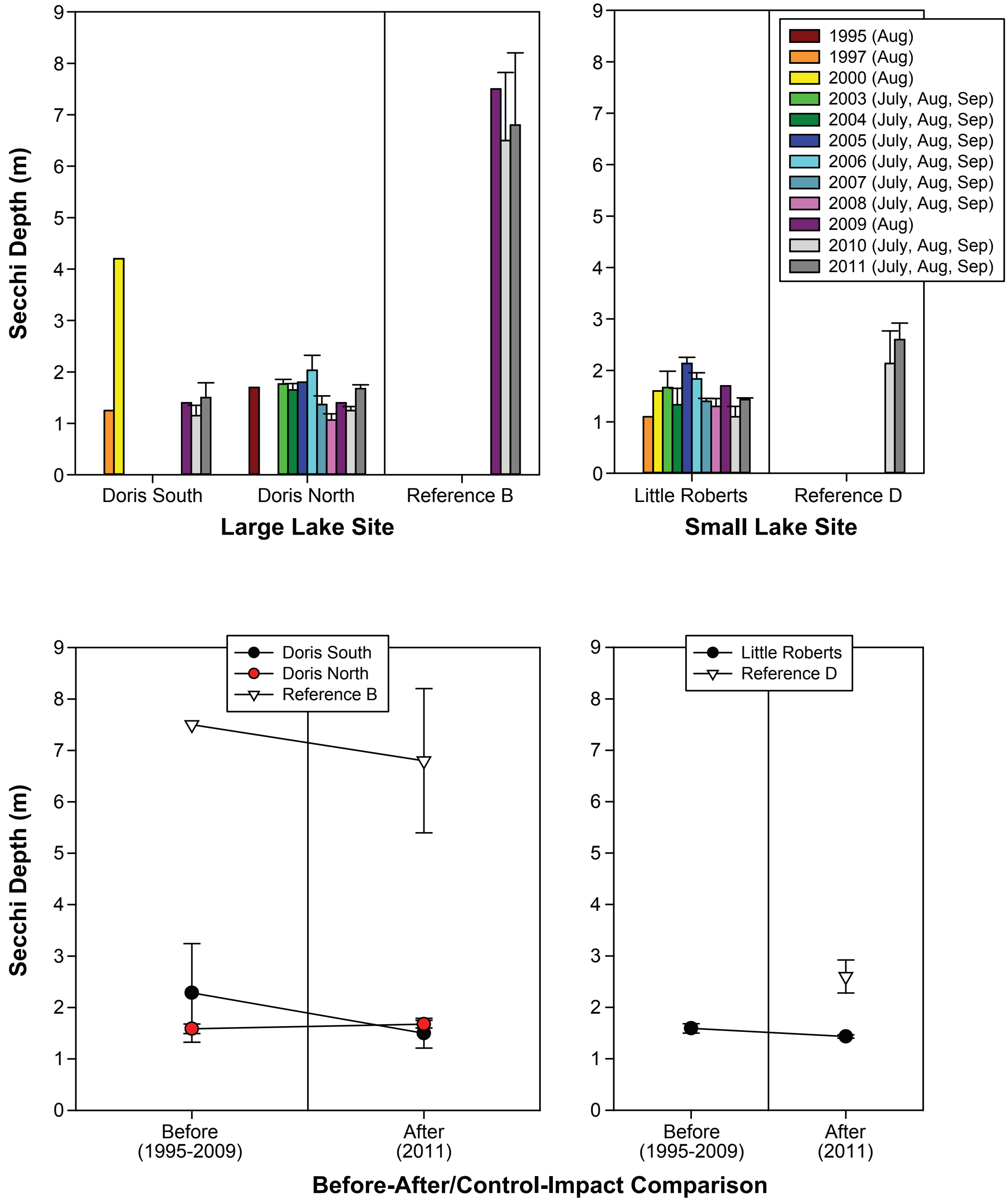
Mean 2011 Secchi depths in the exposure lakes were within range of baseline measurements. The before-after comparison confirmed that the baseline mean Secchi depth was not distinguishable from the 2011 mean Secchi depth in any exposure lake ($p = 0.90$ for Doris Lake South, $p = 0.99$ for Doris Lake North, and $p = 0.68$ for Little Roberts Lake). Therefore, there was no apparent effect of 2011 Project activities on lake Secchi depth.

3.3 WATER QUALITY

A specific set of water quality parameters (see Table 2.3-1) was evaluated to determine whether 2011 Project activities resulted in adverse changes to water quality. Historical data collected from 1995 to 2009 were included in the effects analysis.

Graphical analyses, before-after comparisons, and BACI analyses (where possible) were all used to determine if there were changes in water quality parameters in the Doris North Project area. For all graphical and statistical analyses, replicate samples collected on the same date and from the same depth were averaged prior to analysis. In addition, half the detection limit was substituted for water quality parameters that were below analytical detection limits. The complete results of all statistical methods and analyses are provided in Appendix B.

Water quality parameters were compared to CCME water quality guidelines for the protection of aquatic life (CCME 2011b) to determine whether concentrations posed a concern for freshwater and marine aquatic life. Site-specific baseline conditions were considered in addition to CCME guidelines to determine whether any detected changes would result in a potential adverse effect to freshwater and marine life.



Notes: Error bars represent the standard error of the mean.
The Secchi depth at Reference Lake D on September 25, 2010, reached the lake bottom, so the bottom depth of 3.4 m was used as an estimate of the Secchi depth.

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Secchi Depth in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.2-1

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3.3.1 Streams

Water quality samples from streams were collected from three exposure streams (Doris Outflow, Roberts Outflow, and Little Roberts Outflow) and two reference streams (Reference B Outflow and Reference D Outflow) in 2011. For the exposure streams, relevant baseline data are available from 1996, 1997, 2000, and 2003 to 2009 (though all streams were not sampled each year). For Reference B Outflow, the only available baseline data are from 2009, and no pre-2010 baseline data are available for Reference D Outflow. Graphs showing water quality trends in streams over time are shown in Figures 3.3-1 to 3.3-18. All statistical results are presented in Appendix B.

3.3.1.1 pH

pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER. Mean 2011 stream pH was slightly higher in exposure streams (ranging from 7.5 to 7.7) than reference streams (both 7.3). However, exposure stream pH levels measured in 2011 were within the range of baseline levels measured within each exposure stream (Figure 3.3-1). The before-after comparison confirmed that the baseline (1996-2009) mean pH was not distinguishable from the 2011 mean pH in any exposure stream ($p = 0.31$ for Doris Outflow, $p = 0.44$ for Roberts Outflow, and $p = 0.25$ for Little Roberts Outflow). Therefore, there was no effect of 2011 Project activities on the pH of exposure streams. 2011 pH levels in exposure and reference streams were always within the recommended CCME guideline range of 6.5 to 9.0 (Figure 3.3-1).

3.3.1.2 Total Alkalinity

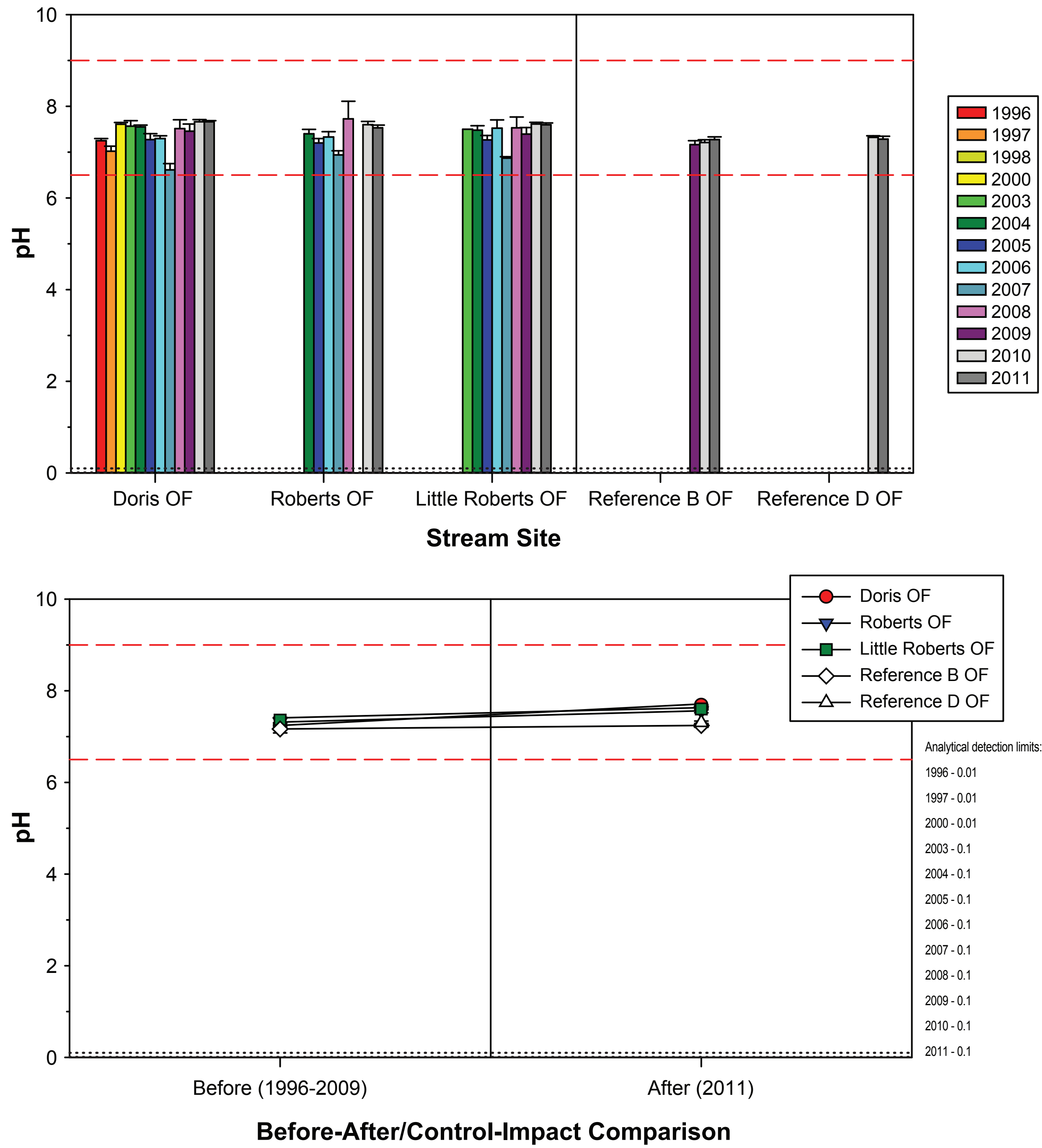
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. Total alkalinity (as $CaCO_3$) varied among streams, but was remarkably consistent within each stream over time (Figure 3.3-2). Total alkalinity levels in exposure streams in 2011 were within baseline ranges. The before-after comparison confirmed that the mean 1996-2009 alkalinity was not statistically different from the mean 2011 alkalinity in any exposure stream ($p = 0.19$ for Doris Outflow, $p = 0.67$ for Roberts Outflow, and $p = 0.99$ for Little Roberts Outflow); therefore, there was no effect of 2011 Project activities on exposure stream alkalinity.

3.3.1.3 Hardness

Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. Similar to total alkalinity, hardness (as $CaCO_3$) varied among streams, but was relatively consistent within each stream over time (Figure 3.3-3). 2011 hardness levels in exposure streams were within baseline ranges, and the before-after comparison confirmed that 2011 means were not distinguishable from 1996-2009 means ($p = 0.019$ for Doris Outflow, $p = 0.38$ for Roberts Outflow, and $p = 0.40$ for Little Roberts Outflow). There was no apparent effect of 2011 Project activities on stream hardness.

3.3.1.4 Total Suspended Solids

Total suspended solids (TSS) are regulated as deleterious substances in effluents as per Schedule 4 of the MMER. Mean TSS concentrations were variable among streams. Within each stream, there was also a large amount of inter-annual and within-year variability (Figure 3.3-4). It is therefore difficult to distinguish natural variability from potential effects resulting from Project activities.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit.
Red dashed lines represent the CCME freshwater guideline pH range (6.5–9.0).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER.

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pH in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-1

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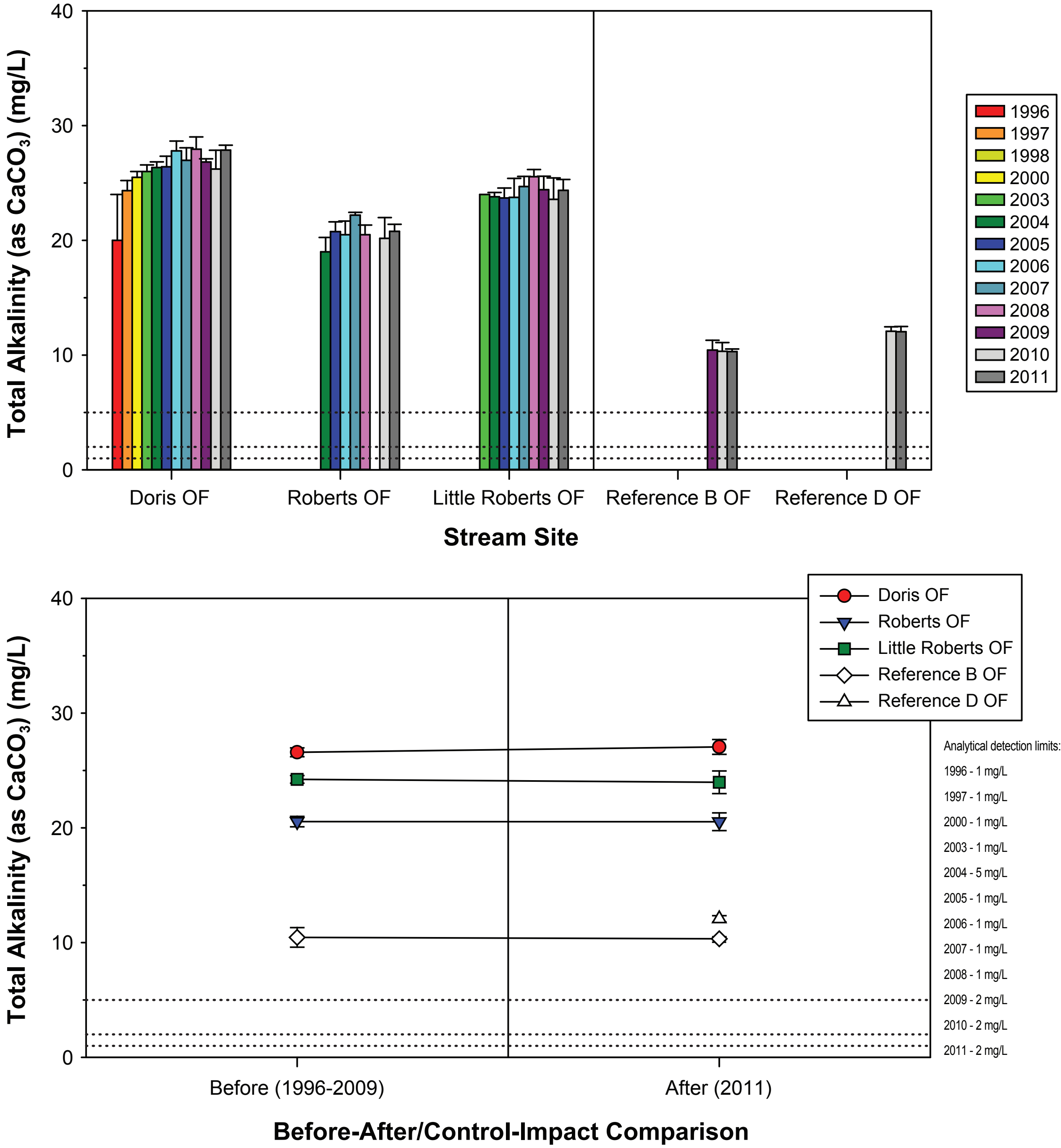

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

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Total Alkalinity in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-2

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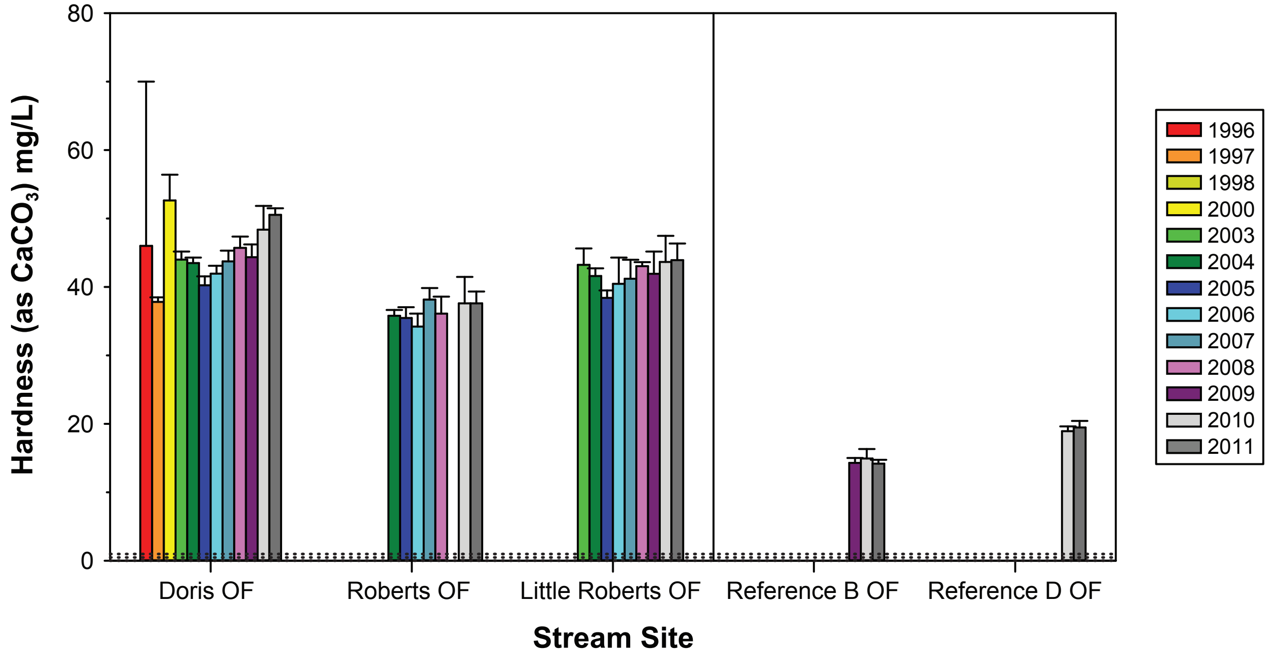

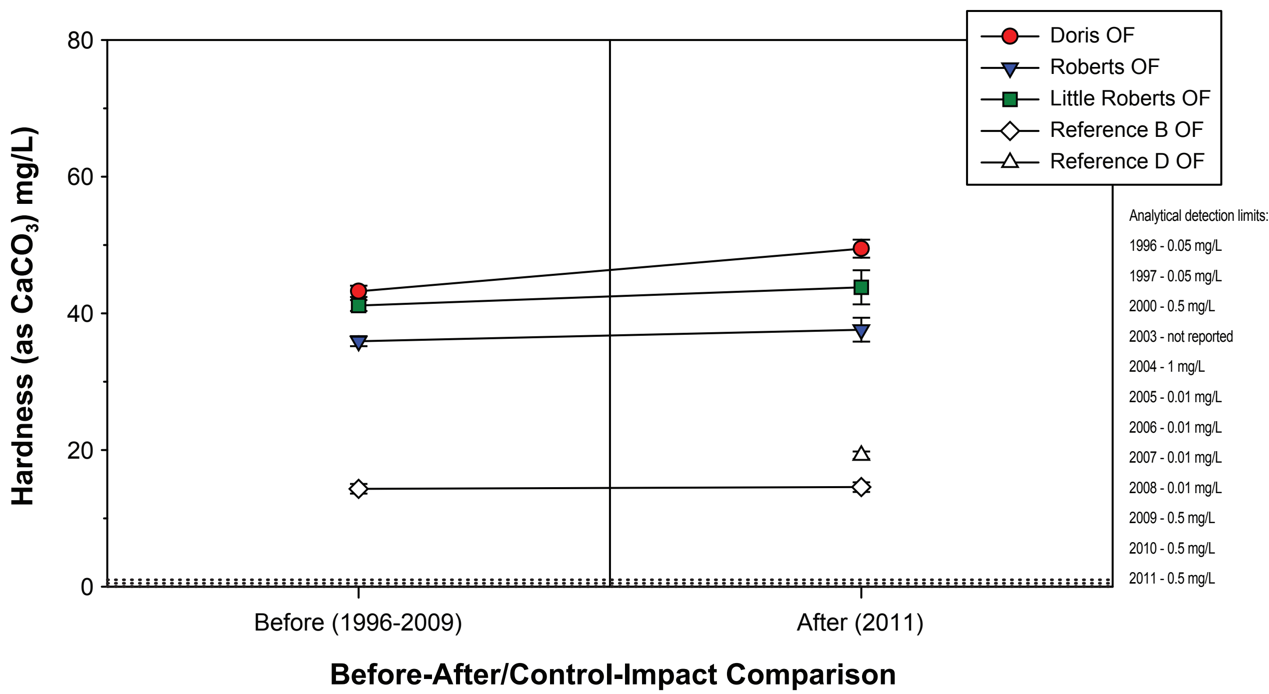

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

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Hardness in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-3

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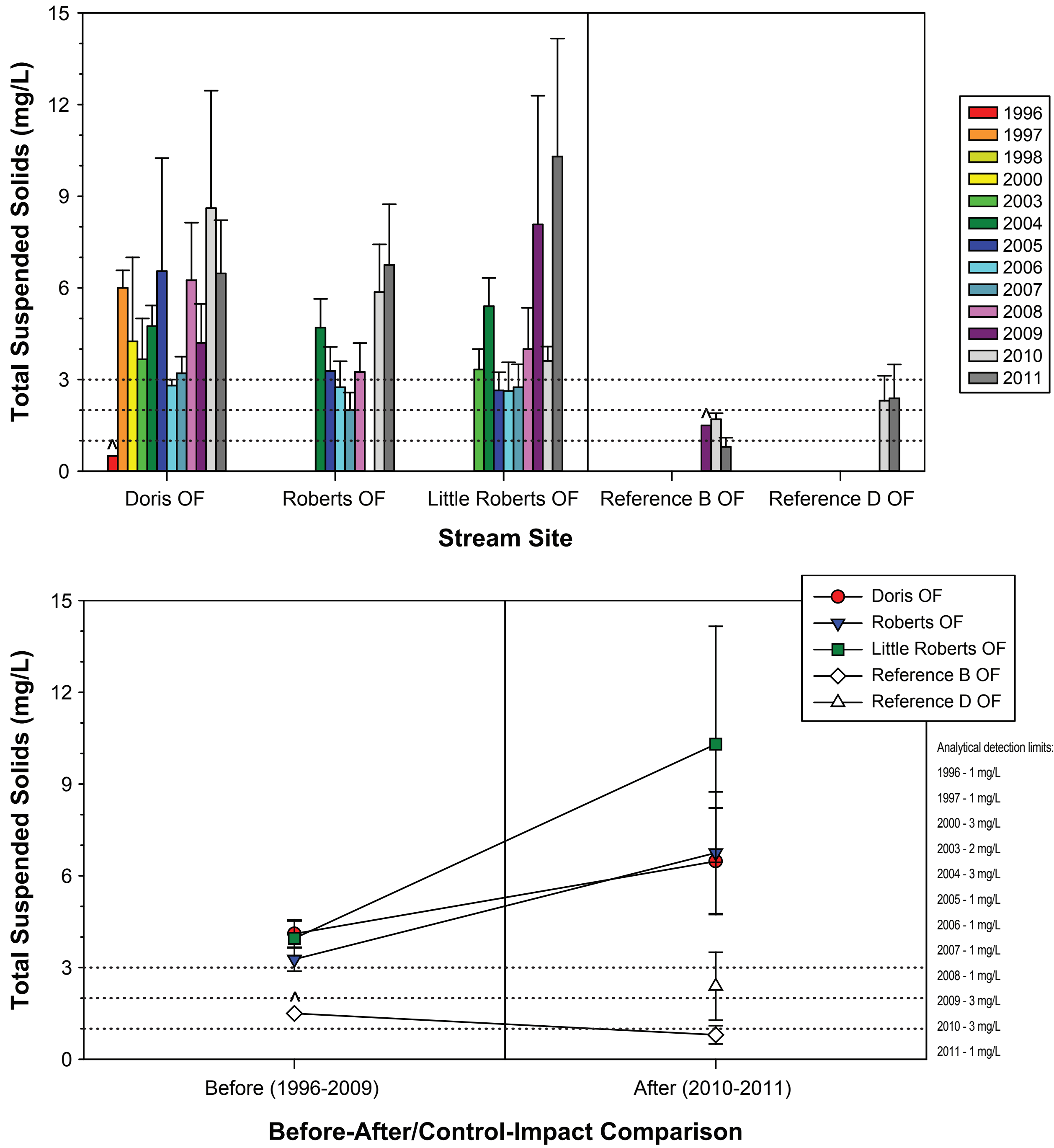

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline for total suspended solids is dependent upon background levels.
Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Total Suspended Solids Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-4

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The mean 2011 TSS concentration in Doris Outflow was within range of baseline means (Figure 3.3-4), and there was no evidence of a difference in means between the baseline and 2011 periods ($p = 0.29$). In Roberts Outflow, the mean TSS level in 2011 was slightly higher than means for all the baseline years, but this difference was not statistically significant ($p = 0.042$). In Little Roberts Outflow, there was evidence of a difference in means between baseline years and 2011 ($p = 0.007$); however, the BACI comparison showed that a parallel change occurred in the reference streams ($p = 0.093$). Therefore, there was no significant effect of 2011 Project activities on TSS concentrations in exposure streams.

The CCME guideline for TSS is dependent upon background levels (for clear-flow waters with background TSS levels below 25 mg/L, a maximum increase of 25 mg/L is allowable for any short-term exposure or 5 mg/L for longer term exposure; CCME 2011b). Because there was no significant increase in TSS concentrations from baseline levels in Doris Outflow and Roberts Outflow, 2011 TSS concentrations in these streams were below the CCME guideline. In Little Roberts Outflow, the highest concentration measured in 2011 (20 mg/L) was within 5 mg/L of the highest baseline concentration (17 mg/L in 2009); therefore, 2011 TSS concentrations in this stream were also below the CCME guideline.

3.3.1.5 Total Ammonia

Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Concentrations of total ammonia were variable within each stream over time. 2011 concentrations of total ammonia in exposure and reference streams were always well below the pH- and temperature-dependent CCME guideline (Figure 3.3-5).

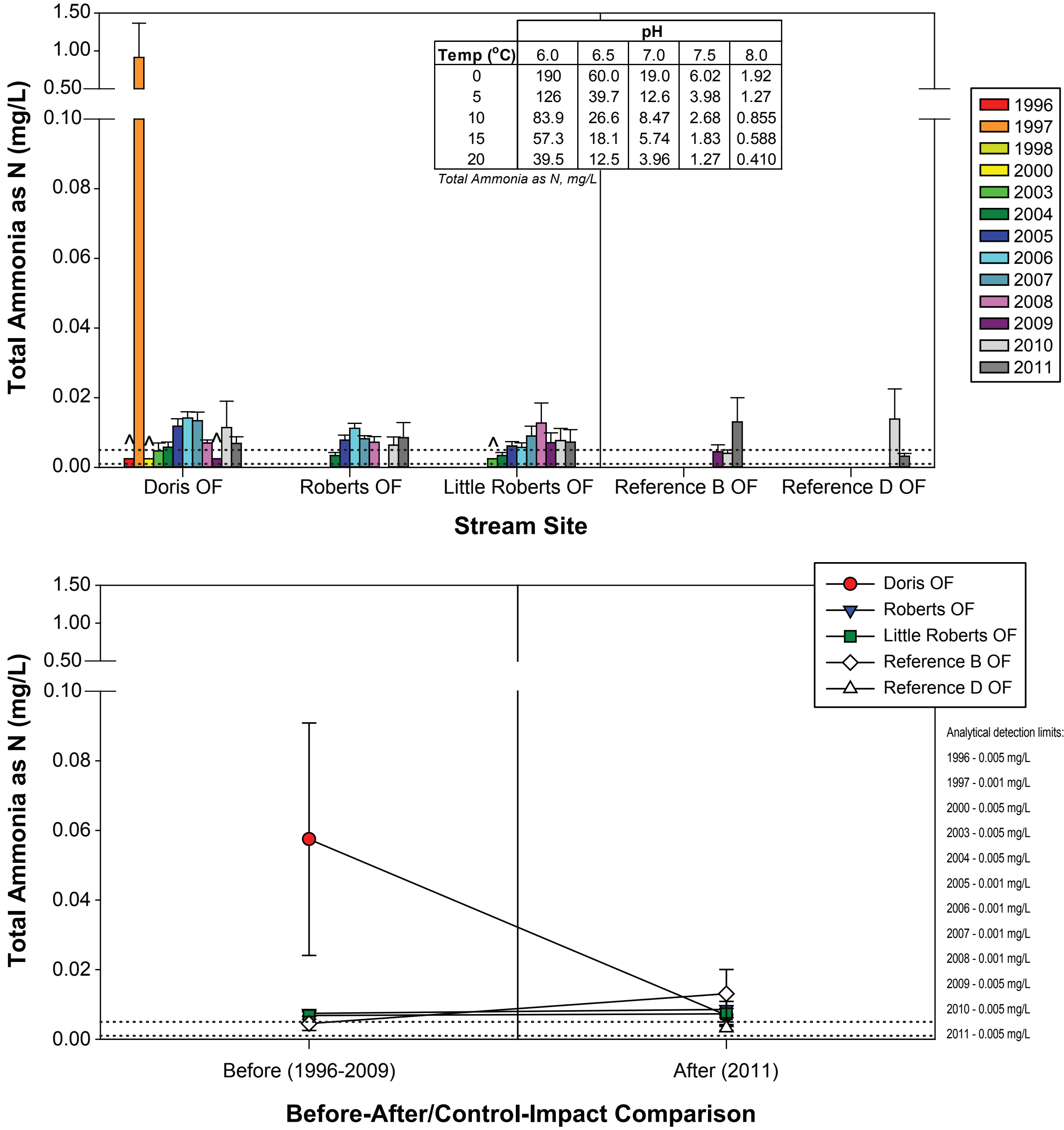
For each exposure stream, the mean 2011 total ammonia concentration was within the range of the 1996-2009 mean (Figure 3.3-5), suggesting that there was no effect of Project activities on ammonia concentrations. The before-after analysis confirmed that there was no difference between 2011 means and baseline means in any exposure stream ($p = 0.85$ for Doris Outflow, $p = 0.73$ for Roberts Outflow, and $p = 0.96$ for Little Roberts Outflow).

3.3.1.6 Nitrate

Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Nitrate concentrations measured in exposure streams during 2011 were usually below the analytical detection limit of 0.005 mg nitrate-N/L, and well below the interim CCME guideline of 2.935 mg nitrate-N/L (Figure 3.3-6). Pre-2010 measurements of nitrate were typically below detection limits, except for a few sporadically elevated readings (Figure 3.3-6). Therefore, there was no evidence of an increase in nitrate in exposure streams in 2011 (before-after analysis results are not presented because > 70% of nitrate concentrations in the datasets for each exposure stream were below detection limits). Results from 2011 indicate that on-site management of surface waters and quarry rock were successful in keeping ammonium nitrate salt and residues out of surface waters.

3.3.1.7 Total Cyanide

Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2011 cyanide concentrations in exposure streams (0.0035 mg/L in Doris Outflow, 0.0032 mg/L in Roberts Outflow, and 0.0038 in Little Roberts Outflow) were generally similar to concentrations in reference streams (0.0026 mg/L in Reference B Outflow and 0.0037 mg/L in Reference D Outflow). However, mean 2011 concentrations in all exposure and reference streams were higher than baseline annual means in exposure streams, which generally did not exceed 0.001 mg/L (with one exception: the total cyanide concentration was 0.005 mg/L in a single sample collected at Doris Outflow in 1996; Figure 3.3-7). The before-after analysis revealed that the mean 2011 total cyanide concentration was



Notes: *Error bars represent the standard error of the mean.*
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Inset table shows the pH- and temperature-dependent CCME freshwater guideline for total ammonia.
Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Ammonia Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-5

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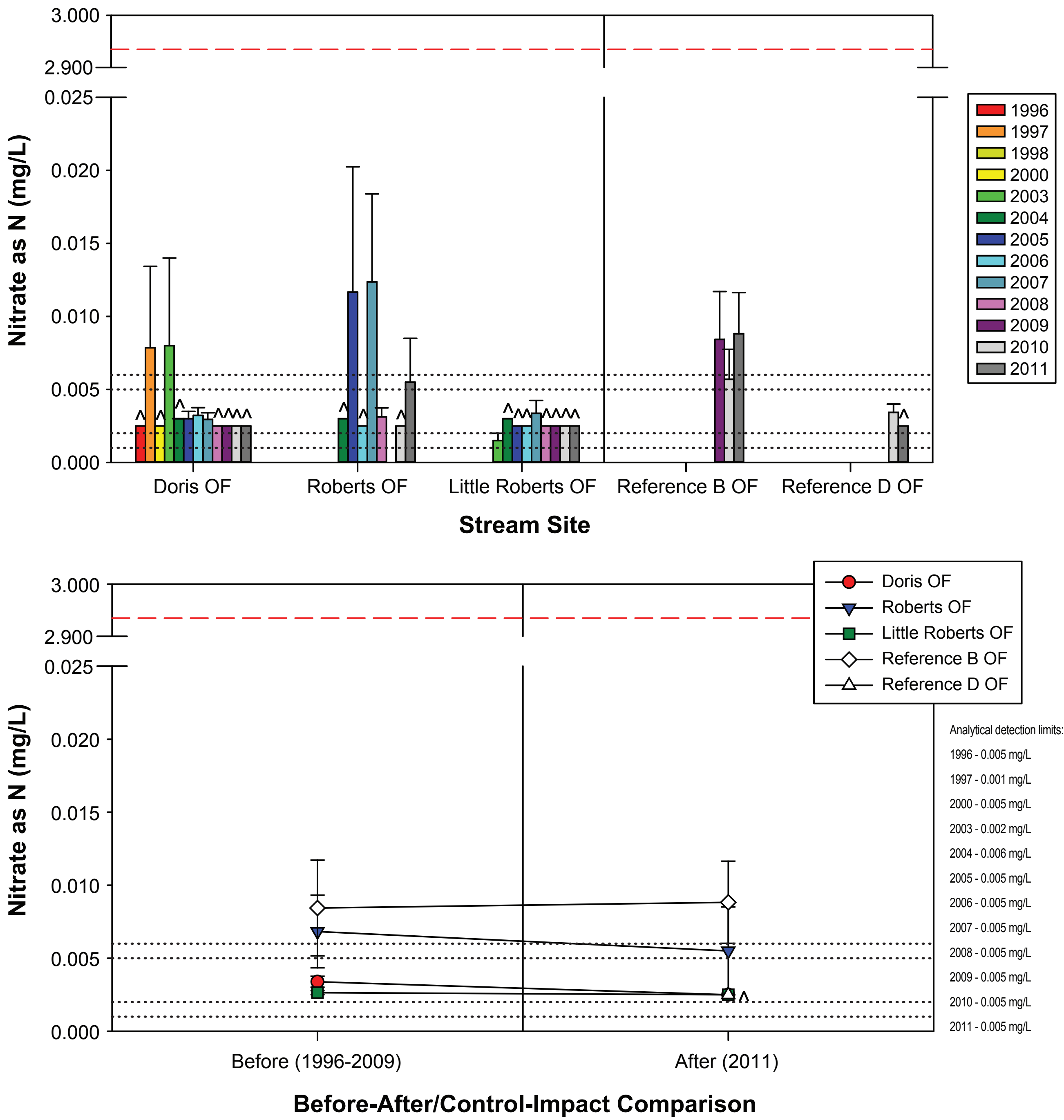

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed line represents the CCME freshwater guideline for nitrate as N (2.935 mg/L).
Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Nitrate Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-6

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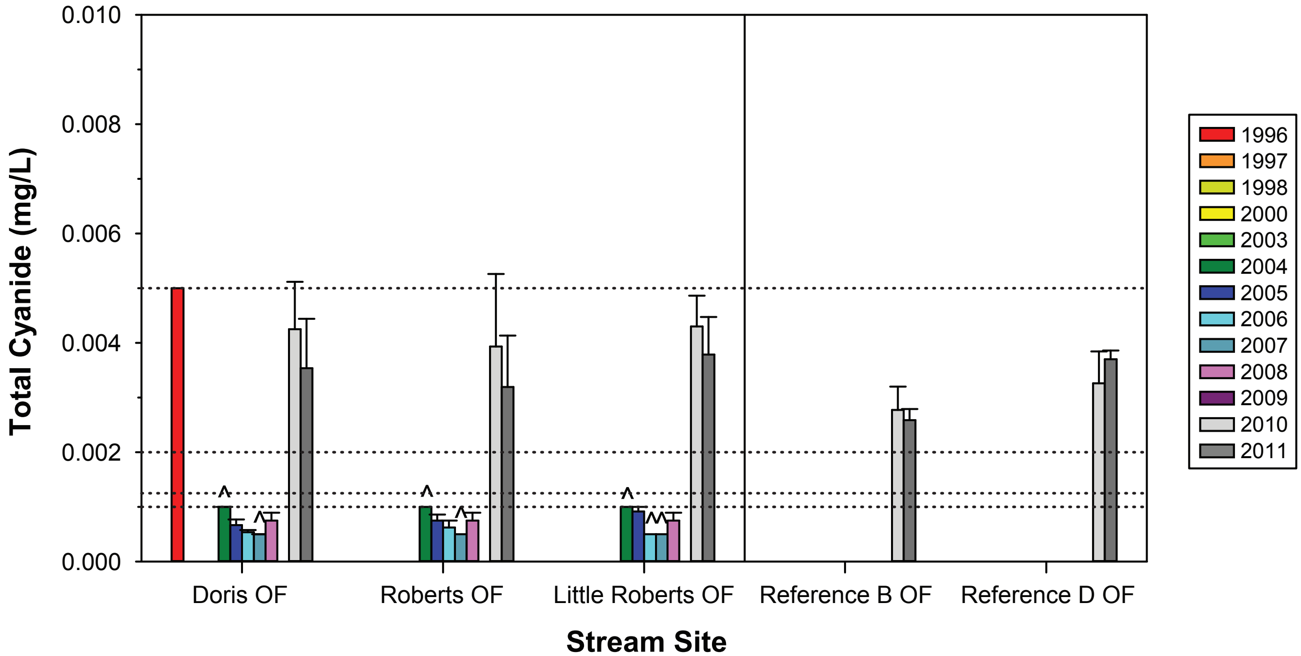

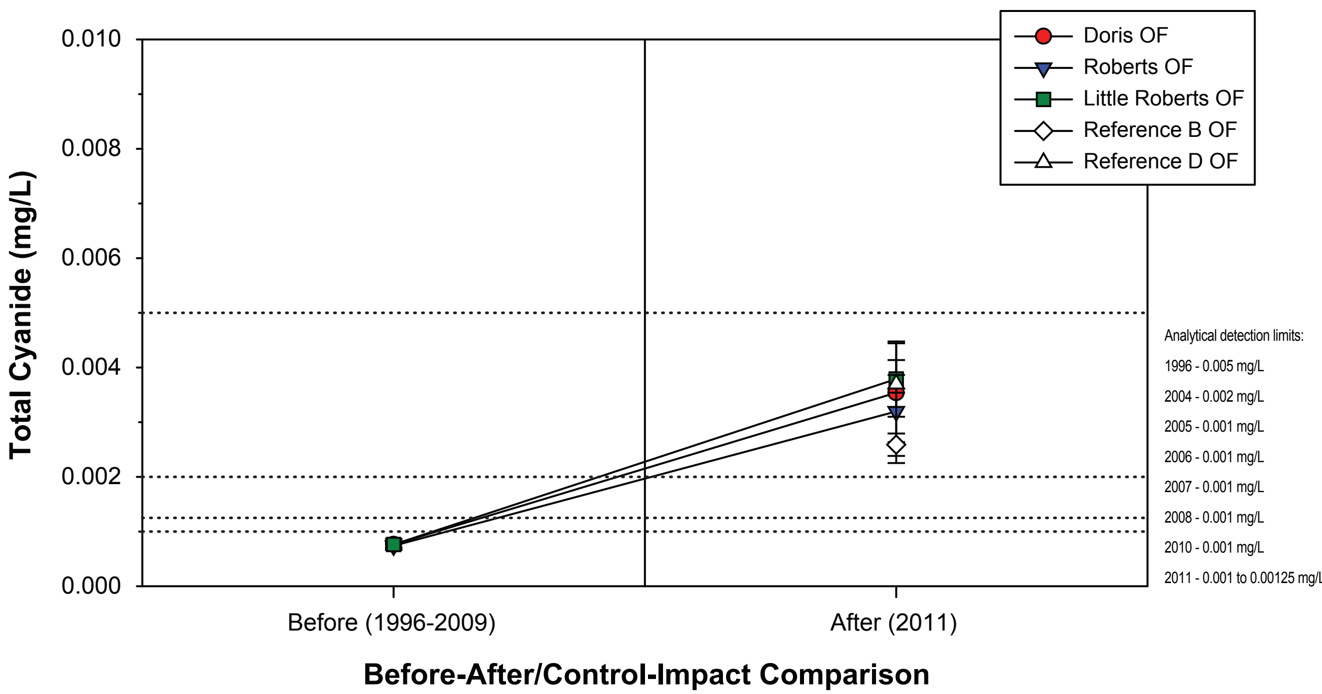

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Cyanide Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-7

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significantly greater than the baseline mean for Roberts Outflow ($p < 0.001$) and Little Roberts Outflow ($p < 0.001$), but not for Doris Outflow ($p = 0.24$). Unfortunately, because there is no baseline total cyanide data for the reference streams, a BACI analysis could not be performed to determine whether this increase in total cyanide in Roberts Outflow and Little Roberts Outflow is a natural phenomenon that also occurred in reference streams outside of the Project area. Based on the criteria set out in the effects analysis methodology section for water quality, statistical analysis would not be recommended for Doris Outflow cyanide concentrations because 75% of the data are below detection limits. However, statistical results are presented for this site because all 2011 data were above detection limits, and even if the baseline values that are below detection are substituted with the highest possible concentration (i.e., the value of the detection limit), the conclusions would be the same.

The similarity of 2011 mean total cyanide concentrations between exposure and reference streams suggests that the recent increase in cyanide at the exposure streams is an analytical anomaly or a natural phenomenon that also occurred in streams outside of the Project area. The particularly low concentration of total cyanide measured in stream samples collected between 2004 and 2008 were analyzed by the Alberta Research Council (ARC) Laboratory in Vegreville, AB, while the higher concentrations measured in 2010 and 2011 were analyzed by ALS Laboratory Group in Burnaby, BC. A laboratory discrepancy could explain the apparent increase in cyanide concentrations, as the timing of the increase coincided with a change in analytical laboratory. This could also be a natural phenomenon as cyanide is naturally produced by a wide variety of plants and microorganisms (Knowles 1979; Singleton 1986). It is highly unlikely that there was an anthropogenic cause for this increase in cyanide, as cyanide was not brought to the Project site in either 2010 or 2011. Cyanide concentrations will continue to be closely monitored in both reference and exposure streams in the future.

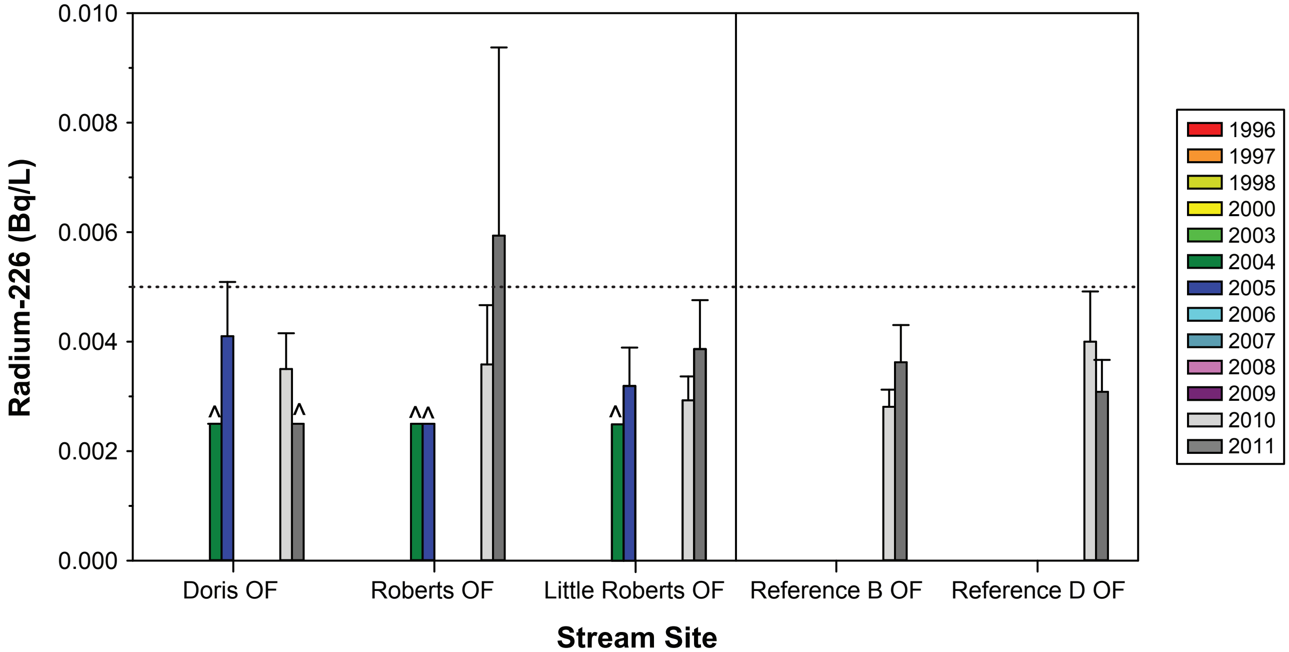
Free cyanide concentrations (cyanide existing in the form of HCN and CN^-) in stream samples were measured for the first time in 2011 to allow for direct comparisons with the CCME guideline for cyanide (0.005 mg/L as free cyanide). Concentrations of free cyanide in stream samples were always below the detection limits of 0.005 mg/L (June and July samples) or 0.001 mg/L (August and September samples), and the CCME guideline for free cyanide of 0.005 mg/L (Appendix A). Therefore, the cyanide in exposure streams in 2011 would not be expected to pose a threat to freshwater aquatic life.

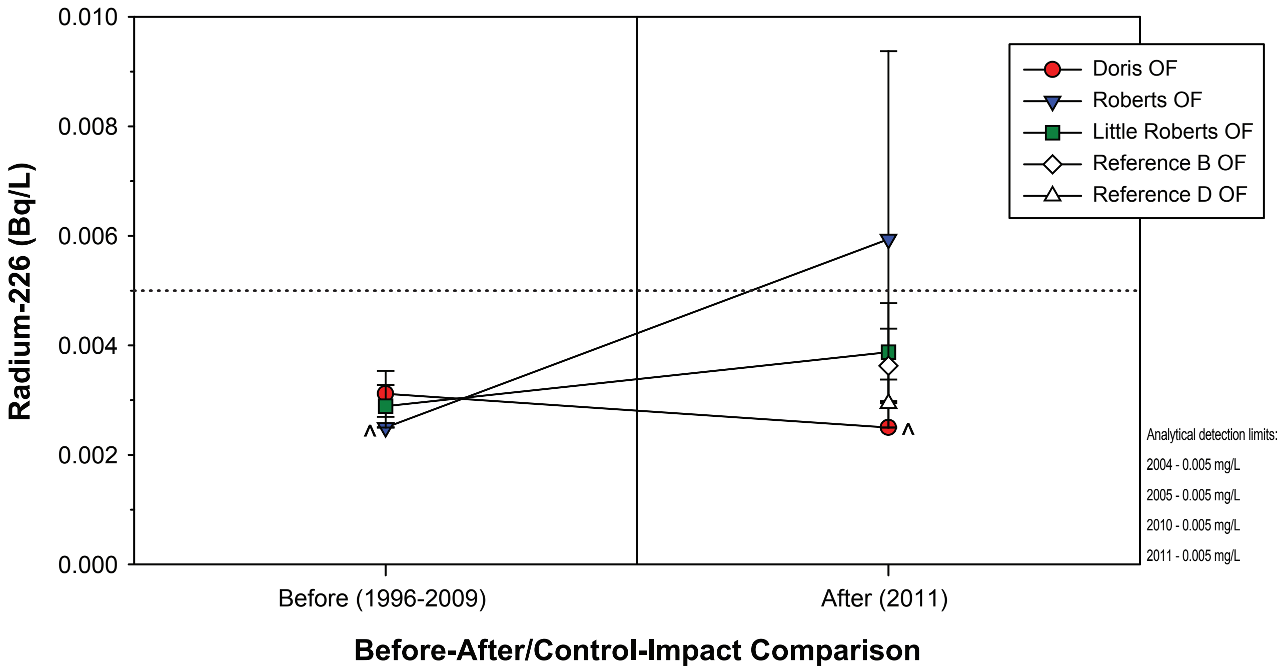
3.3.1.8 Radium-226

Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In both exposure and reference streams, more than 80% of radium-226 concentrations measured during 2011 were below the analytical detection limit of 0.005 Bq/L, and the remaining concentrations were slightly above this detection limit (Figure 3.3-8). Baseline concentrations were similarly near or below the detection limit of 0.005 Bq/L. Therefore, 2011 activities had no effect on radium-226 concentrations. Statistical analysis is not recommended for total radium-226, because > 70% of baseline and 2011 concentrations were below analytical detection limits.

3.3.1.9 Total Aluminum

Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total aluminum concentrations were variable among streams. Within each stream, there was also a large amount of inter-annual and seasonal variability. At all streams sites, except Reference B Outflow, mean 2011 concentrations of total aluminum were higher than the pH-dependent CCME guideline of 0.1 mg/L. However, this guideline was frequently exceeded in all exposure streams during baseline years, particularly in Roberts and Little Roberts outflows where nearly all baseline mean concentrations exceeded this CCME guideline (Figure 3.3-9).





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Radium-226 Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-8

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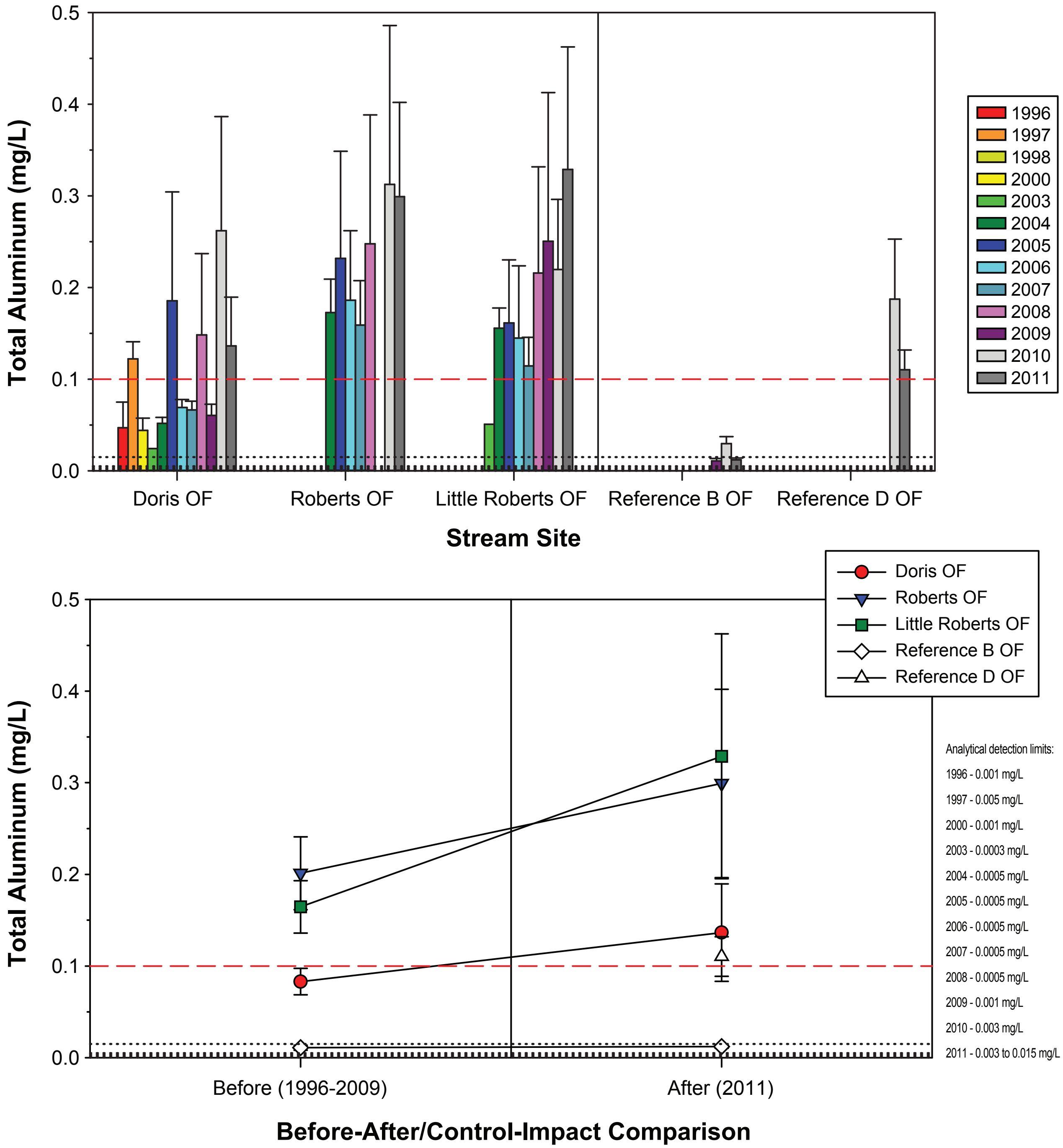

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the pH-dependent CCME freshwater guideline for aluminum (0.005 mg/L at pH < 6.5; 0.1 mg/L at pH ≥ 6.5).
Mean annual pH levels were greater than 6.5 in all exposure and reference streams.
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Aluminum Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-9

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The before-after plot shows that mean 2011 total aluminum concentrations in all exposure streams were higher than baseline means (Figure 3.3-9). However, there was a large overlap between total aluminum concentrations measured in 2011 and concentrations measured prior to 2010. The before-after analysis confirmed that there was no significant difference in the baseline mean compared to the 2011 mean for any exposure stream ($p = 0.61$ for Doris Outflow, $p = 0.47$ for Roberts Outflow, and $p = 0.10$ for Little Roberts Outflow), suggesting that Project activities did not affect total aluminum concentrations in exposure streams.

3.3.1.10 Total Arsenic

Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2011, mean concentrations of total arsenic were similar among exposure streams, but were generally higher in exposure than in reference streams (Figure 3.3-10). Mean total arsenic concentrations in all stream samples were more than an order of magnitude lower than the CCME guideline of 0.005 mg/L. Baseline arsenic concentrations in exposure streams were generally similar to or slightly higher than 2011 concentrations (Figure 3.3-10), indicating that there was no Project-related increase in arsenic concentrations. The before-after comparison confirmed that there was no change in arsenic concentrations in exposure streams in 2011 ($p = 0.56$ for Doris Outflow, $p = 0.043$ for Roberts Outflow, and $p = 0.36$ for Little Roberts Outflow).

3.3.1.11 Total Cadmium

Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. With one exception, all total cadmium concentrations measured in exposure streams during 2011 were below the analytical detection limit of 0.000005 mg/L. All 2011 total cadmium concentrations were below the hardness-dependent CCME guideline for cadmium (Figure 3.3-11). There was therefore no evidence of a Project-related increase in cadmium concentrations between baseline years and 2011 (Figure 3.3-11). Before-after statistical analysis results are not presented for cadmium because of the high proportion of concentrations that were below detection limits in the datasets for exposure streams.

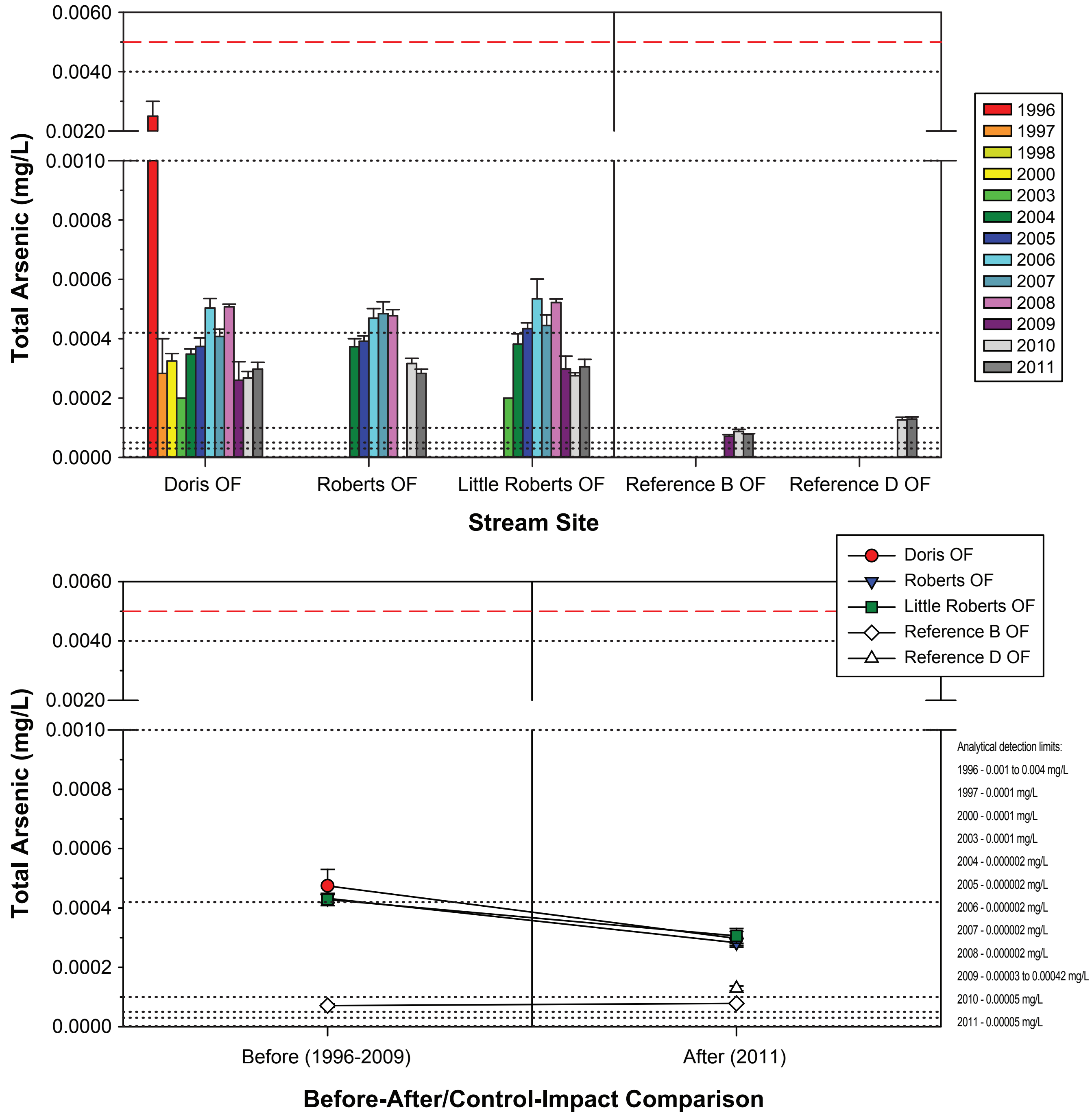
3.3.1.12 Total Copper

Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In all exposure streams, mean 2011 copper concentrations were within the range of baseline means and below the hardness-dependent CCME guideline (Figure 3.3-12). The before-after analysis confirmed that there was no evidence of an increase in the mean copper concentration between baseline years and 2011 in any exposure stream site ($p = 0.92$ for Doris Outflow, $p = 0.40$ for Roberts Outflow, and $p = 0.29$ for Little Roberts Outflow). Therefore, there was no effect of 2011 Project activities on total copper concentrations.

3.3.1.13 Total Iron

Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total iron concentrations were variable among streams. Within each stream, there was also a large amount of inter-annual and seasonal variability (Figure 3.3-13). It may therefore be difficult to distinguish natural variability from effects resulting from Project activities.

The before-after plot shows that mean 2011 total iron concentrations in all exposure streams were higher than baseline means (Figure 3.3-13). However, there was a large overlap between total iron concentrations measured in 2011 and concentrations measured prior to 2010. Mean 2011 total iron concentrations in Roberts Outflow and Little Roberts Outflow were slightly higher than the CCME



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater guideline for arsenic (0.005 mg/L).
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Arsenic Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-10

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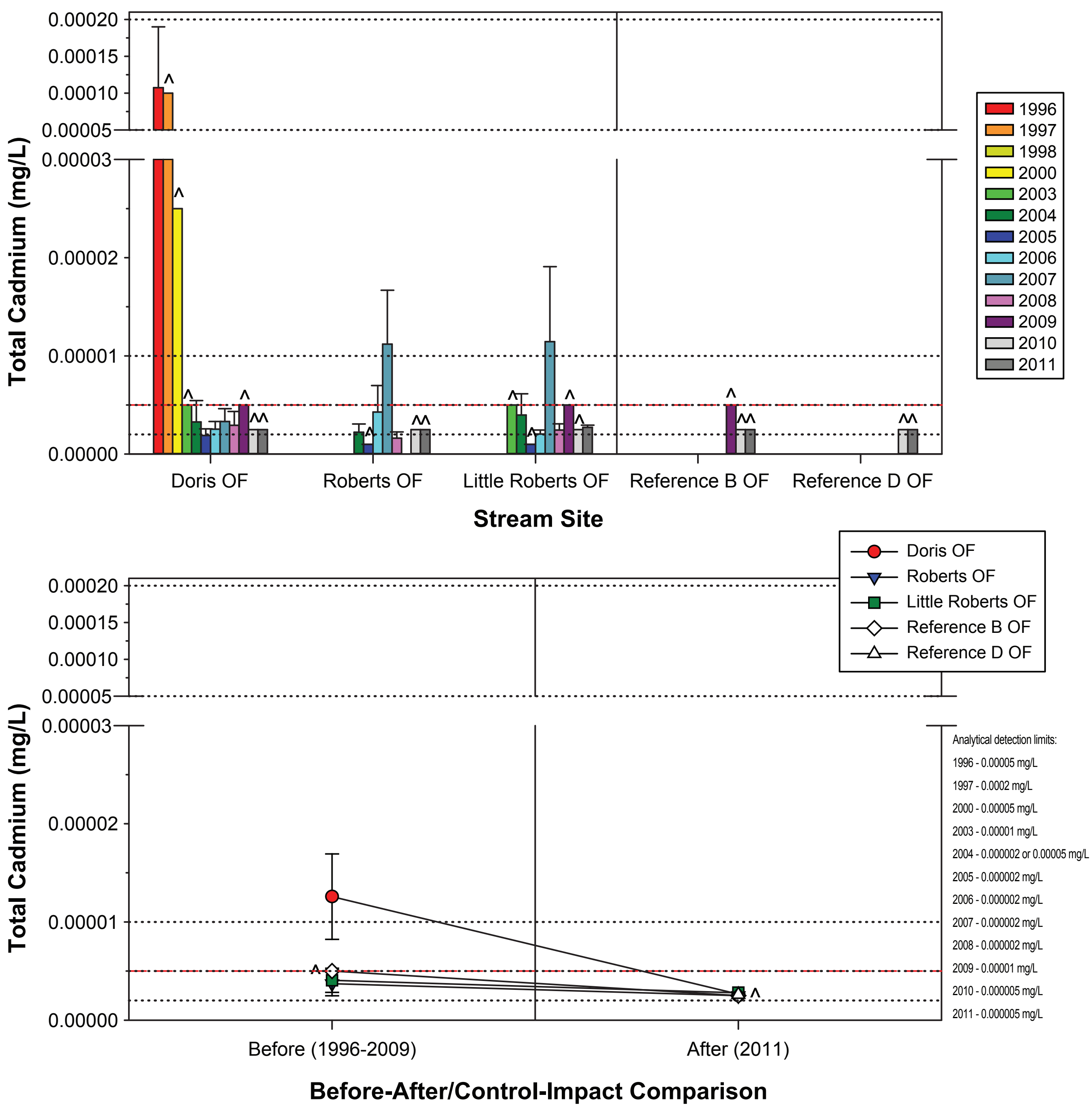

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline for cadmium is hardness dependent.
Red dashed lines represent the minimum CCME freshwater guideline for cadmium based on the minimum hardness measured in exposure and reference streams between 1996 and 2011 (hardness: 12 mg/L; CCME guideline: 0.000005 mg/L).
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Cadmium Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-11

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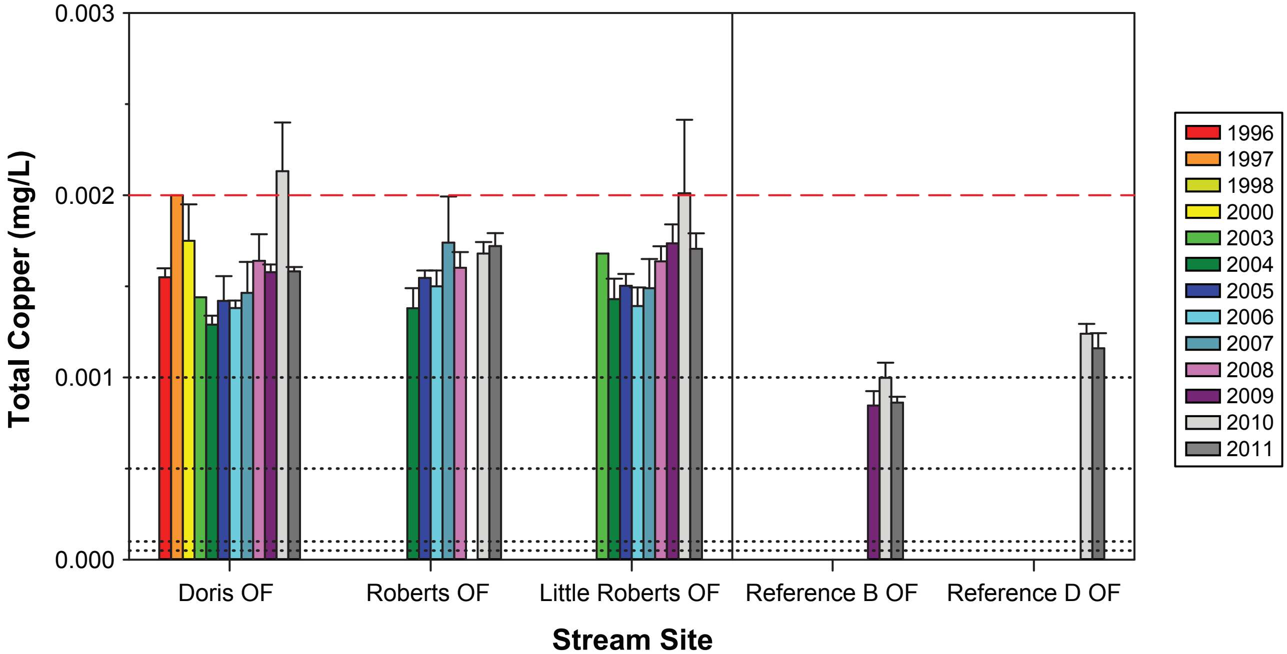

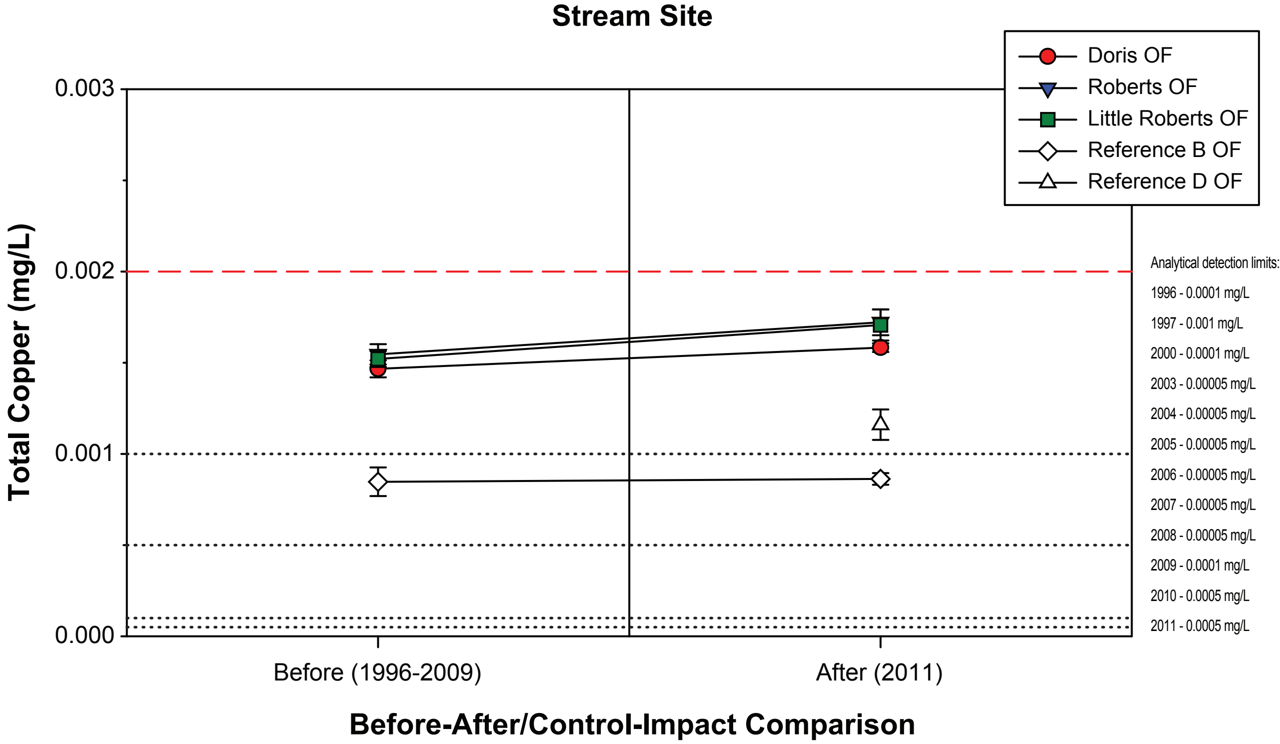

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
The CCME freshwater guideline for copper is hardness dependent.
Red dashed lines represent the minimum CCME freshwater guideline for copper regardless of water hardness (0.002 mg/L).
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Copper Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-12

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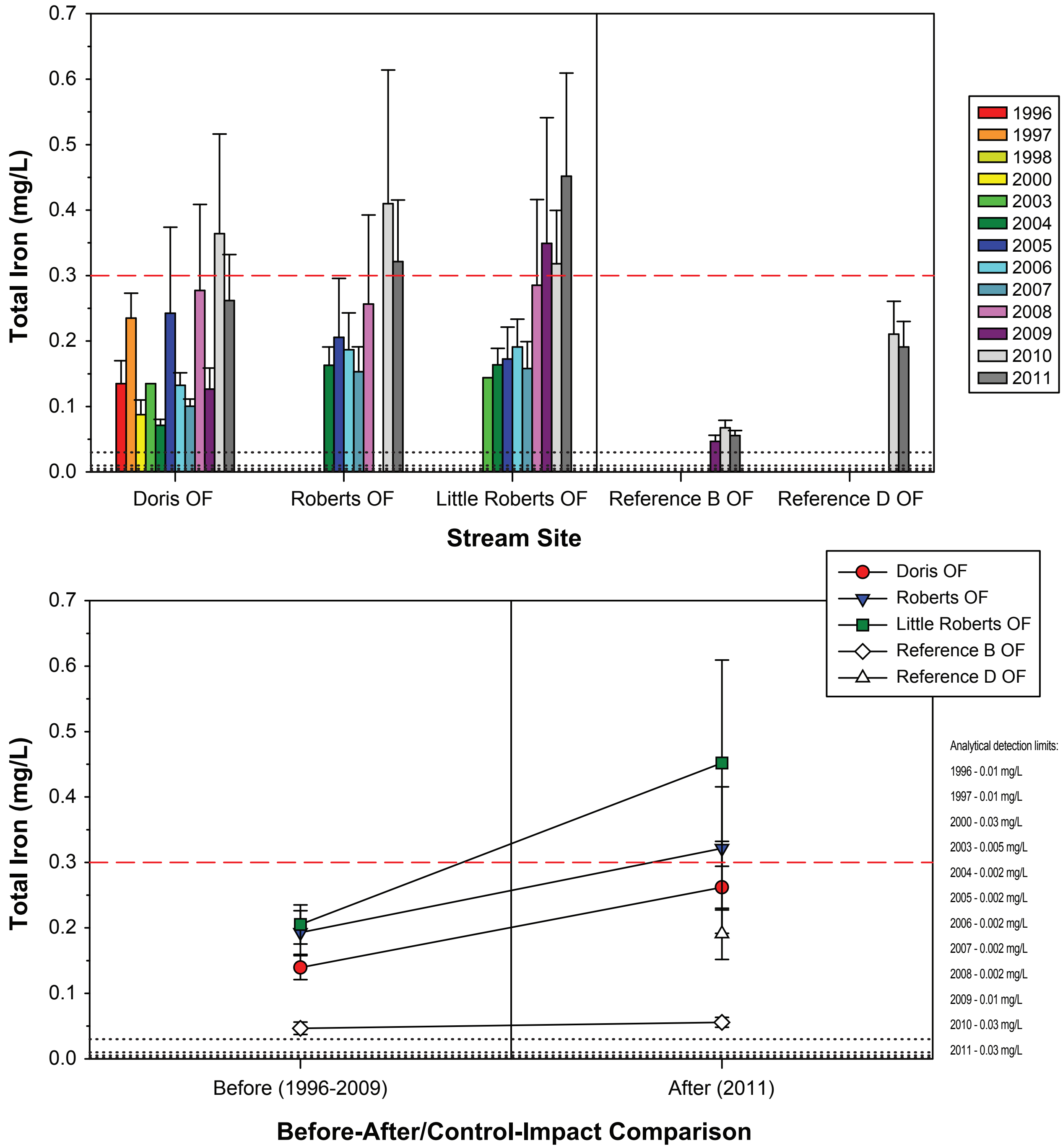

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater guideline for iron (0.3 mg/L).
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Iron Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-13

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guideline of 0.3 mg/L. In the historical dataset, the only time a mean iron concentration exceeded the CCME guideline was in Little Roberts Outflow in 2009; however, individual replicates collected before 2010 sometimes surpassed this guideline (Figure 3.3-13). The before-after analysis showed that there was no significant difference in the baseline mean compared to the 2011 mean for any exposure stream ($p = 0.22$ for Doris Outflow, $p = 0.16$ for Roberts Outflow, and $p = 0.014$ for Little Roberts Outflow), suggesting that Project activities did not affect total iron concentrations in exposure streams.

3.3.1.14 Total Lead

Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. 2011 mean lead concentrations in exposure streams were similar to baseline means, and were well below the hardness-dependent CCME guideline (Figure 3.3-14). The before-after comparison confirmed that there was no effect of 2011 Project activities on total lead concentrations in exposure streams ($p = 0.71$ for Doris Outflow, $p = 0.78$ for Roberts Outflow, and $p = 0.41$ for Little Roberts Outflow).

3.3.1.15 Total Mercury

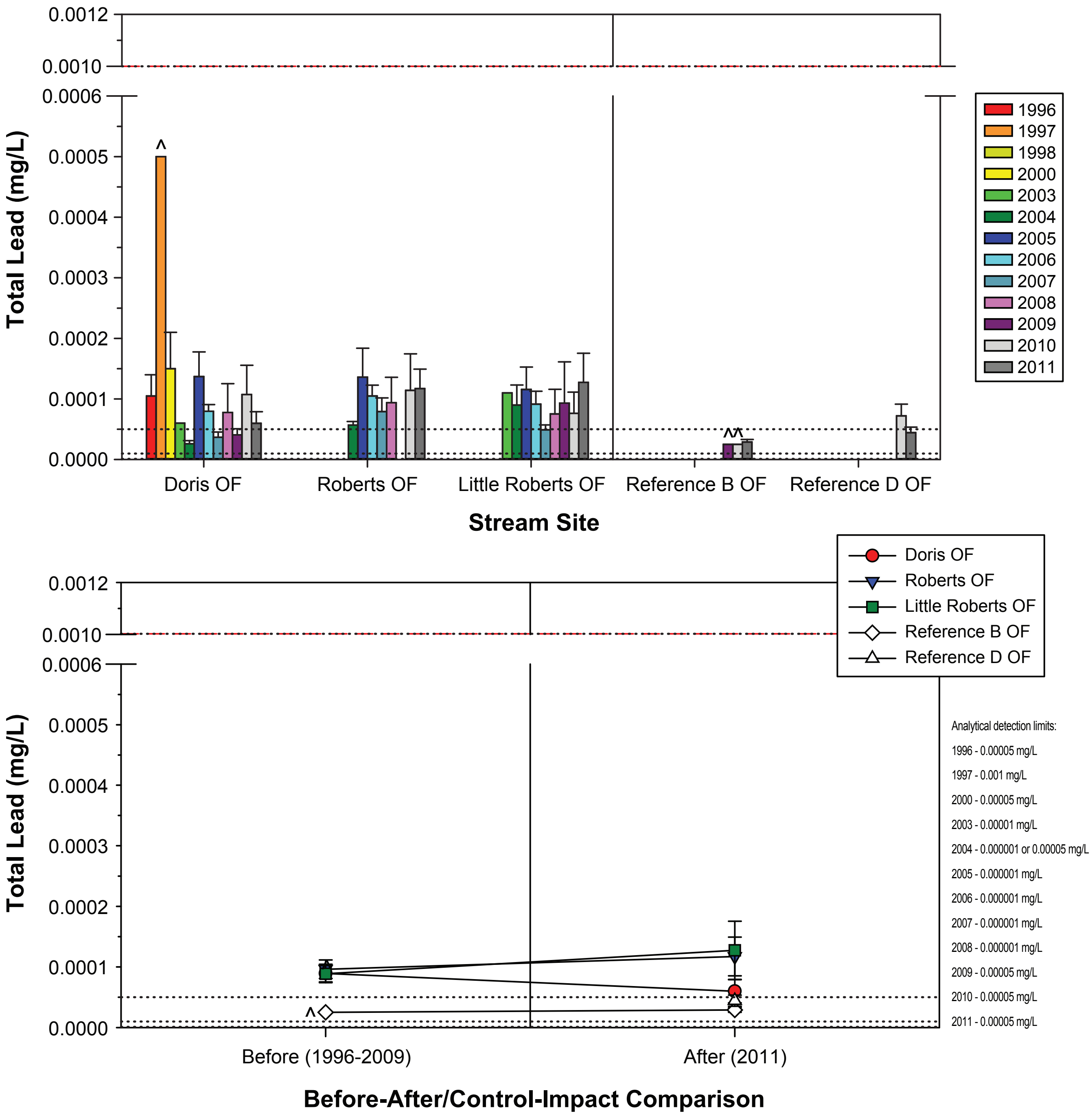
Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. A high proportion of total mercury concentrations in the datasets for exposure streams were below detection limits (72% for Doris Outflow, 52% for Roberts Outflow, and 68% for Little Roberts Outflow). Total mercury concentrations measured in exposure streams in 2011 were always above the ultra-low detection limit (0.0000005 mg/L) and ranged from 0.0000011 to 0.0000022 mg/L. This was well below the CCME guideline for inorganic mercury of 0.000026 mg/L (Figure 3.3-15). The comparisons to pre-2010 data are problematic because of the high proportion of baseline data that were below detection limits, and the widely variable historical detection limits. The before-after analysis suggests that there was no difference in means between baseline years and 2011 ($p = 0.96$ for Doris Outflow, $p = 0.090$ for Roberts Outflow, and $p = 0.90$ for Little Roberts Outflow), but statistical results should be interpreted cautiously because of the high proportion of non-detectable concentrations in the baseline data. There was no evidence of an increase in mercury concentrations due to 2011 Project activities.

3.3.1.16 Total Molybdenum

Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Mean total molybdenum concentrations within each exposure stream were remarkably consistent from year to year (Figure 3.3-16). In both Roberts Outflow and Little Roberts Outflow, 2011 concentrations were similar to baseline concentrations, and the before-after comparison confirmed that there was no effect of 2011 Project activities on total molybdenum in these streams ($p = 0.32$ for Roberts Outflow and $p = 0.38$ for Little Roberts Outflow). In Doris Outflow, the 2011 mean concentration was slightly higher than the baseline mean, and the before-after analysis determined that this difference was statistically significant ($p = 0.006$). However, the BACI analysis showed that this before-after trend paralleled the before-after trend for the reference sites ($p = 0.11$), indicating that the slight increase in molybdenum that occurred at Doris Outflow was not related to 2011 Project activities. Total molybdenum concentrations in all 2011 samples were more than two orders of magnitude lower than the interim CCME guideline of 0.073 mg/L (Figure 3.3-16).

3.3.1.17 Total Nickel

Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2011 nickel concentrations in all streams were well below the hardness-dependent CCME guideline (Figure 3.3-17). In all three exposure streams, the before-after plot suggests that concentrations increased slightly in 2011 compared to baseline concentrations (Figure 3.3-17). However, the before-after analysis revealed that these increases were not statistically significant



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline for lead is hardness dependent.
Red dashed lines represent the minimum CCME freshwater guideline for lead regardless of water hardness (0.001 mg/L).
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Lead Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-14

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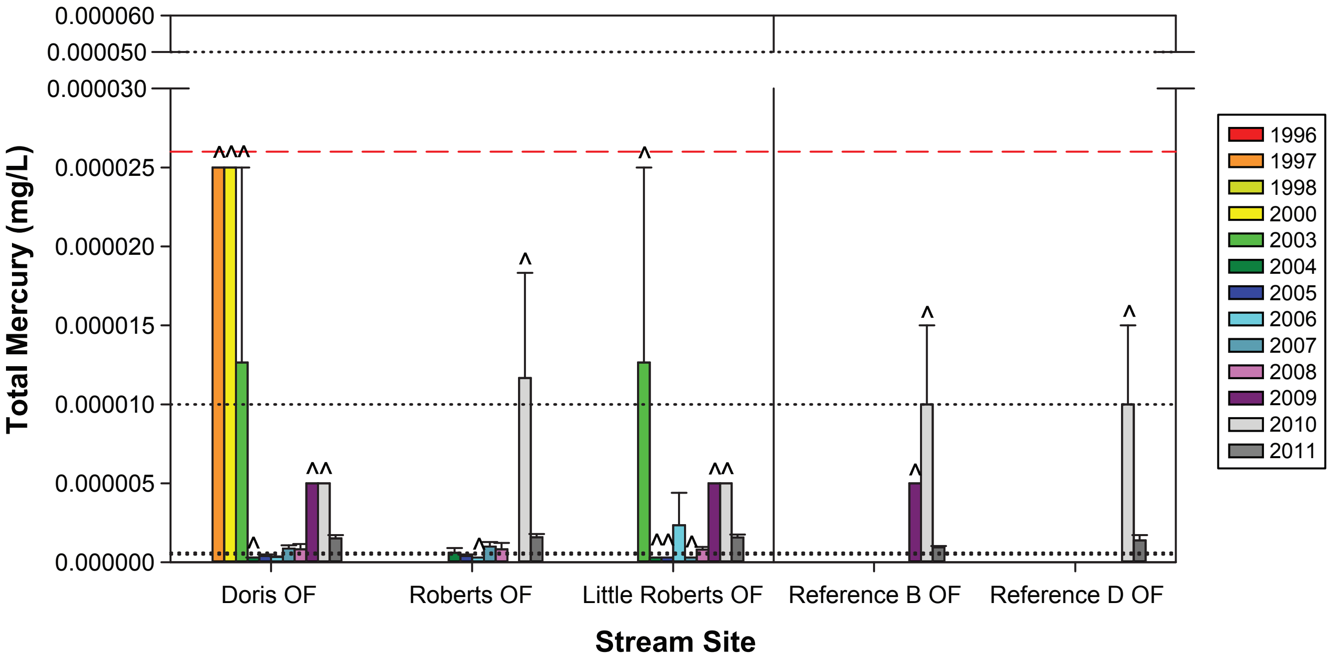

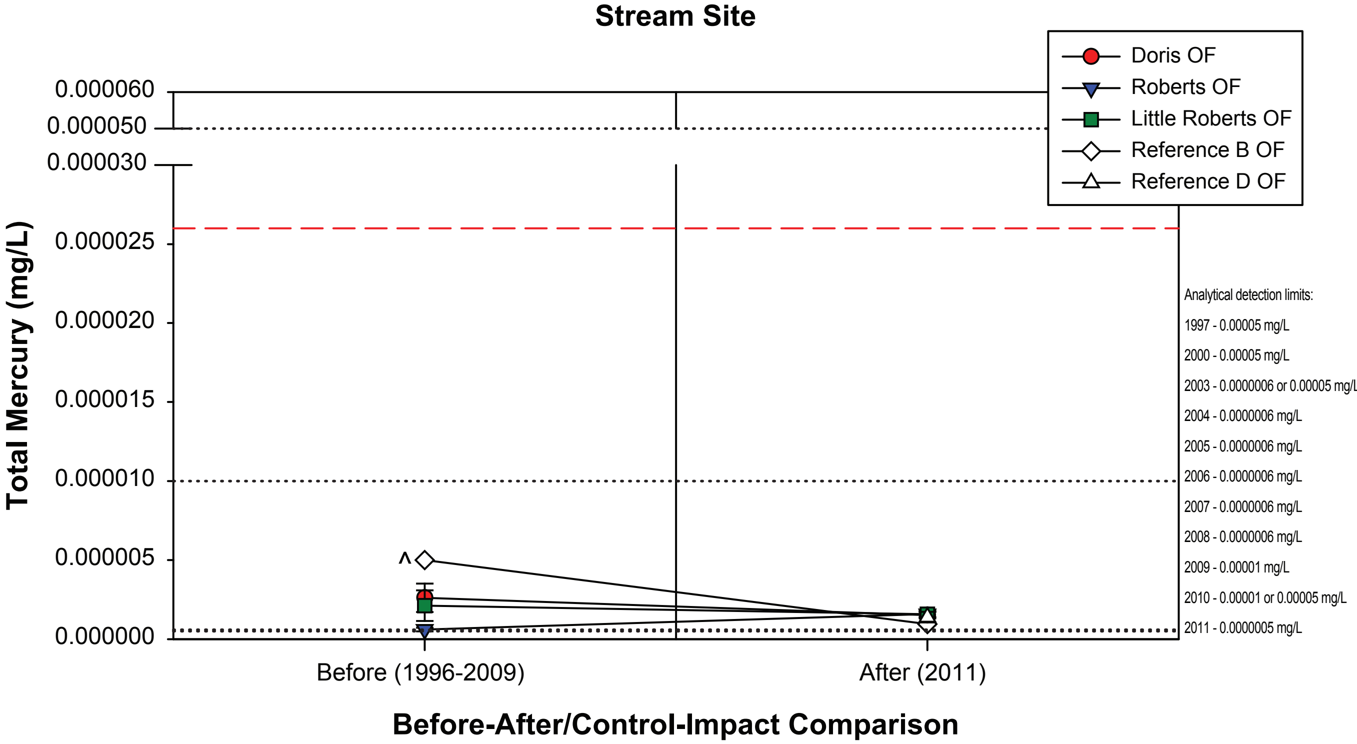

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater guideline for inorganic mercury (0.000026 mg/L).
Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Mercury Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-15

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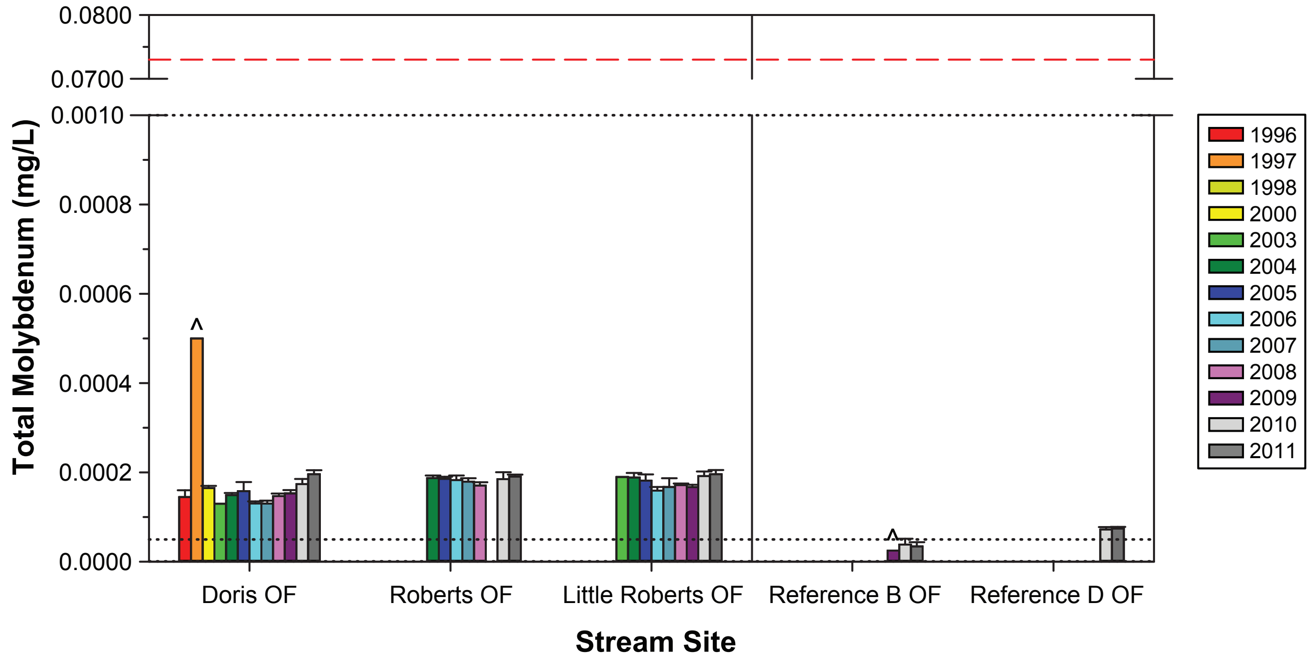

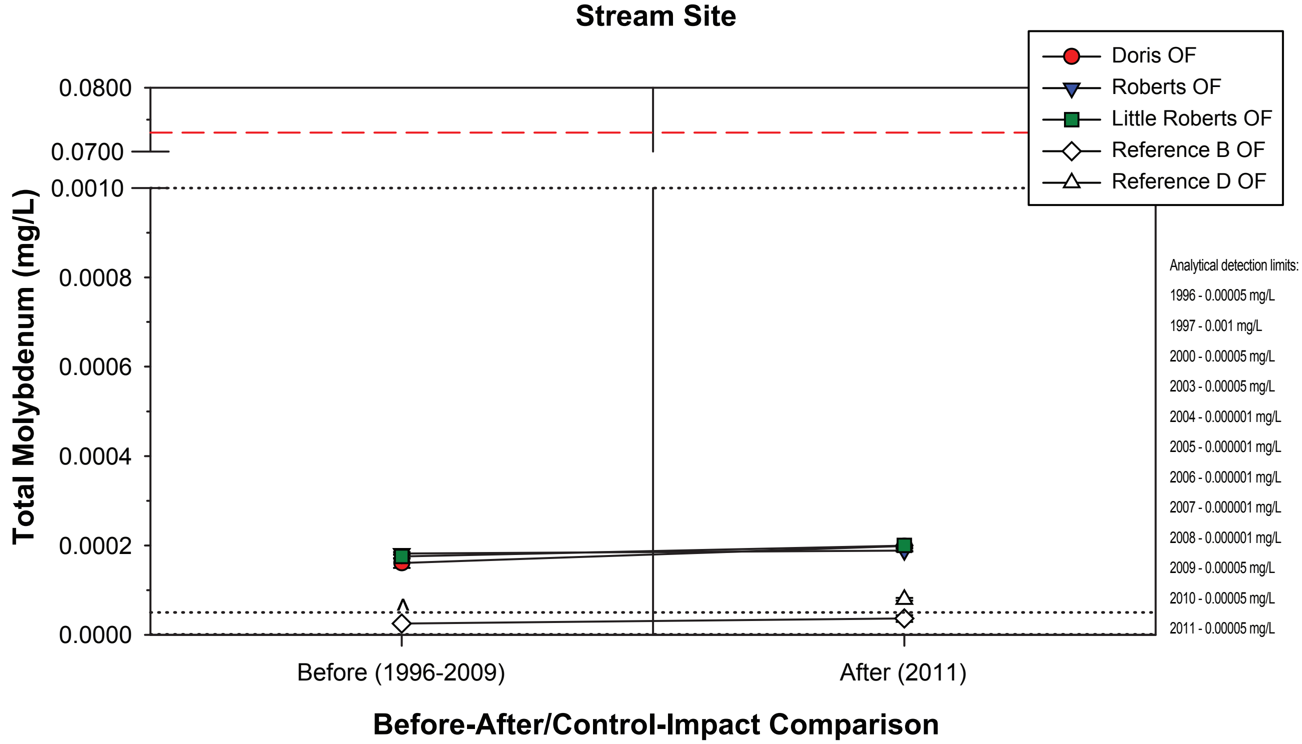

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the interim CCME freshwater guideline for molybdenum (0.073 mg/L).
Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Molybdenum Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-16

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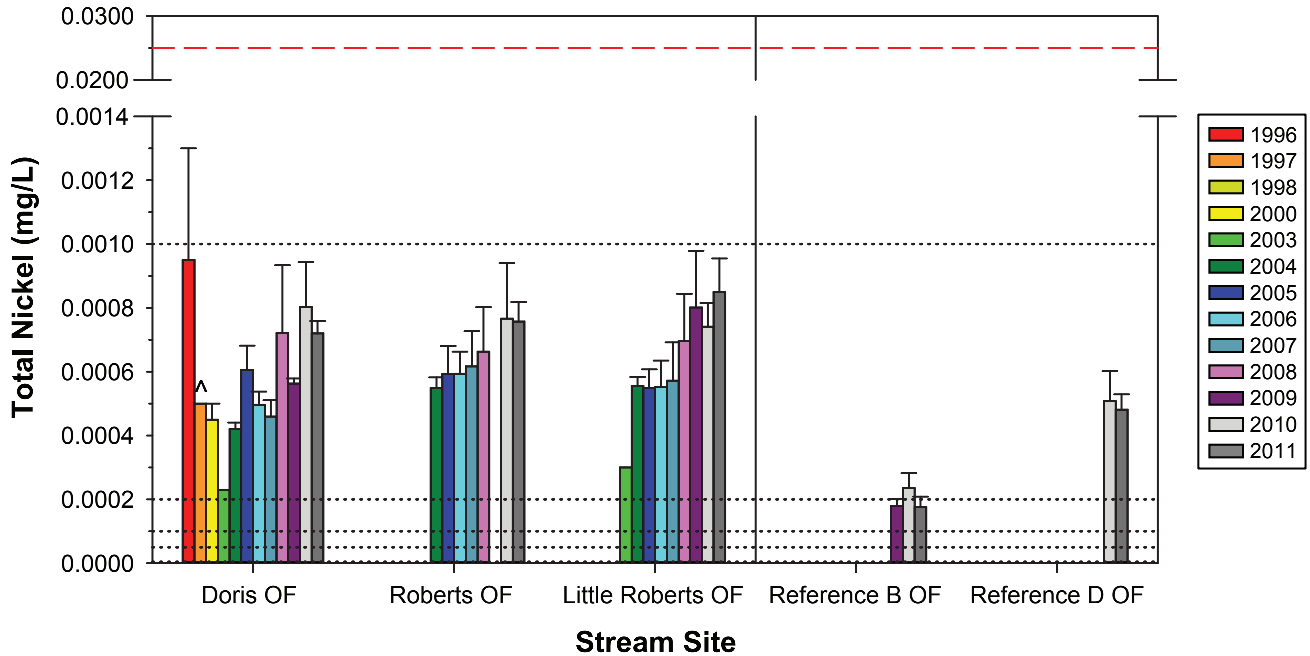

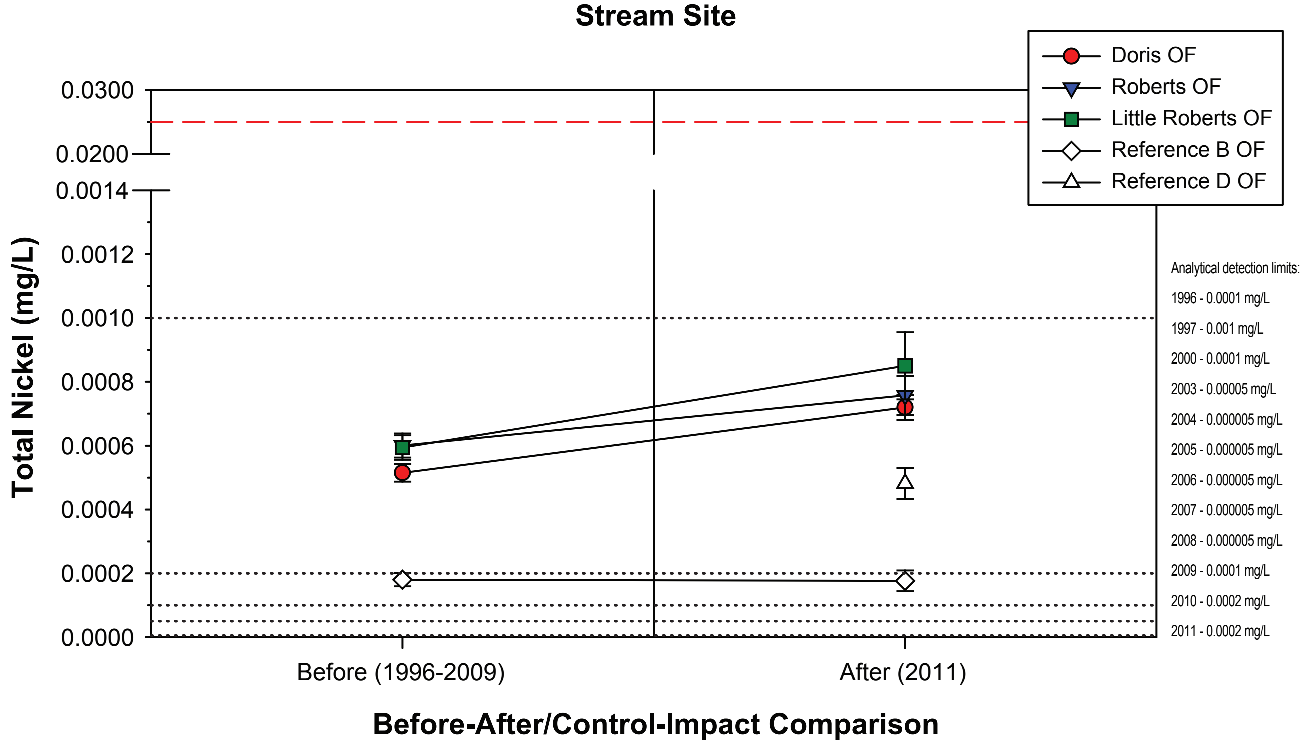

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline for nickel is hardness dependent.
Red dashed lines represent the minimum CCME freshwater guideline for nickel regardless of water hardness (0.025 mg/L).
Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Nickel Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

Figure 3.3-17

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($p = 0.37$ for Doris Outflow, $p = 0.17$ for Roberts Outflow, and $p = 0.10$ for Little Roberts Outflow). Therefore, there was no effect of 2011 Project activities on total nickel concentrations in streams.

3.3.1.18 Total Zinc

Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2011, total zinc concentrations were below the analytical detection limit of 0.003 mg/L in all samples collected from exposure streams between June and September, except two replicates collected at Doris Outflow in August (which contained total zinc concentrations of 0.0047 and 0.0055 mg/L). All 2011 total zinc concentrations were well below the CCME guideline of 0.03 mg/L (Figure 3.3-18). Since nearly all 2011 values were below analytical detection limits, there were no apparent Project-related effects on total zinc.

3.3.2 Lakes

Water quality samples from lakes were collected from three exposure lakes (Doris Lake South, Doris Lake North, and Little Roberts Lake) and two reference lakes (Reference Lake B and Reference Lake D) in 2011. For the exposure lakes, relevant baseline data were available from 1995 to 1998, 2000, and 2003 to 2009 (though all lake sites were not sampled each year). The only available baseline data for Reference Lake B were from 2009, and no pre-2010 baseline data are available for Reference Lake D.

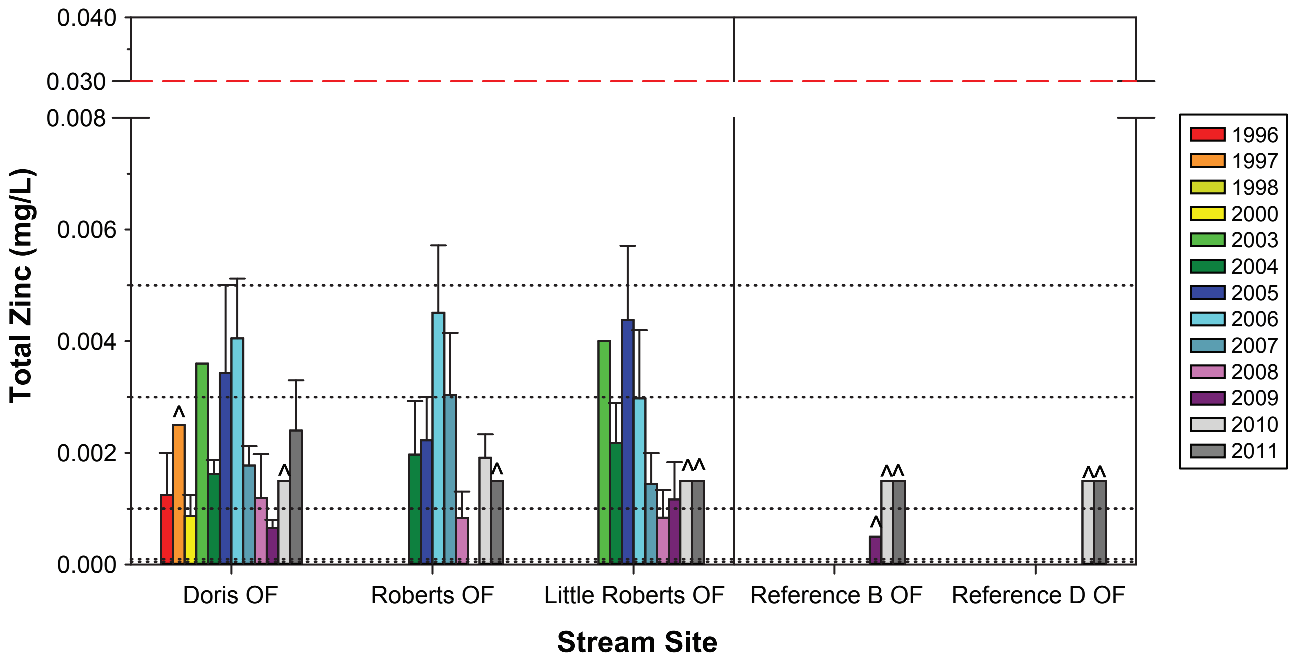
Because of comparability in lake sizes, Reference Lake B was used as a reference site for Doris Lake (these larger lakes are both > 3 km^2 in surface area) and Reference Lake D was used as a reference site for Little Roberts Lake (these smaller lakes are both < 1 km^2 in surface area). There was little evidence of vertical chemical stratification in any lake, so all samples were included in graphical and statistical analyses regardless of depth of sampling, and no depth effect was introduced into statistical models. Because no baseline data are available for Reference Lake D, no statistical analyses were possible for this lake, and no BACI analysis was possible for Little Roberts Lake. Graphs showing water quality trends in lakes over time are shown in Figures 3.3-19 to 3.3-36. All statistical results are presented in Appendix B.

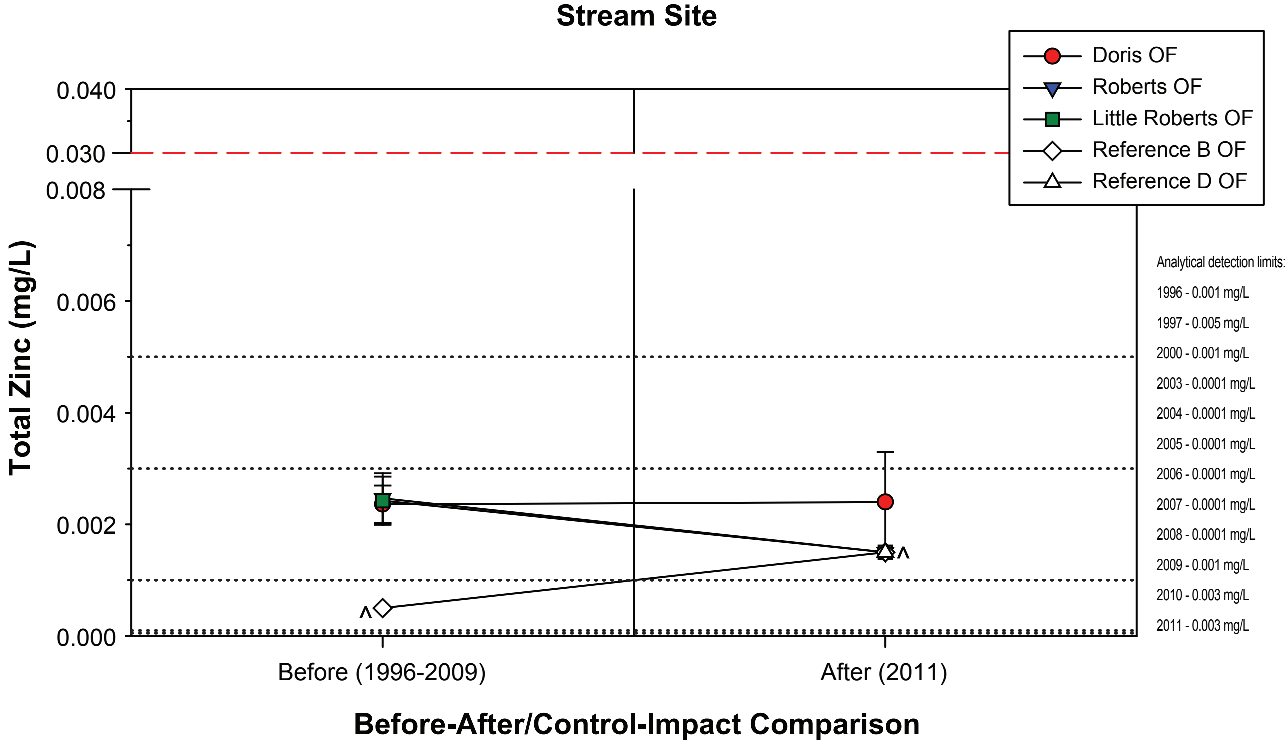
3.3.2.1 pH

pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER. pH levels measured in 2011 in exposure lakes were always within the recommended CCME guideline range of 6.5 to 9.0, and were similar to baseline pH levels (Figure 3.3-19). The before-after analysis confirmed that the mean baseline pH was not distinguishable from the mean 2011 pH in any exposure lake ($p = 0.58$ for Doris Lake South, $p = 0.36$ for Doris Lake North, and $p = 0.034$ for Little Roberts Lake). Therefore, there was no apparent effect of 2011 activities on pH in exposure lakes.

3.3.2.2 Total Alkalinity

Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. Total alkalinity (as $CaCO_3$) levels measured in 2011 were always within the range of baseline alkalinity levels (Figure 3.3-20), and there was no evidence of any Project-related effects. The before-after analysis confirmed that there was no change in alkalinity in any exposure lake in 2011 ($p = 0.39$ for Doris Lake South, $p = 0.53$ for Doris Lake North, and $p = 0.96$ for Little Roberts Lake).





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater guideline for zinc (0.03 mg/L).
Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Figure 3.3-18

Total Zinc Concentration in AEMP Stream Sites, Doris North Project, 1996-2011

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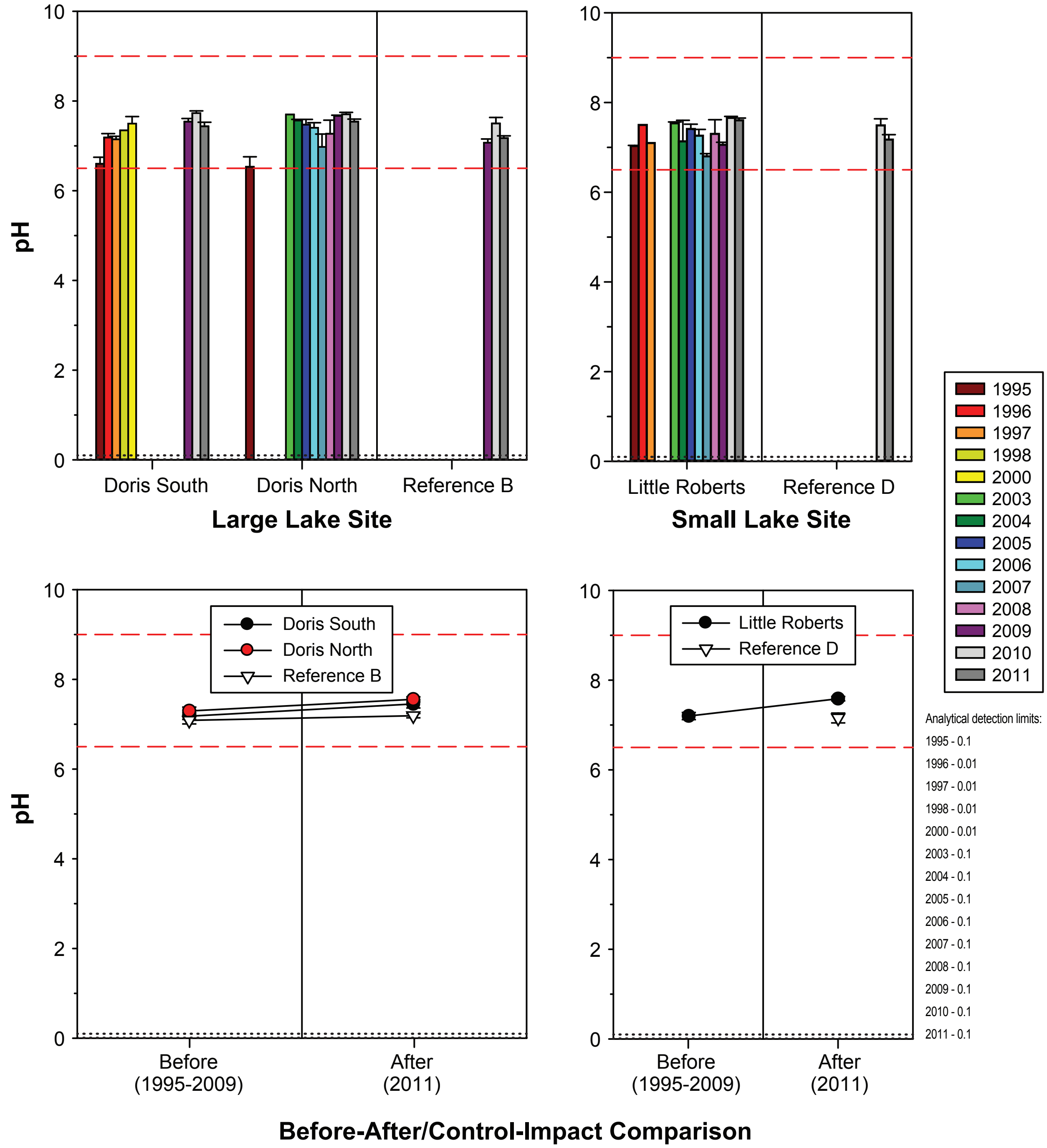

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
Red dashed lines represent the CCME freshwater guideline pH range (6.5–9.0).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER.

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pH in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-19

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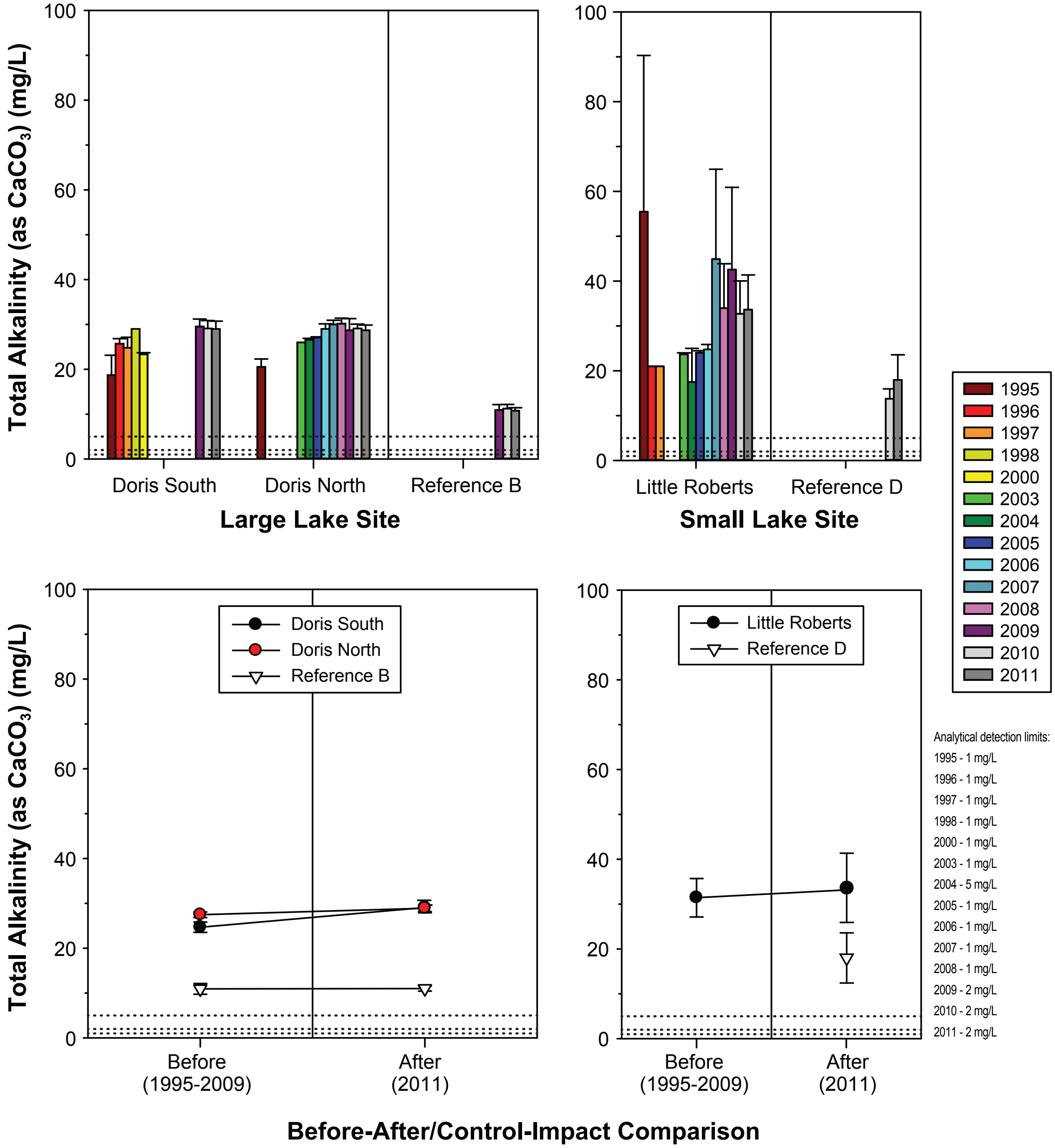

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

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Total Alkalinity in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-20

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3.3.2.3 Hardness

Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. At the large lake exposure sites, 2011 mean hardness levels were slightly higher than the baseline means (Figure 3.3-21), but the before-after analysis indicated that this difference was not statistically significant ($p = 0.085$ for Doris Lake South and $p = 0.13$ for Doris Lake North). In Little Roberts Lake, 2011 hardness levels were within the range of baseline hardness levels, and the 2011 mean was not distinguishable from the baseline mean ($p = 0.96$). Therefore, 2011 activities did not affect hardness in exposure lakes.

3.3.2.4 Total Suspended Solids

TSS are regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean TSS concentrations were inter-annually variable, particularly in Little Roberts Lake (Figure 3.3-22). 2011 TSS concentrations measured in the exposure lakes were within the range of baseline concentrations, and the before-after analysis showed that 2011 means were not statistically different from baseline means in any of the exposure lakes ($p = 0.44$ for Doris Lake South, $p = 0.73$ for Doris Lake North, and $p = 0.38$ for Little Roberts Lake). Therefore, there was no apparent effect of 2011 activities on TSS levels in these lakes.

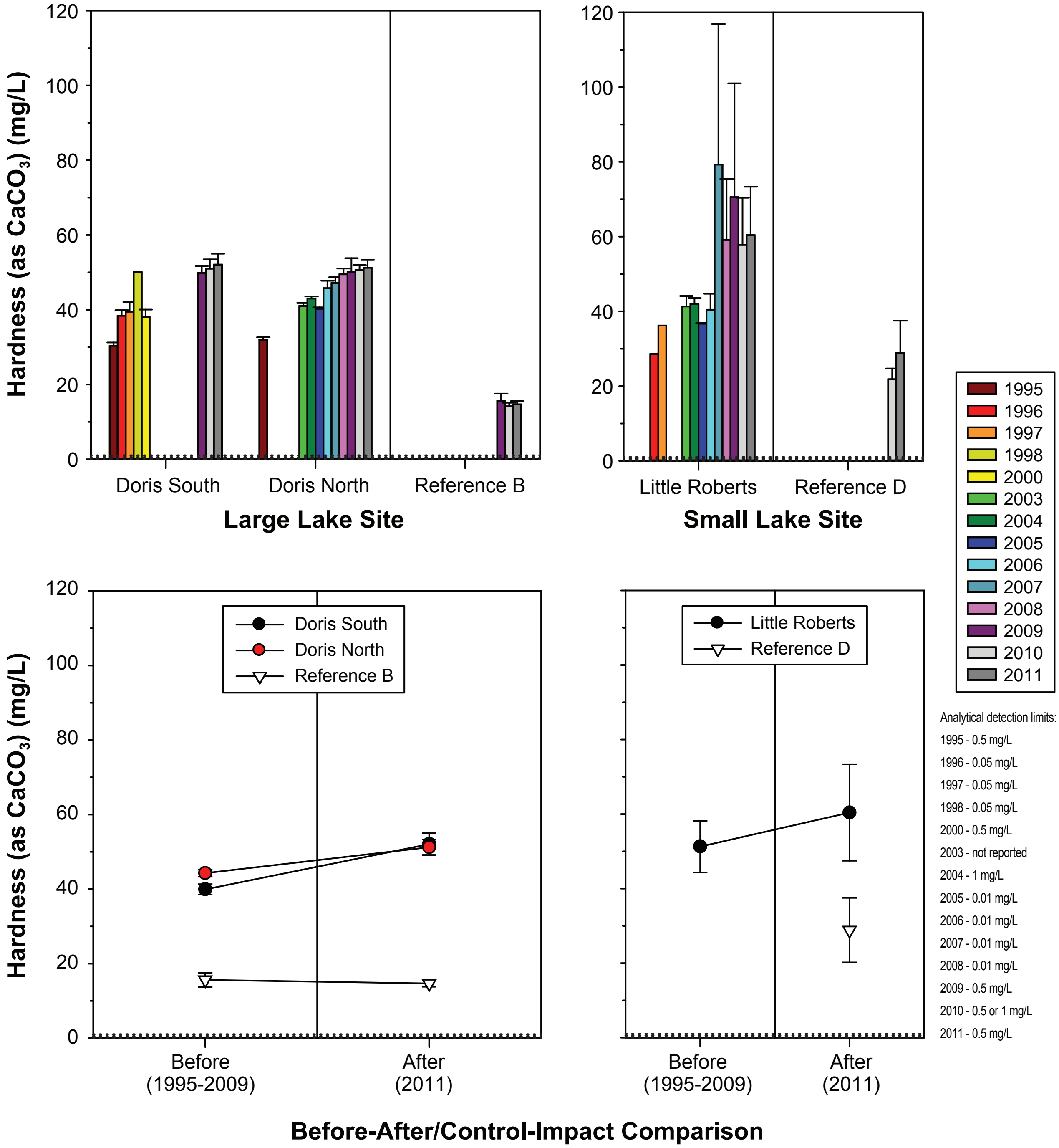
The CCME guideline for TSS is dependent upon background levels (for clear-flow waters with background TSS levels below 25 mg/L, a maximum increase of 25 mg/L is allowable for any short-term exposure or 5 mg/L for longer term exposure; CCME 2011b). Because there was no increase in TSS concentrations from background levels, 2011 TSS concentrations in exposure lakes were below the CCME guideline.

3.3.2.5 Total Ammonia

Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Mean ammonia concentrations for most years were near or below analytical detection limits; however, there were some sporadically elevated mean concentrations in the baseline dataset (e.g., Little Roberts Lake in 1995 and 2007; Figure 3.3-23). Historical and 2011 concentrations of total ammonia in exposure and reference lakes were always well below the pH- and temperature-dependent CCME guideline (Figure 3.3-23). Total ammonia concentrations measured in 2011 in exposure lakes were within baseline ranges, suggesting that 2011 Project activities did not cause an increase in ammonia levels (Figure 3.3-23). This was confirmed by the before-after analysis, which determined that there were no significant differences between baseline and 2011 means for any exposure lake ($p = 0.25$ for Doris Lake South, $p = 0.43$ for Doris Lake North, and $p = 0.39$ for Little Roberts Lake).

3.3.2.6 Nitrate

Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Nitrate concentrations measured in exposure lakes in 2011 were within range of baseline concentrations and were well below the interim CCME guideline of 2.935 mg nitrate-N/L (Figure 3.3-24). The before-after analysis showed that 2011 mean nitrate concentrations were not distinguishable from baseline means for any exposure lake ($p = 0.37$ for Doris Lake South, $p = 0.46$ for Doris Lake North, and $p = 0.15$ for Little Roberts Lake). 2011 results indicate that there were no effects of Project activities on nitrate concentrations in exposure lakes, and on-site management of surface waters and quarry rock were successful in keeping ammonium nitrate salt and residues out of surface waters.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

Hardness in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-21

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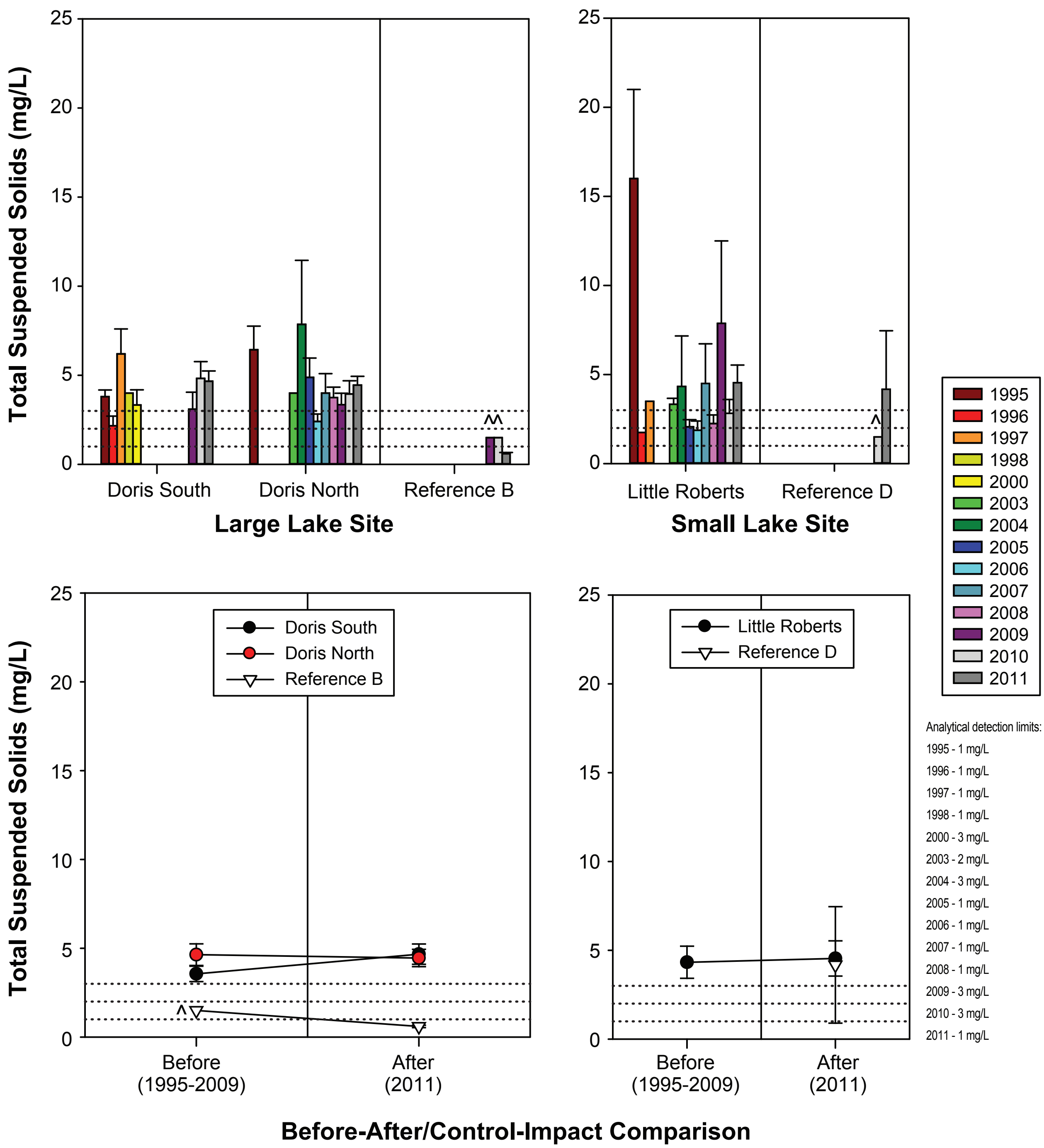

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater guideline; the guideline for total suspended solids is dependent upon background levels.
Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Total Suspended Solids Concentration in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-22

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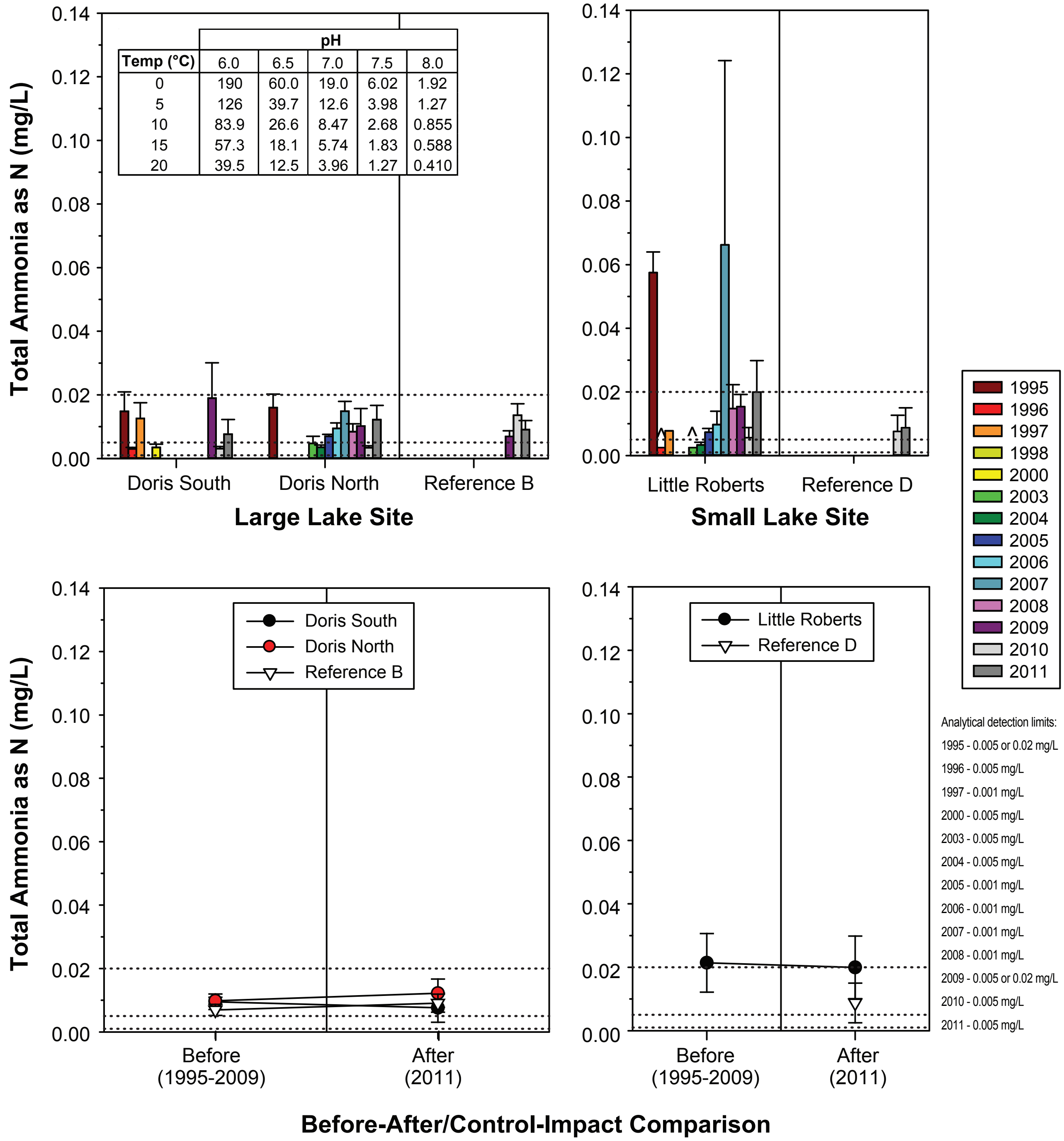

	pH				
Temp (°C)	6.0	6.5	7.0	7.5	8.0
0	190	60.0	19.0	6.02	1.92
5	126	39.7	12.6	3.98	1.27
10	83.9	26.6	8.47	2.68	0.855
15	57.3	18.1	5.74	1.83	0.588
20	39.5	12.5	3.96	1.27	0.410

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Inset table shows the pH- and temperature-dependent CCME freshwater guideline for total ammonia.
Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Ammonia Concentration in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-23

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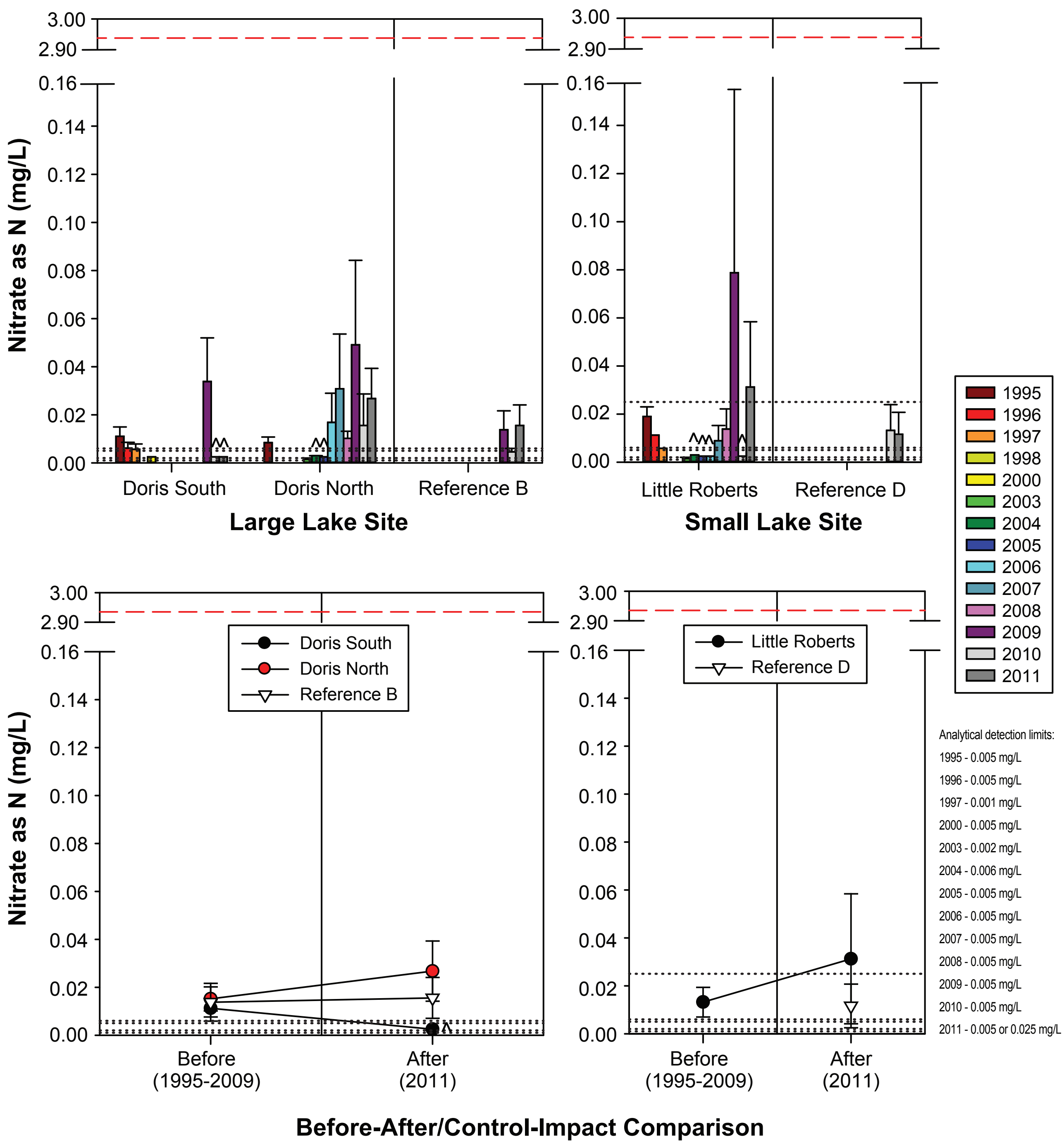

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed line represents the CCME freshwater guideline for nitrate as N (2.935 mg/L).
The anomalously high nitrate concentrations of 4.51 mg/L reported for Doris South in August 1996 and 5.3 mg/L reported for Little Roberts Lake in September 2004 were considered outliers and was excluded from plots.
Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Nitrate Concentration in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-24

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3.3.2.7 Total Cyanide

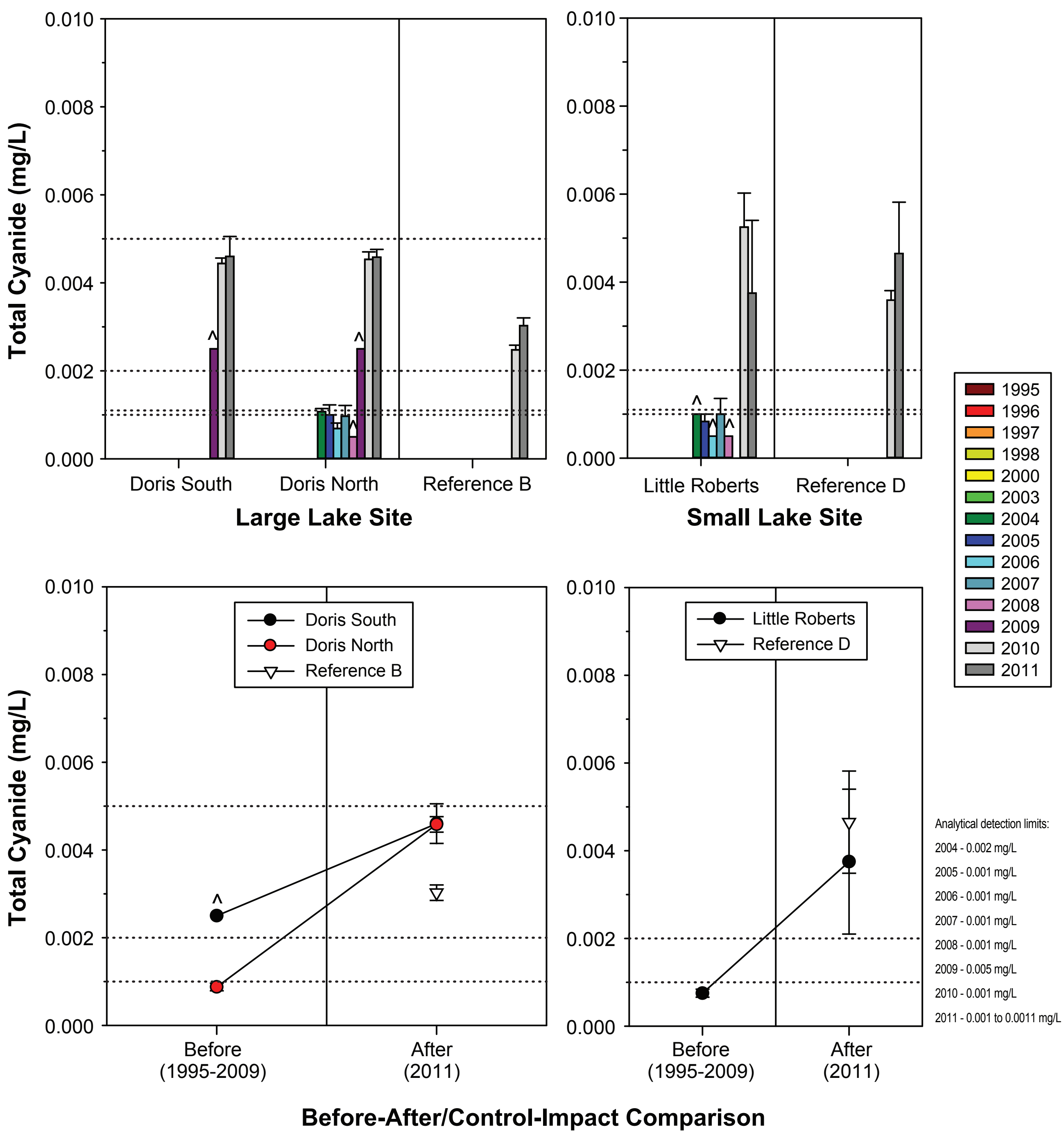
Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Similar to the pattern seen for streams, mean 2011 cyanide concentrations measured in the exposure lakes (0.0046 mg/L in both Doris Lake South and Doris Lake North, and 0.0038 mg/L in Little Roberts Lake) were similar to concentrations measured in the reference lakes (0.0030 mg/L in Reference Lake B, and 0.0047 mg/L in Reference Lake D; Figure 3.3-25). However, 2011 total cyanide concentrations in exposure lakes were higher than baseline annual means, which rarely exceeded 0.001 mg/L (Figure 3.3-25). The 2009 total cyanide concentrations measured in Doris Lake South and Doris Lake North were below the analytical detection limit of 0.005 mg/L (which was higher than the detection limit achieved for other years), so it is unknown whether concentrations in 2009 may have been similar to those in 2011. This complicates the analysis of total cyanide for these large lakes, particularly Doris Lake South for which the only available baseline cyanide data are from 2009. The before-after comparison showed that mean 2011 and baseline total cyanide concentrations were not significantly different for Doris Lake South ($p = 0.26$), marginally non-significantly different for Doris Lake North ($p = 0.01$), and significantly different for Little Roberts Lake ($p < 0.001$). Unfortunately, because there is no baseline total cyanide data for the reference lakes, a BACI analysis could not be performed to determine whether this increase in total cyanide in Little Roberts Lake is a natural phenomenon that also occurred in Reference Lake D.

The similarity of 2011 mean total cyanide concentrations between exposure and reference lakes suggests that any recent increase in cyanide at the exposure lakes is an analytical anomaly or a natural phenomenon that also occurred in lakes outside of the Project area. The particularly low concentration of total cyanide measured in lake samples collected between 2004 and 2008 were analyzed by the Alberta Research Council (ARC) Laboratory in Vegreville, AB, while the higher concentrations measured in 2010 and 2011 were analyzed by ALS Laboratory Group in Burnaby, BC (2009 concentrations were also analyzed by ALS, but because of the higher than usual detection limit, it is unclear whether concentrations may have been elevated in 2009). A laboratory discrepancy could explain the apparent increase in cyanide concentrations, as the timing of the increase coincided with a change in analytical laboratory. This could also be a natural phenomenon as cyanide is naturally produced by a wide variety of plants and microorganisms (Knowles 1979; Singleton 1986). It is highly unlikely that there was an anthropogenic cause for this increase in cyanide, as cyanide was not brought to the Project site in either 2010 or 2011. Cyanide concentrations will continue to be closely monitored in both reference and exposure lakes in the future.

Free cyanide concentrations (cyanide existing in the form of HCN and CN^-) in lake samples were measured for the first time in 2011 to allow for direct comparisons with the CCME guideline for cyanide (0.005 mg/L as free cyanide). Concentrations of free cyanide in lakes samples were almost always below the detection limits of 0.005 mg/L (July samples) or 0.001 mg/L (August and September samples; Appendix A). The only detectable concentrations of free cyanide were measured in the deep sample collected at Doris Lake South in August (0.0020 mg/L) and in both replicates collected at Reference Lake D in August (0.0034 and 0.0018 mg/L; Appendix A). Without exception, all free cyanide concentrations measured in lakes in 2011 were below the CCME guideline for free cyanide of 0.005 mg/L. Therefore, the cyanide in exposure lakes in 2011 would not be expected to pose a threat to freshwater aquatic life.

3.3.2.8 Radium-226

Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Concentrations of radium-226 measured in 2011 at all lake sites were near or below the analytical detection limit of 0.005 Bq/L (Figure 3.3-26). Baseline concentrations in exposure lakes were similarly near or below the detection limit of 0.005 Bq/L. Therefore, there was no evidence of an increase in radium-226 concentrations in exposure lakes in 2011. Statistical analysis results are not presented for radium-226 because > 80% of concentrations in the datasets for Doris Lake North and Little Roberts Lake were below analytical detection limits, and there is no baseline radium-226 data available for Doris Lake South.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Cyanide Concentration in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-25

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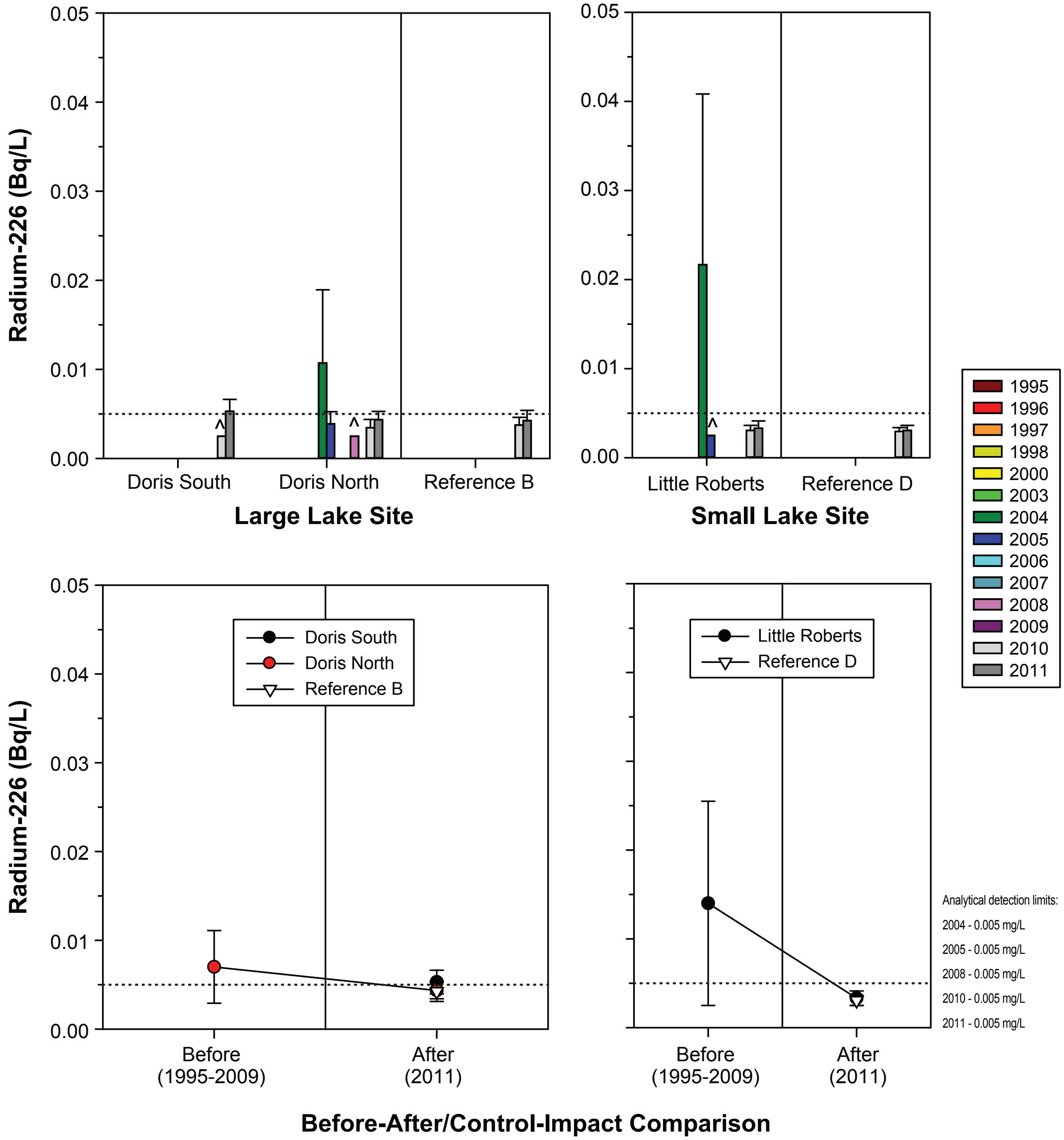

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

Figure 3.3-26

Radium-226 Concentration in AEMP Lake Sites, Doris North Project, 1995-2011

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3.3.2.9 Total Aluminum

Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. At both Little Roberts Lake and Reference Lake D, mean 2011 total aluminum concentrations exceeded the pH-dependent CCME guideline of 0.1 mg/L. However, this guideline was commonly exceeded in Little Roberts Lake between 1996 and 2009 (Figure 3.3-27). In the large lake sites, all 2011 and most baseline concentrations were below this CCME guideline. Concentrations of total aluminum measured in exposure lakes in 2011 were within the range of baseline concentrations (Figure 3.3-27). Therefore, there was no apparent effect of 2011 Project activities on total aluminum concentrations. The before-after analysis confirmed that the mean 2011 concentration was not distinguishable from the baseline mean for any exposure lake site ($p = 0.70$ for Doris Lake South, $p = 0.71$ for Doris Lake North, and $p = 0.79$ for Little Roberts Lake).

3.3.2.10 Total Arsenic

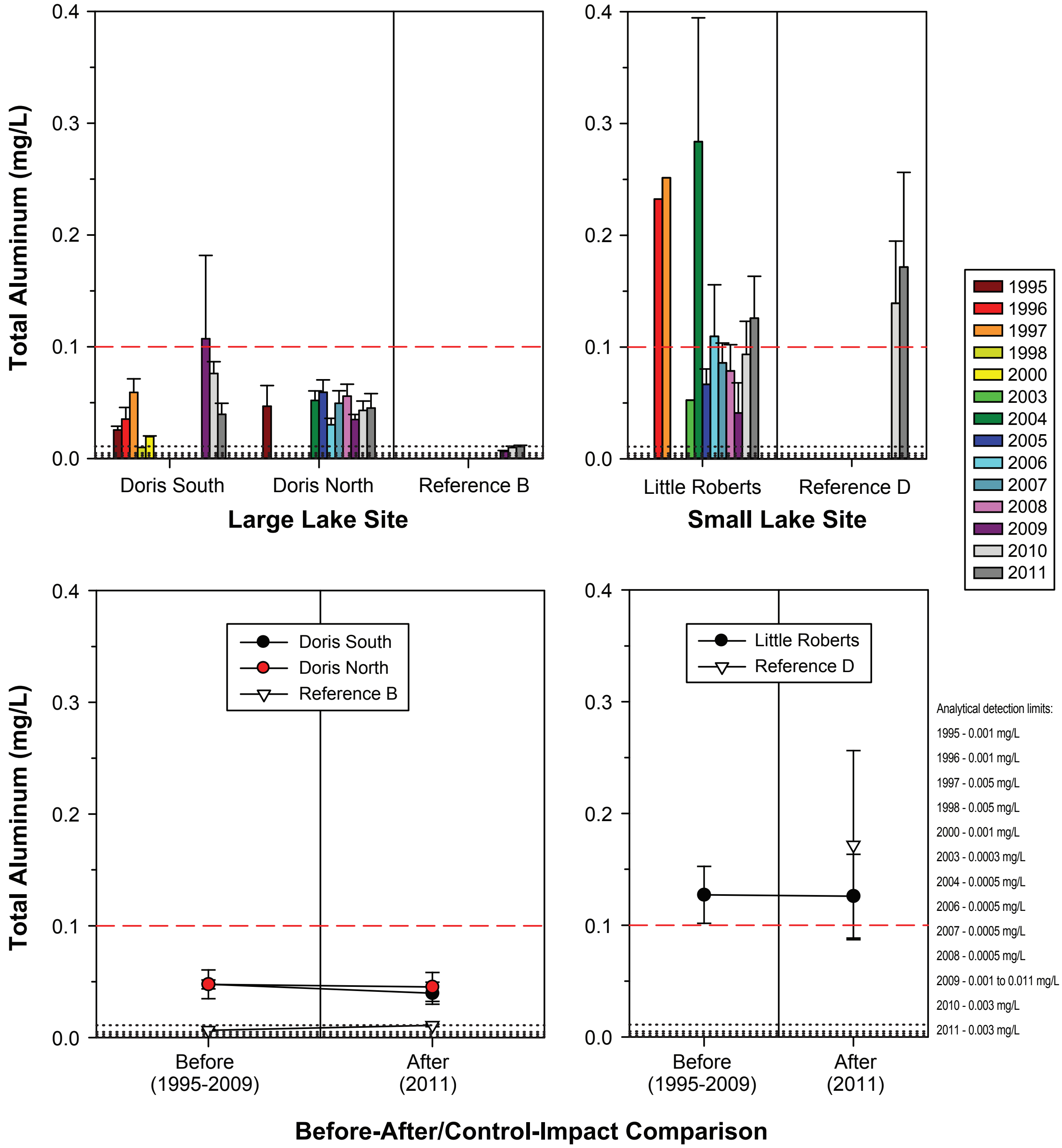
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2011 total arsenic concentrations in all exposure lakes were well below the CCME guideline of 0.005 mg/L, and were similar to or less than baseline means (Figure 3.3-28), so 2011 activities did not cause an increase in arsenic concentrations in lakes. For Doris Lake South and Little Roberts Lake, the before-after comparison showed that there was no difference between 2011 mean arsenic concentrations and baseline means ($p = 0.43$ for Doris Lake South, $p = 0.47$ for Little Roberts Lake). However, there was a significant difference between the baseline and 2011 mean for Doris Lake North ($p = 0.007$). In this case, arsenic concentrations were significantly lower in 2011 compared to historical levels, which is not of concern. Therefore, there was no adverse effect of 2011 Project activities on arsenic concentrations in the exposure lakes.

3.3.2.11 Total Cadmium

Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. In the large lake sites, mean 2011 cadmium concentrations were similar to or lower than baseline means, indicating that Project activities did not cause an increase in cadmium concentrations (Figure 3.3-29). Statistical analysis results are not presented for Doris Lake North and Doris Lake South because > 70% of cadmium concentrations in the baseline and 2011 datasets were below analytical detection limits. In Little Roberts Lake, the before-after analysis showed a slight increase in the mean cadmium concentration in 2011 compared to the baseline mean (once non-detectable outlier values from 1995-1997 were removed; $p = 0.009$); however, a high proportion (67%) of the concentrations in the dataset were below detection limits, and this apparent increase could be an artifact of substituting one half of the detection limit for values that were below detection. All 2011 total cadmium concentrations in exposure lakes were near or below analytical detection limits, and below the hardness-dependent CCME guideline for cadmium (Figure 3.3-29; Appendix A); therefore, there were no adverse effects of 2011 Project activities on total cadmium concentrations.

3.3.2.12 Total Copper

Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In all three exposure lakes, mean 2011 copper concentrations were within the range of baseline annual means and below the hardness-dependent CCME guideline (Figure 3.3-30). Therefore, there was no apparent effect of 2011 activities on total copper levels in any exposure lake. The before-after analysis confirmed that 2011 mean copper concentrations were not distinguishable from baseline means in the exposure lakes ($p = 0.37$ for Doris Lake South, $p = 0.46$ for Doris Lake North, and $p = 0.60$ for Little Roberts Lake).



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the pH-dependent CCME freshwater guideline for aluminum (0.005 mg/L at pH < 6.5; 0.1 mg/L at pH ≥ 6.5).
Mean annual pH levels were greater than 6.5 in all exposure and reference lakes.
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Aluminum Concentration in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-27

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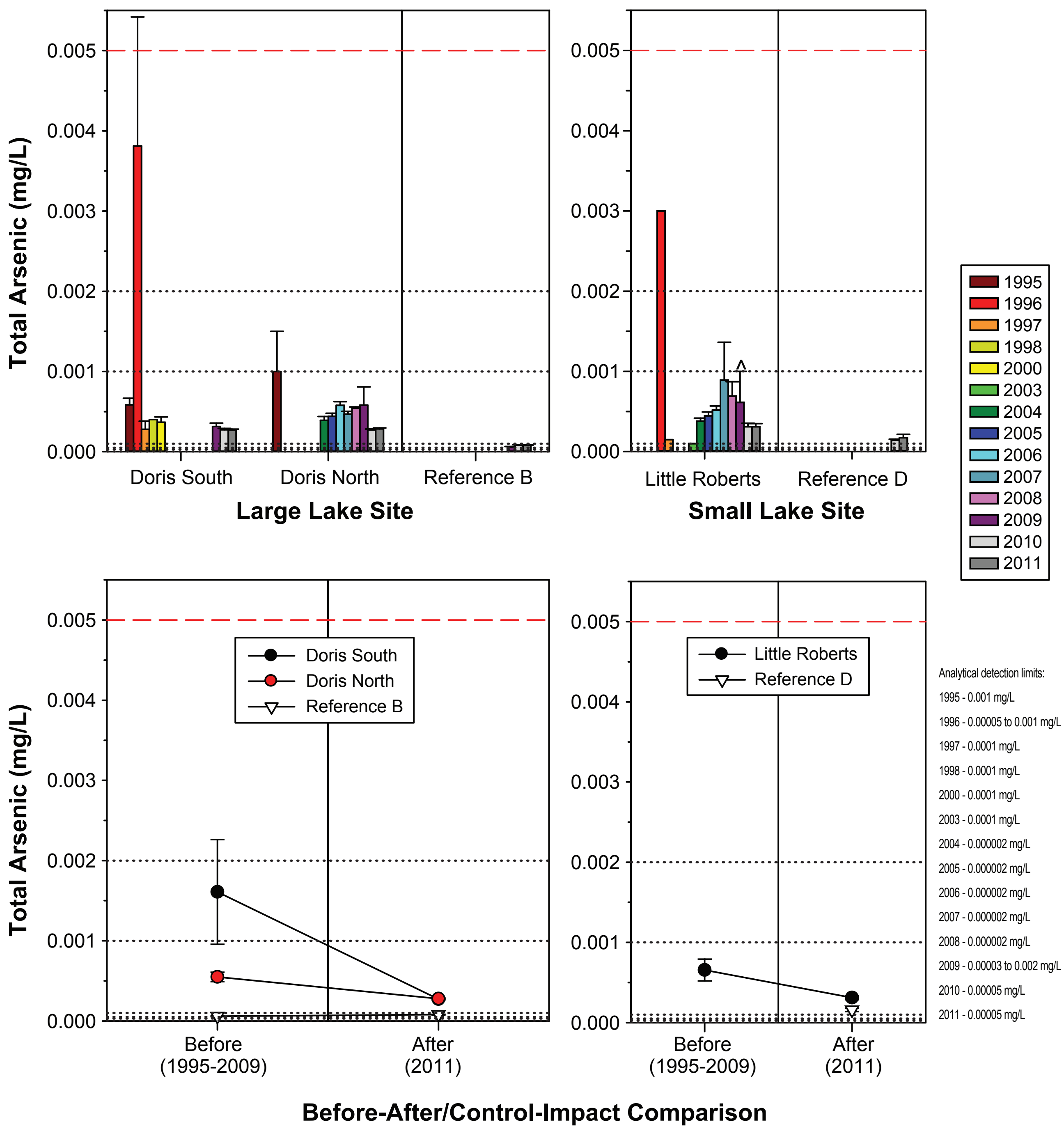

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater guideline for arsenic (0.005 mg/L).
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Arsenic Concentration in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-28

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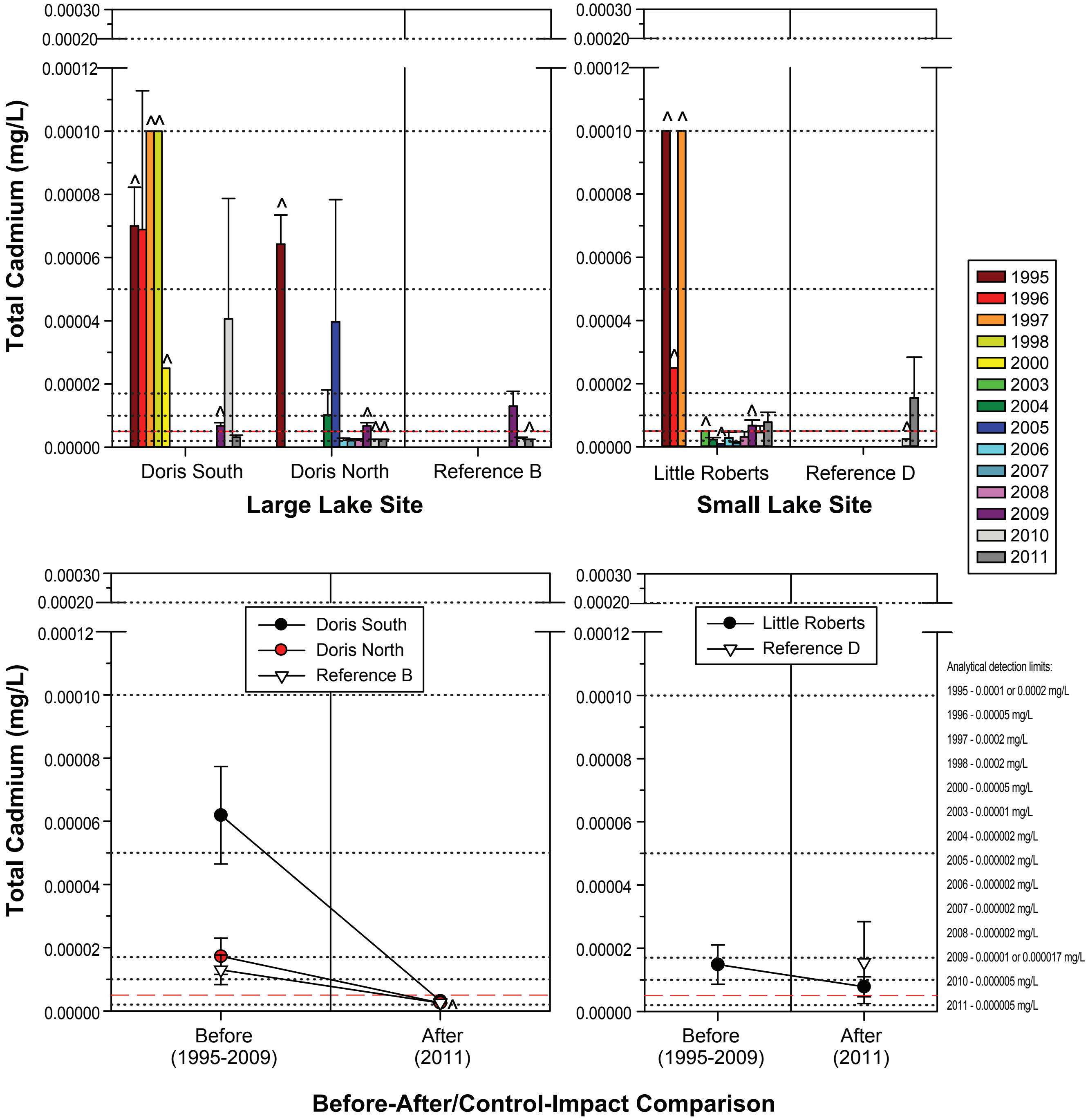

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline for cadmium is hardness dependent.
Red dashed lines represent the minimum CCME freshwater guideline for cadmium based on the minimum hardness measured in exposure and reference lakes between 1996 and 2011 (hardness: 12 mg/L; CCME guideline: 0.000005 mg/L).
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Cadmium Concentration in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-29

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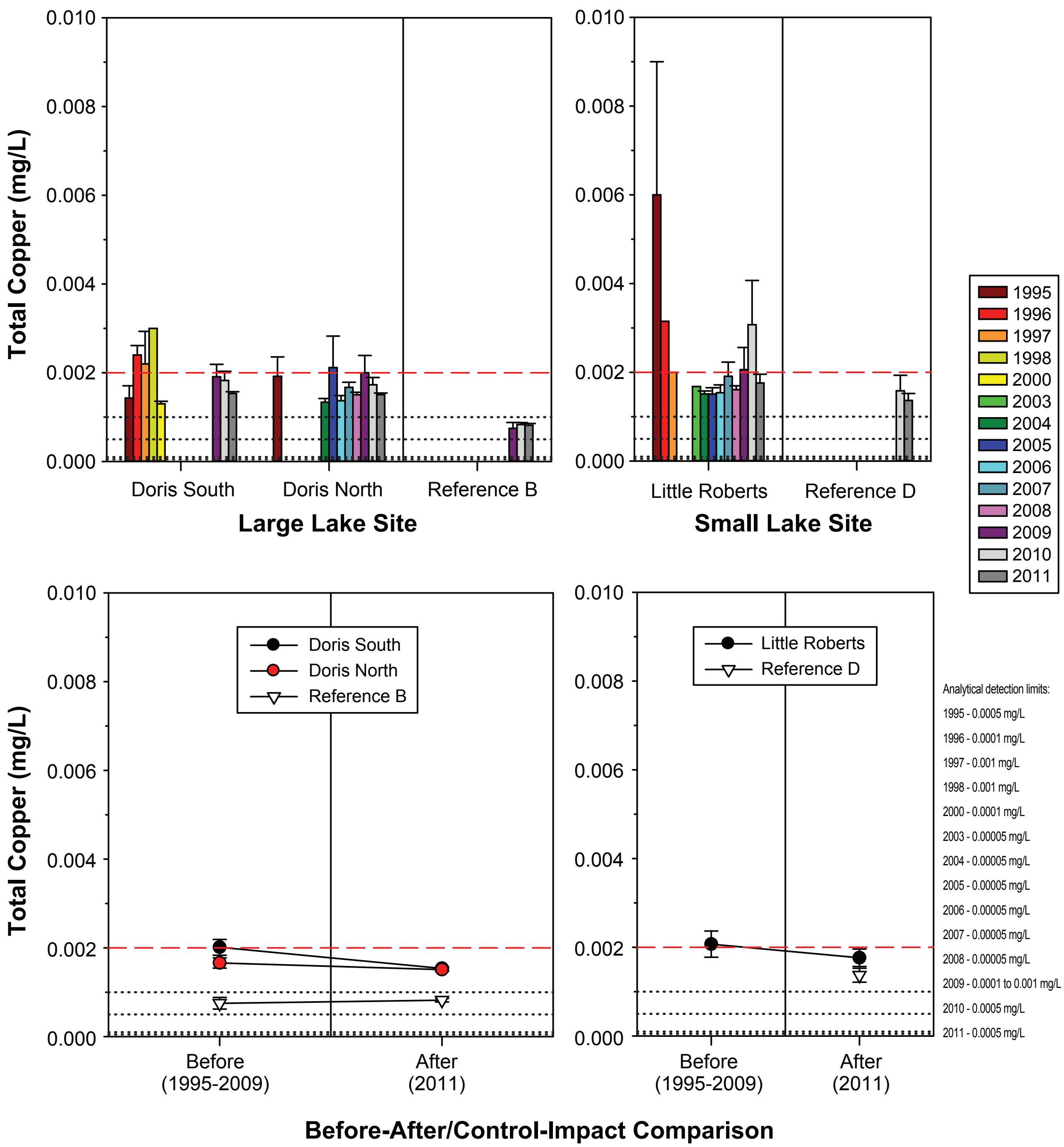

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
The CCME freshwater guideline for copper is hardness dependent.
Red dashed lines represent the minimum CCME freshwater guideline for copper regardless of water hardness (0.002 mg/L).
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Copper Concentration in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-30

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3.3.2.13 Total Iron

Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Mean 2011 total iron concentrations were within the range of baseline means at all exposure sites, suggesting that 2011 Project activities had no effect on iron concentrations (Figure 3.3-31). Mean 2011 concentrations exceeded the CCME guideline of 0.3 mg/L at both small lake sites, Little Roberts Lake and Reference Lake D; however, this guideline was commonly exceeded between 1996 and 2009 in Little Roberts Lake (Figure 3.3-31). The before-after comparison confirmed that there was no change in iron concentrations in the exposure lakes in 2011 compared to baseline concentrations ($p = 0.65$ for Doris Lake South, $p = 0.84$ for Doris Lake North, and $p = 0.82$ for Little Roberts Lake).

3.3.2.14 Total Lead

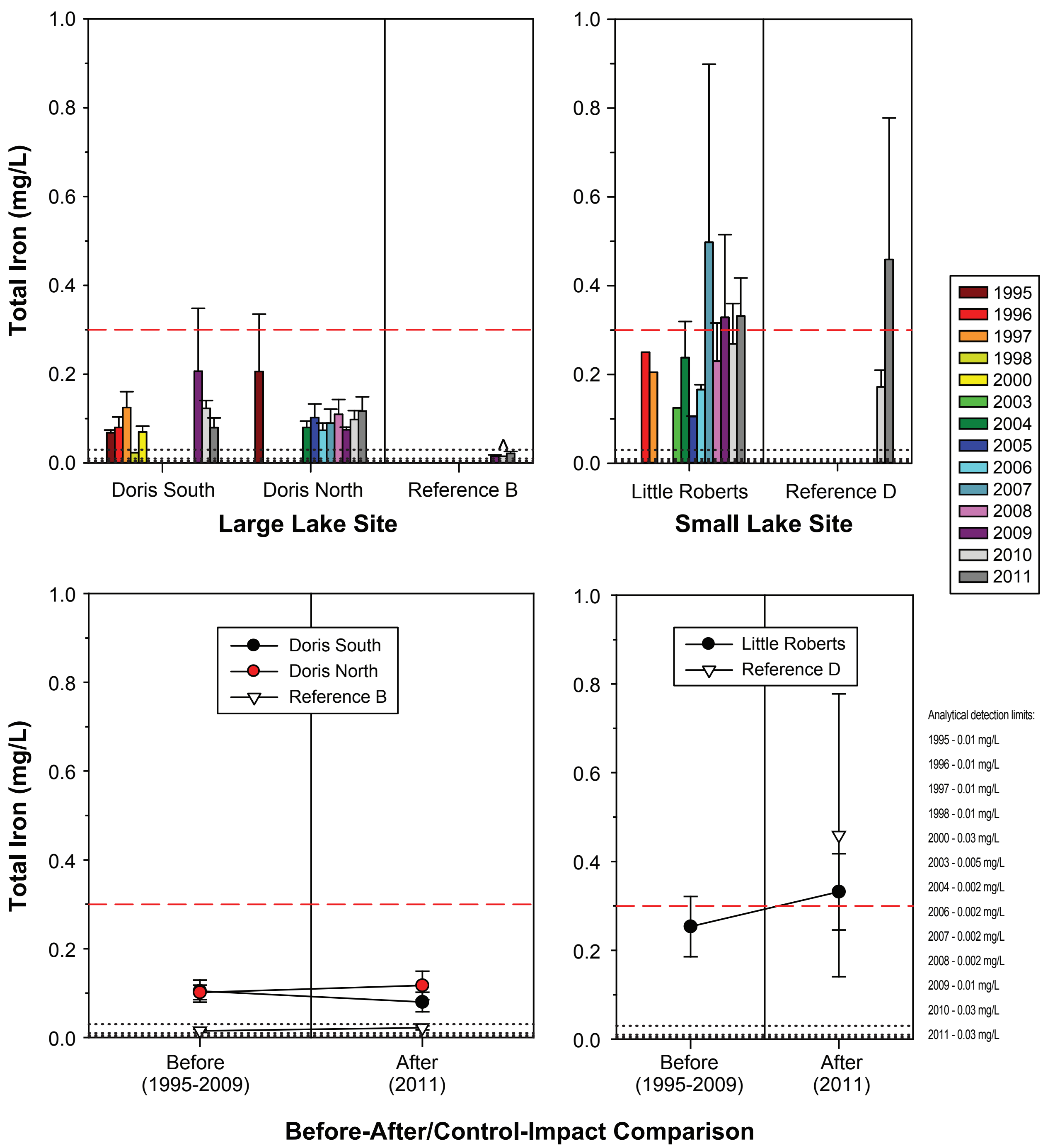
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean concentrations of total lead were inter-annually variable in all lakes, making it difficult to distinguish potential Project-related effects from natural variability (Figure 3.3-32). For all exposure lakes, the before-after analysis showed that mean 2011 total lead concentrations were not distinguishable from baseline means ($p = 0.92$ for Doris Lake South, $p = 0.86$ for Doris Lake North, and $p = 0.72$ for Little Roberts Lake), suggesting that 2011 Project activities had no effect on lead concentrations. Mean 2011 lead concentrations in all exposure lakes were below the hardness-dependent CCME guideline for lead (Figure 3.3-32).

3.3.2.15 Total Mercury

Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. A high proportion of total mercury concentrations in the datasets for exposure lakes were below detection limits (72% for Doris Lake South, 48% for Doris Lake North, and 57% for Little Roberts Lake). All total mercury concentrations measured in exposure and reference lakes in April 2010 were below the analytical detection limit of 0.00001 mg/L (Appendix A). Total mercury concentrations measured in exposure lakes between July and September 2011 were always above the ultra-low detection limit (0.0000005 mg/L) and ranged from 0.00000076 to 0.0000029 mg/L, which is well below the CCME guideline for inorganic mercury of 0.000026 mg/L (Figure 3.3-33; Appendix A). Comparisons to pre-2010 data are problematic because of the high proportion of data that were below detection limits, and the widely variable historical detection limits. The before-after analysis showed that there was no difference in means between baseline years and 2011 for Doris Lake North ($p = 0.90$) and Little Roberts Lake ($p = 0.66$), suggesting that Project activities did not affect total mercury concentrations in these exposure lake sites. At Doris Lake South, baseline total mercury concentrations were all below detection limits, but these detection limits were more than an order of magnitude higher than the detection limit achieved between July and September 2011 (Figure 3.3-33). Statistical results are not presented for Doris Lake South because of the high proportion of total mercury concentrations collected at this site that were below detection limits. However, total mercury concentrations measured at this site in 2011 were similar to concentrations measured at the other exposure and reference sites, and there was no evidence of a Project-related increase in total mercury concentrations at Doris Lake South.

3.3.2.16 Total Molybdenum

Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total molybdenum concentrations were generally similar over time within each lake (Figure 3.3-34), suggesting that there was no effect of 2011 activities on total molybdenum concentrations. For all three exposure lakes, the before-after comparison confirmed that there was no change in 2011 mean molybdenum concentrations compared to baseline means ($p = 0.92$ for Doris Lake South, $p = 0.047$ for Doris Lake North, and $p = 0.40$ for Little Roberts Lake). Mean 2011 total molybdenum concentrations in all lake sites were more than two orders of magnitude lower than the interim CCME guideline of 0.073 mg/L (Figure 3.3-34).



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater guideline for iron (0.3 mg/L).
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Iron Concentration in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-31

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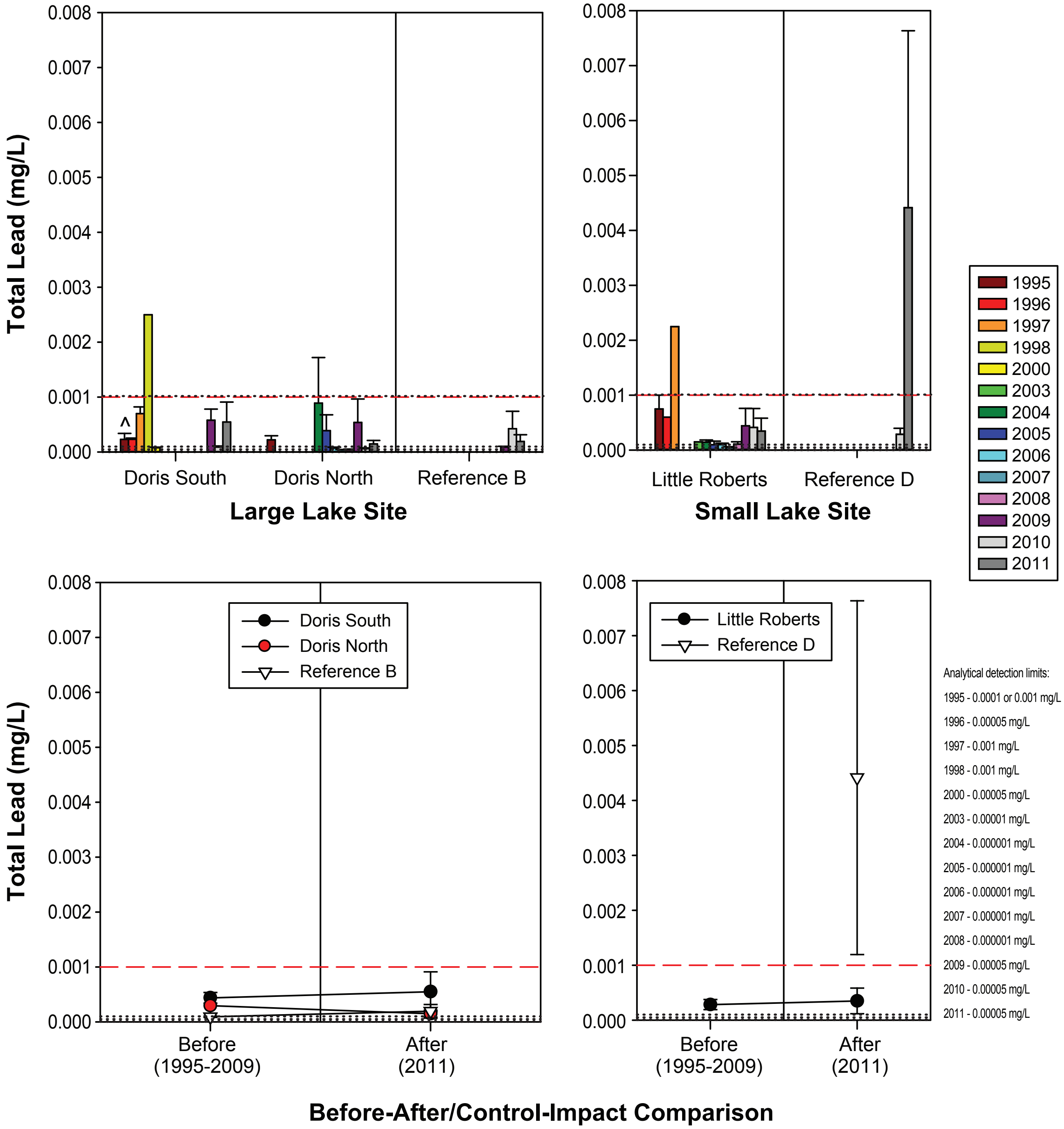
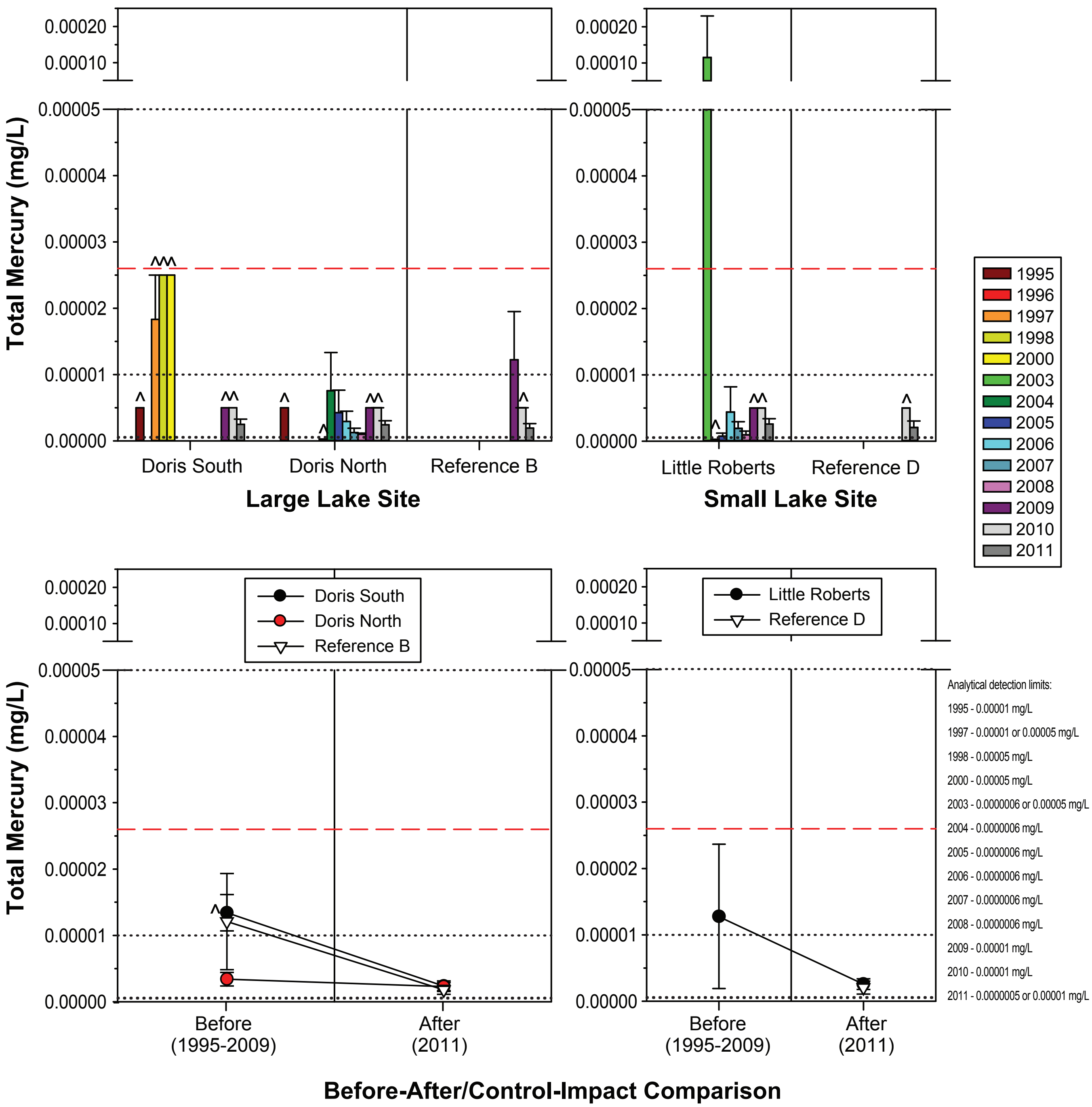


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline for lead is hardness dependent.
Red dashed lines represent the minimum CCME freshwater guideline for lead regardless of water hardness (0.001 mg/L).
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

Figure 3.3-32

Total Lead Concentration in AEMP Lake Sites, Doris North Project, 1995-2011



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater guideline for inorganic mercury (0.000026 mg/L).
Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Mercury Concentration in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-33

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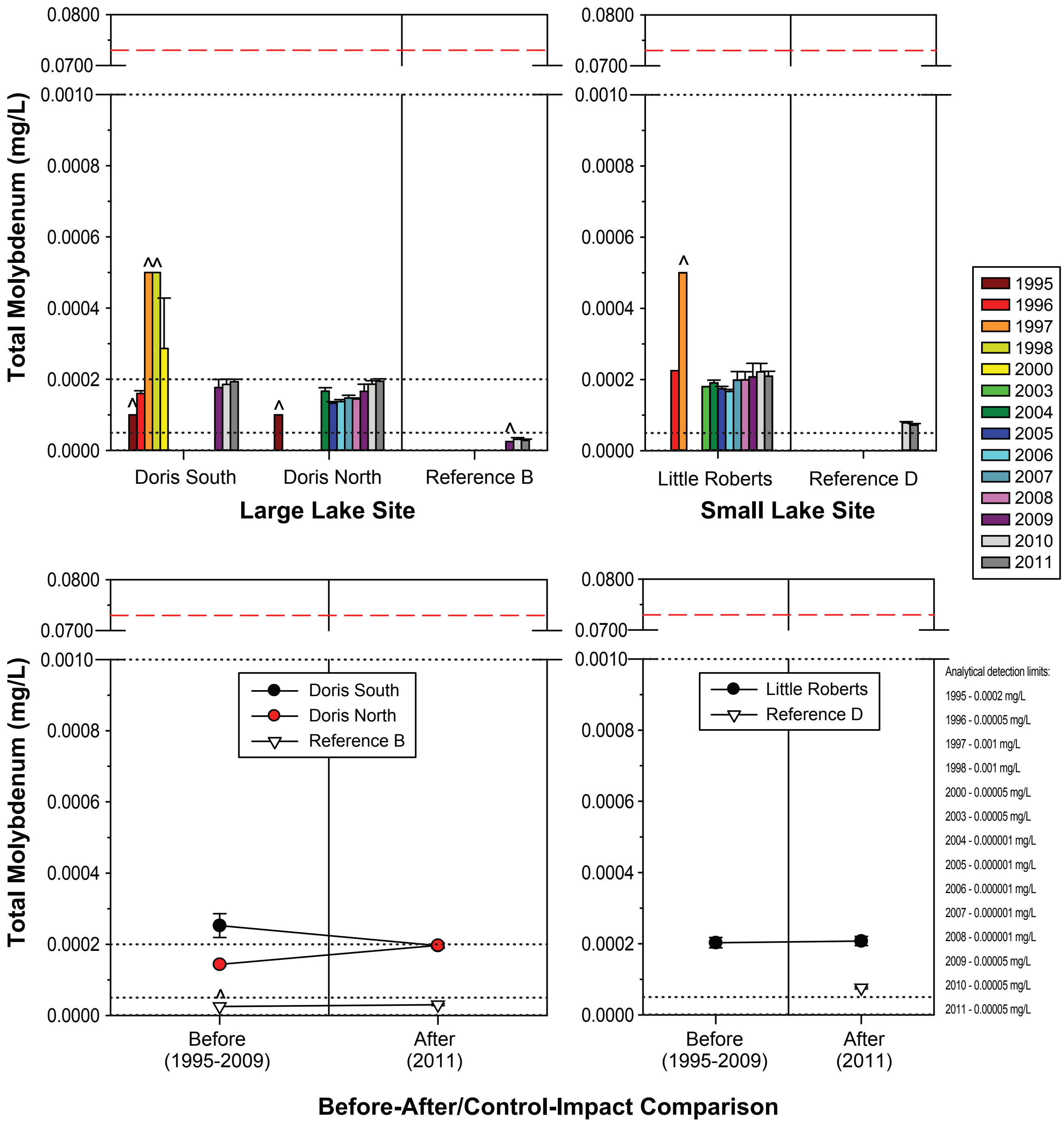

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the interim CCME freshwater guideline for molybdenum (0.073 mg/L).
Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Molybdenum Concentration in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-34

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3.3.2.17 Total Nickel

Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Total nickel concentrations measured in exposure lake sites in 2011 were well below the hardness-dependent CCME guideline for nickel and generally similar to baseline concentrations (Figure 3.3-35), suggesting that 2011 Project activities did not cause an increase in total nickel concentration in exposure lakes. The before-after comparison confirmed that mean nickel concentrations did not change significantly in any exposure lake in 2011 compared to baseline years ($p = 0.92$ for Doris Lake South, $p = 0.88$ for Doris Lake North, and $p = 0.85$ for Little Roberts Lake).

3.3.2.18 Total Zinc

Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. In 2011, all total zinc concentrations measured in exposure lakes were below the analytical detection limit of 0.003 mg/L and the CCME guideline of 0.03 mg/L (Figure 3.3-36). Therefore, there was no evidence of an increase in zinc in exposure lakes as a result of 2011 activities.

3.3.3 Marine

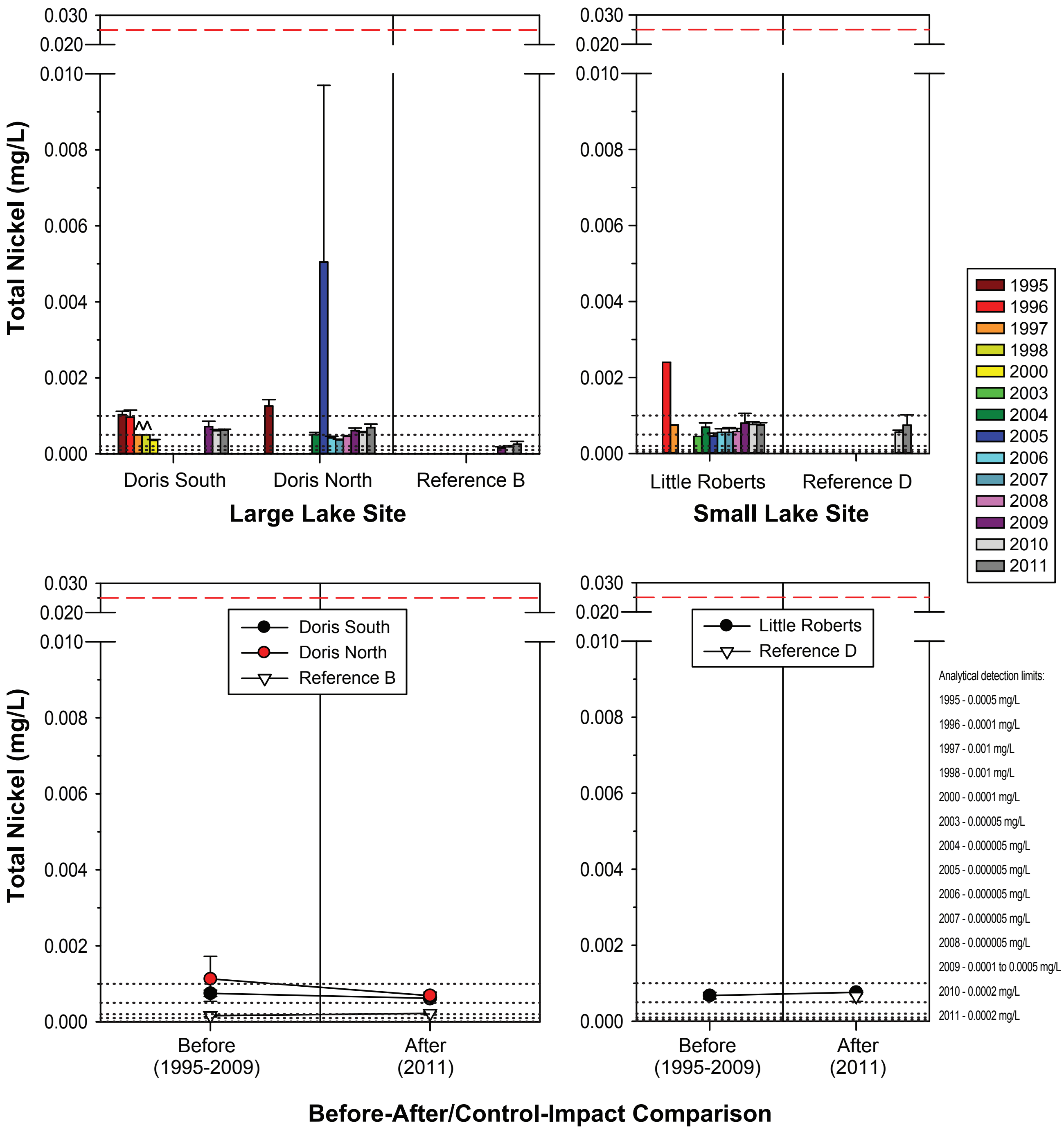
Water quality samples from marine areas were collected from two exposure sites in Roberts Bay (RBW and RBE) and one reference site in Ida Bay (REF-Marine 1) in 2011. Baseline data from 2009 are available for all sites, and additional baseline data from 1996 and 2004 to 2008 are available for site RBE. All 2011 samples were collected at the surface (0.5 to 1 m depth), so any baseline data collected from near the water-sediment interface were excluded from the baseline dataset used for the effects analyses. Graphs showing water quality trends in marine sites over time are shown in Figures 3.3-37 to 3.3-54, and all statistical results are presented in Appendix B.

3.3.3.1 pH

pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER. Mean 2011 pH levels in marine exposure and reference sites were always within the recommended marine CCME guideline range of 7.0 to 8.7 (Figure 3.3-37). pH levels measured at RBW and RBE in 2011 were similar to levels measured at REF-Marine 1 and to baseline pH levels (Figure 3.3-37). Marine environments have a high buffering capacity compared to freshwater systems, so pH levels are relatively insensitive to change. The before-after comparison confirmed that there was no change in marine pH at the exposure sites in 2011 compared to baseline years ($p = 0.055$ for RBW and $p = 0.51$ for RBE). Therefore, there was no apparent effect of 2011 Project activities on marine pH.

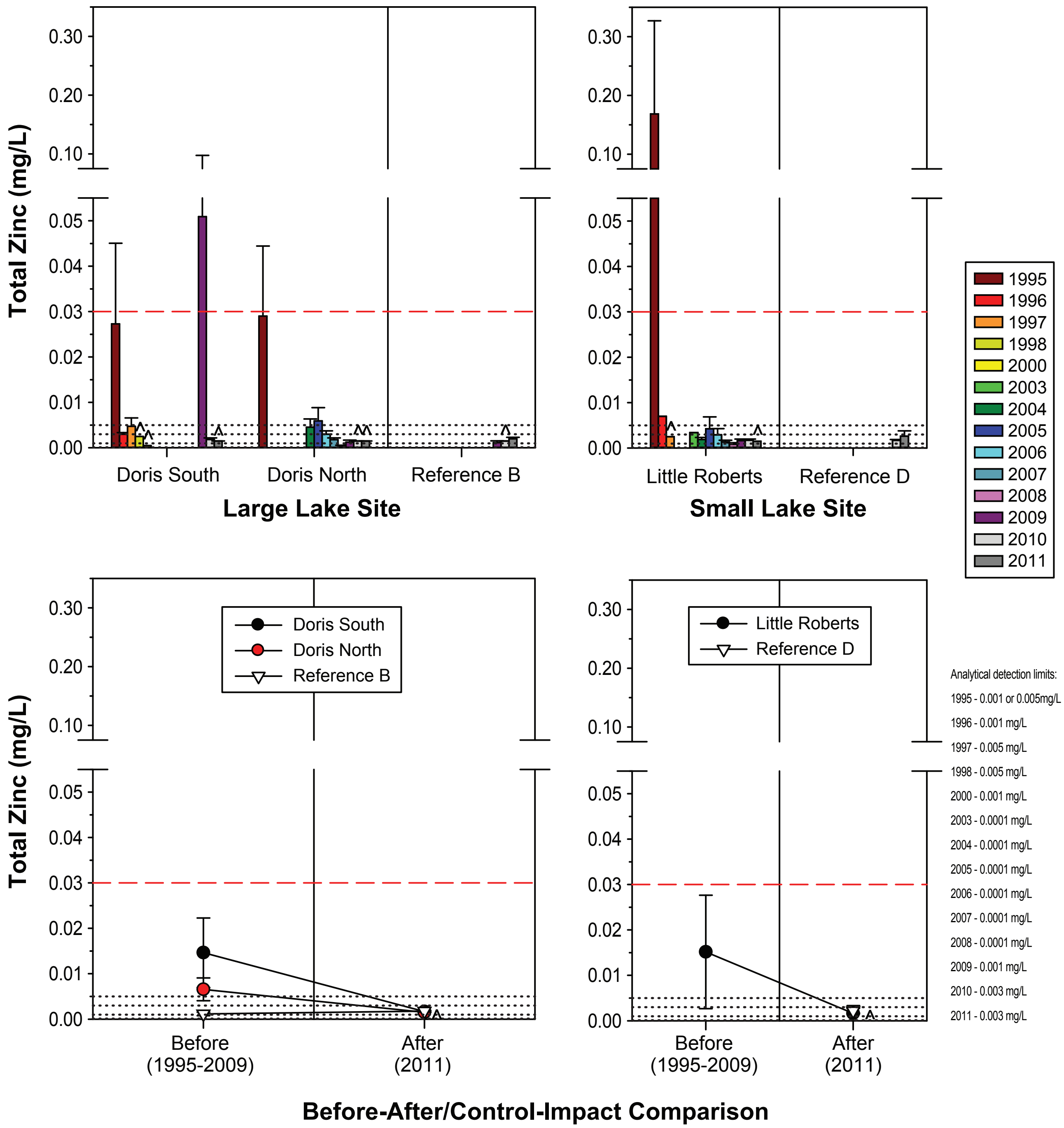
3.3.3.2 Total Alkalinity

Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. RBE is the only site for which baseline total alkalinity data are available. At this site, the mean 2011 alkalinity was slightly higher than the baseline mean, but there was some overlap in alkalinity values because of high within-year variability (Figure 3.3-38). The before-after comparison indicated that there was no statistically significant change in alkalinity in 2011 at RBE compared to baseline levels ($p = 0.051$). Therefore, there is no evidence of an effect of Project activities on alkalinity at this site. Although no statistical analysis is possible for site RBW, 2011 alkalinity levels were generally comparable among the three sites monitored (RBE, RBW, and REF-Marine 1; Figure 3.3-38). Freshwater inputs can affect marine alkalinity because, as observed in lakes and streams sampled as part of the AEMP, freshwater typically has lower alkalinity than marine water. Any variability in alkalinity levels in Roberts Bay was likely due to natural inter-annual variability in the volume of freshwater inflow to Roberts Bay.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME freshwater guideline for nickel is hardness dependent.
Red dashed lines represent the minimum CCME freshwater guideline for nickel regardless of water hardness (0.025 mg/L).
Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

Total Nickel Concentration in AEMP Lake Sites, Doris North Project, 1995-2011



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater guideline for zinc (0.03 mg/L).
Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Zinc Concentration in AEMP Lake Sites, Doris North Project, 1995-2011

Figure 3.3-36

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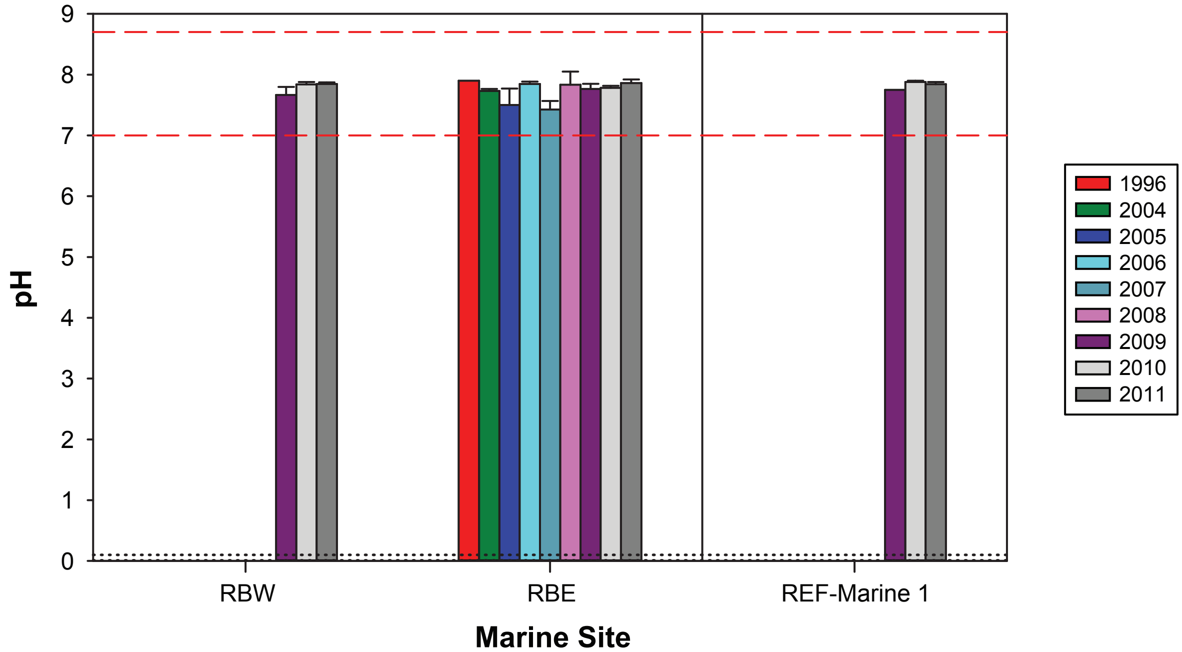

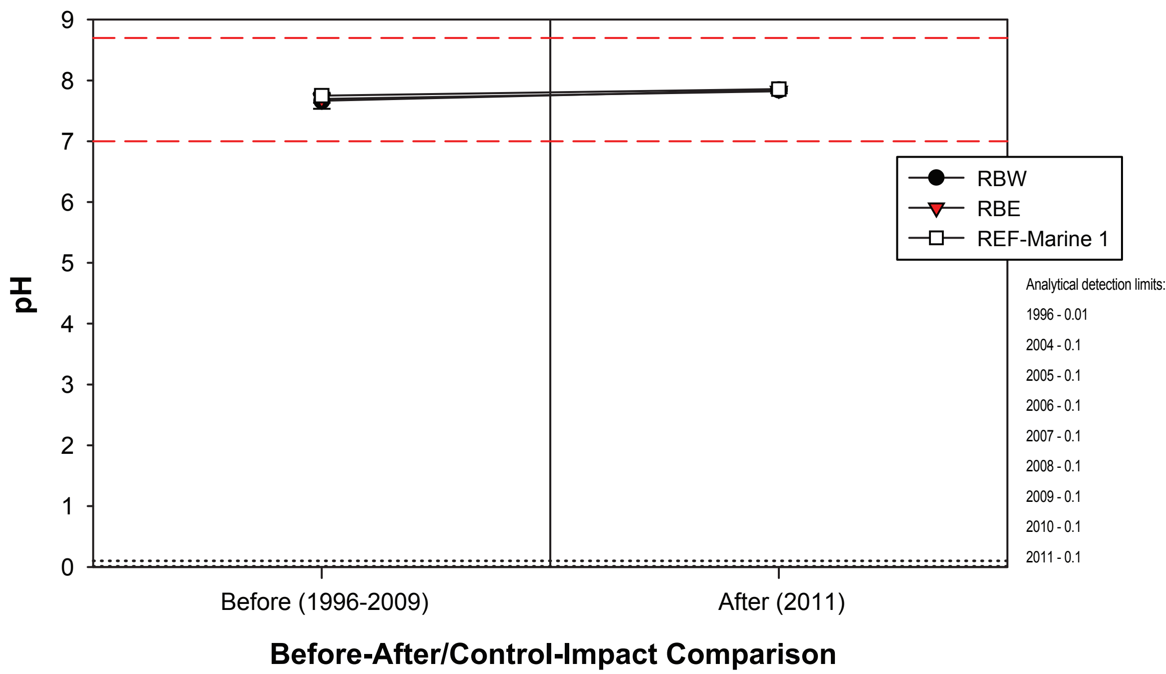

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
Red dashed lines represent the CCME marine and estuarine guideline pH range (7.0–8.7).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER.

Figure 3.3-37

pH in AEMP Marine Sites, Doris North Project, 1996-2011

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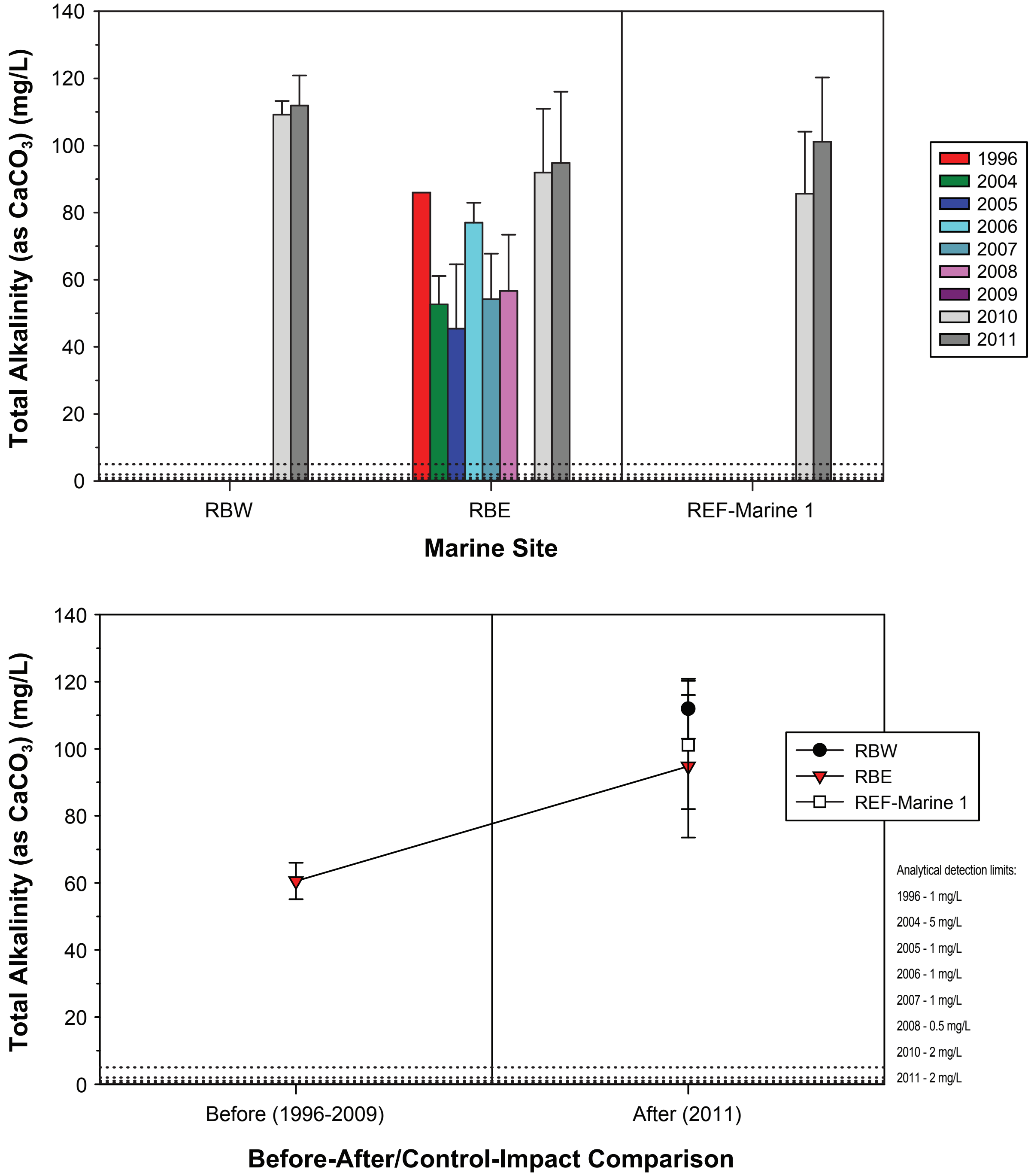

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

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Total Alkalinity in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-38

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3.3.3.3 Hardness

Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER. Hardness (as $CaCO_3$) levels measured in 2011 in Roberts Bay sites were generally similar to baseline hardness levels, and were also similar to the hardness levels measured in Ida Bay (Figure 3.3-39). The before-after comparison confirmed that 2011 hardness levels at RBW and RBE were not distinguishable from baseline levels ($p = 0.83$ for RBW and $p = 0.51$ for RBE), suggesting that there was no effect of 2011 Project activities on the hardness of marine waters.

3.3.3.4 Total Suspended Solids

TSS are regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2011 TSS concentrations at RBW and RBE were lower than baseline means (Figure 3.3-40). For site RBE, the before-after comparison indicated that the 2011 mean was not statistically distinguishable from the baseline mean ($p = 0.25$). Statistical analysis results for RBW are not presented because of the high proportion of data that were below detection limits (73%); however, concentrations in 2011 were lower than in 2009, and decreases in TSS concentrations are not of concern. There were no apparent adverse effects of 2011 Project activities on marine TSS concentrations.

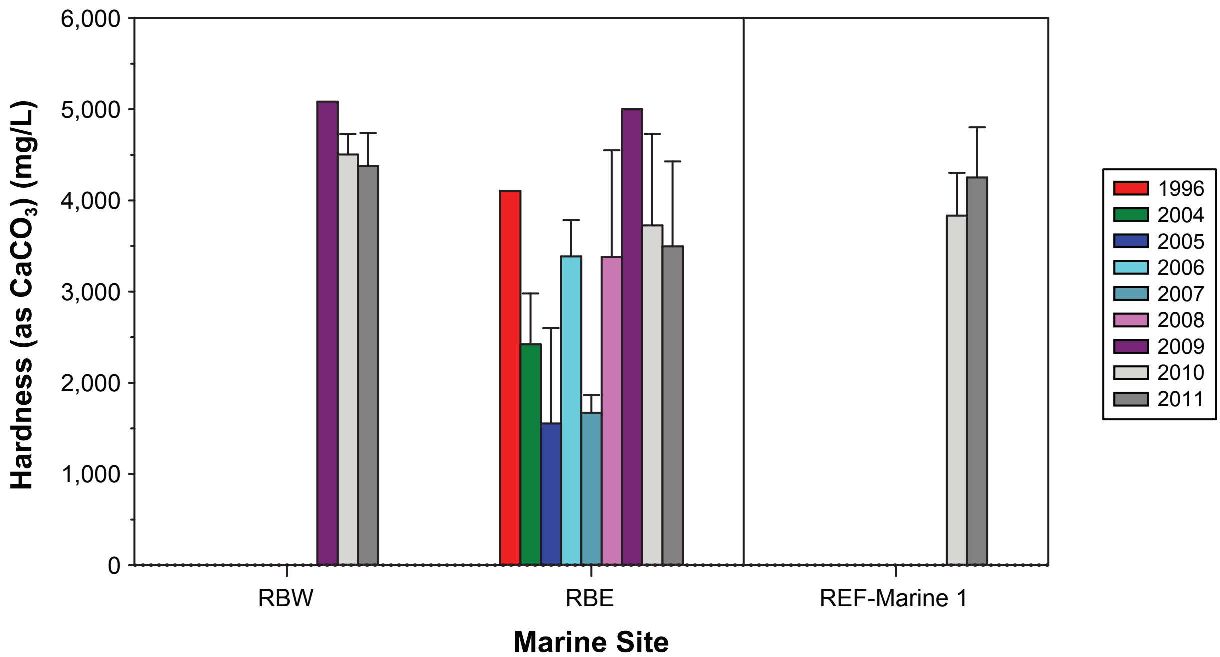
The marine CCME guideline for TSS is dependent upon background levels (for clear-flow waters with background TSS levels below 25 mg/L, a maximum increase of 25 mg/L is allowable for any short-term exposure or 5 mg/L for longer term exposure; CCME 2011b). Because there was no increase in TSS concentrations from background levels at either RBW or RBE, 2011 TSS concentrations in marine exposure sites were below the CCME guideline.

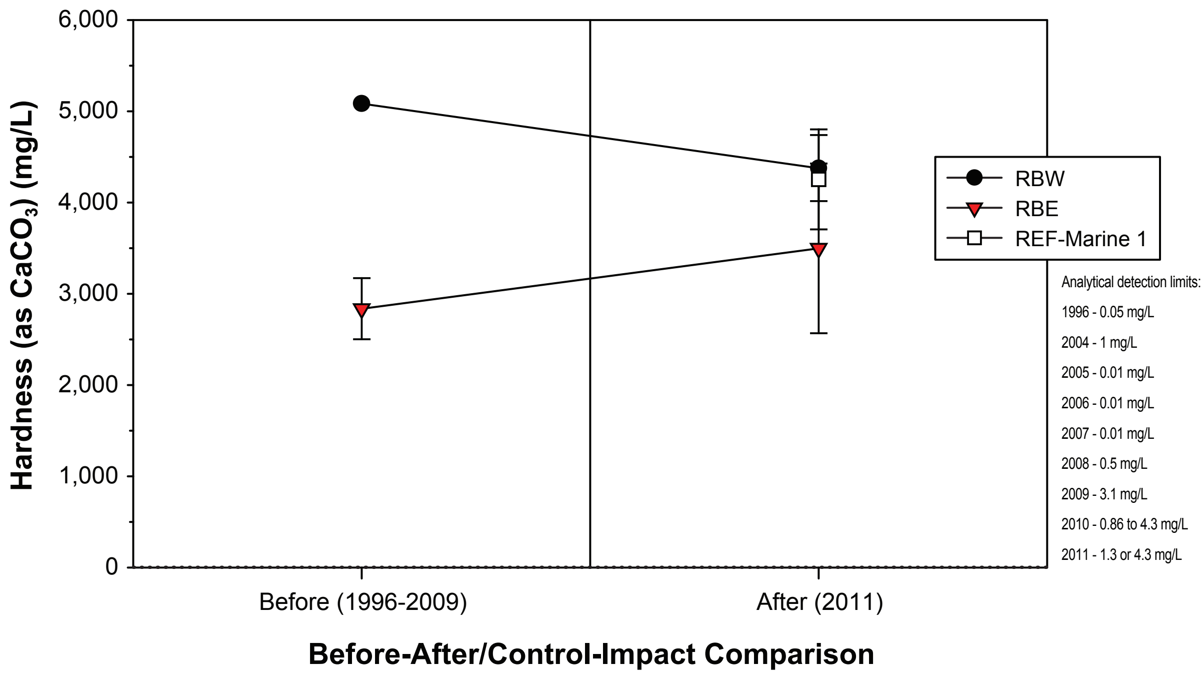
3.3.3.5 Total Ammonia

Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Total ammonia concentrations in all 2011 samples from Roberts Bay were near or below the analytical detection limit of 0.005 mg ammonia-N/L (Figure 3.3-41). At site RBE, baseline ammonia concentrations were widely variable and were frequently higher than 2011 concentrations (Figure 3.2-41). The before-after comparison showed that the 2011 mean total ammonia concentration at RBE was not significantly different from the baseline mean ($p = 0.37$). Statistical analysis results for RBW are not presented because of the high proportion of data that were below detection limits (73%). There was no evidence of an effect of 2011 Project activities on total ammonia concentrations in the marine environment.

3.3.3.6 Nitrate

Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All 2011 and baseline nitrate concentrations measured in marine reference and exposure sites were well below the marine CCME guideline of 3.612 mg nitrate-N/L (Figure 3.3-42). The mean 2011 nitrate concentration at RBW was higher than the mean 2009 concentration (Figure 3.3-42), but the before-after analysis indicated that the 2009 and 2011 means were not statistically distinguishable ($p = 0.78$). At site RBE, the 2011 mean was within the range of baseline means, but statistical analysis results are not presented because 81% of the nitrate concentrations in the RBE dataset were below analytical detection limits. There was no apparent effect of 2011 Project activities on nitrate concentrations in the marine exposure sites.





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

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Hardness in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-39

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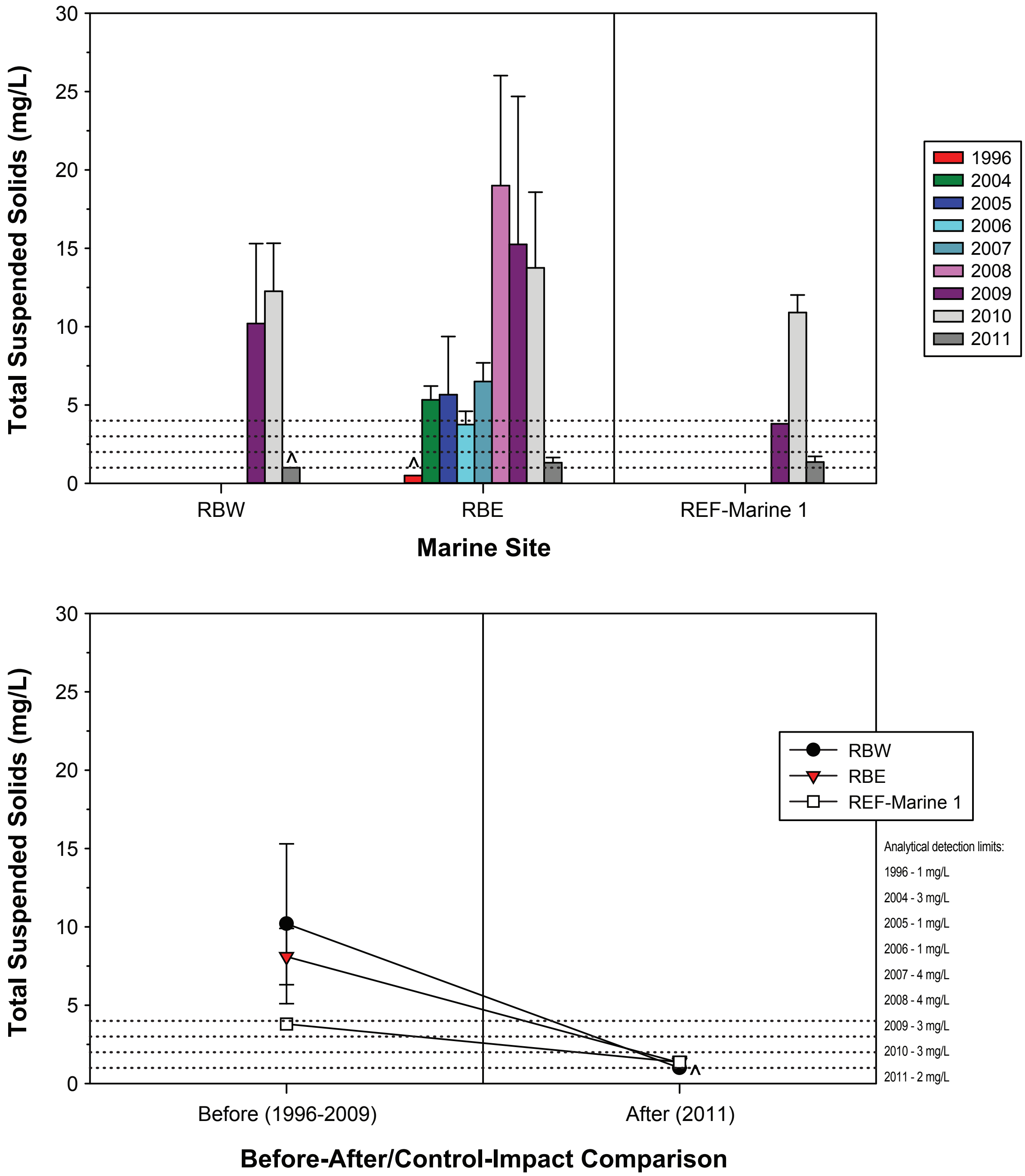

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
The CCME marine guideline for total suspended solids is dependent upon background levels.
Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Total Suspended Solids Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-40

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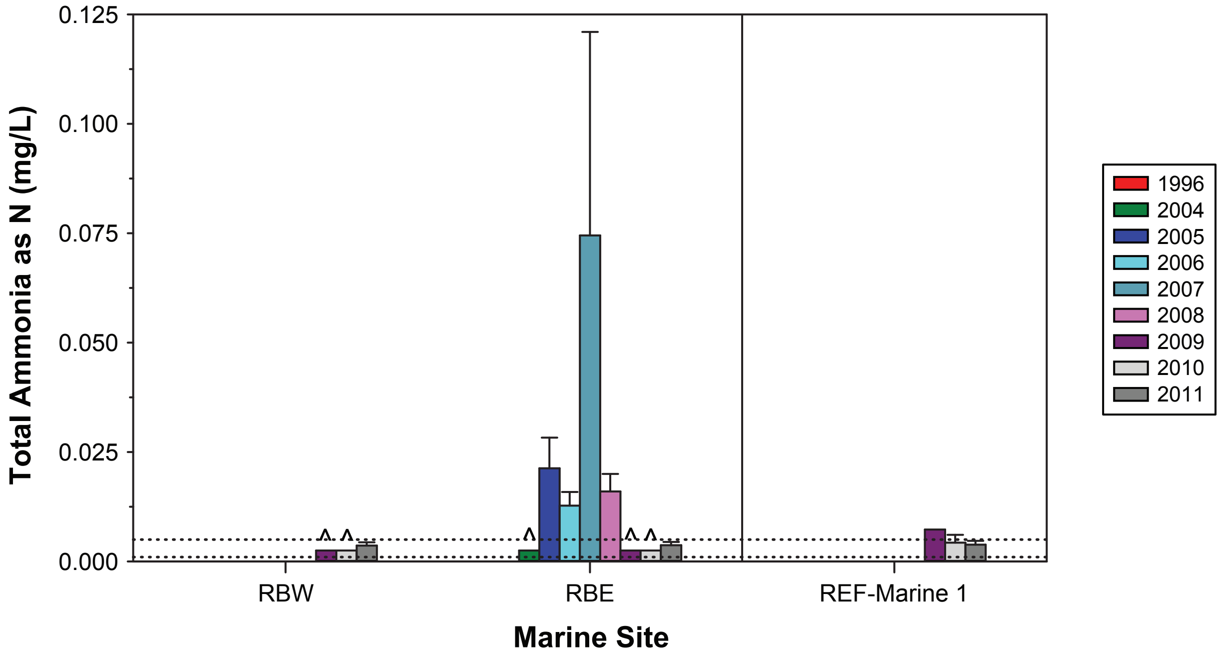

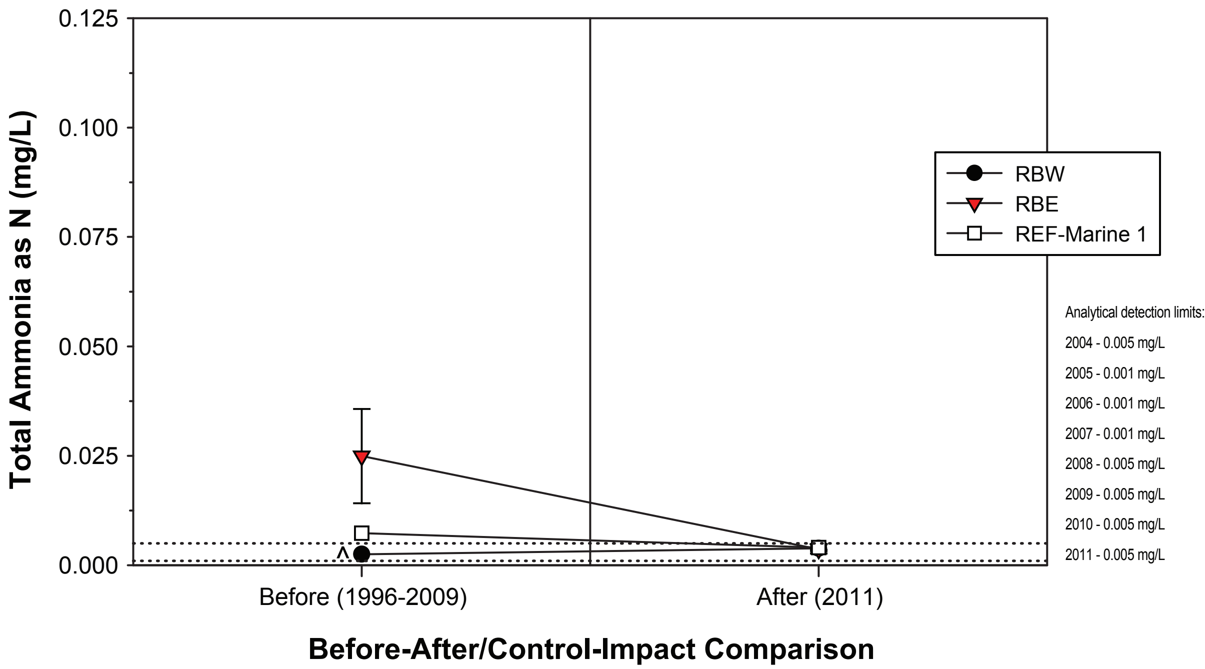

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Sample concentrations that were below the very high detection limit of 5 mg/L were excluded from plots.
^ Indicates that concentrations were below the detection limit in all samples.
Total ammonia is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

Total Ammonia Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-41

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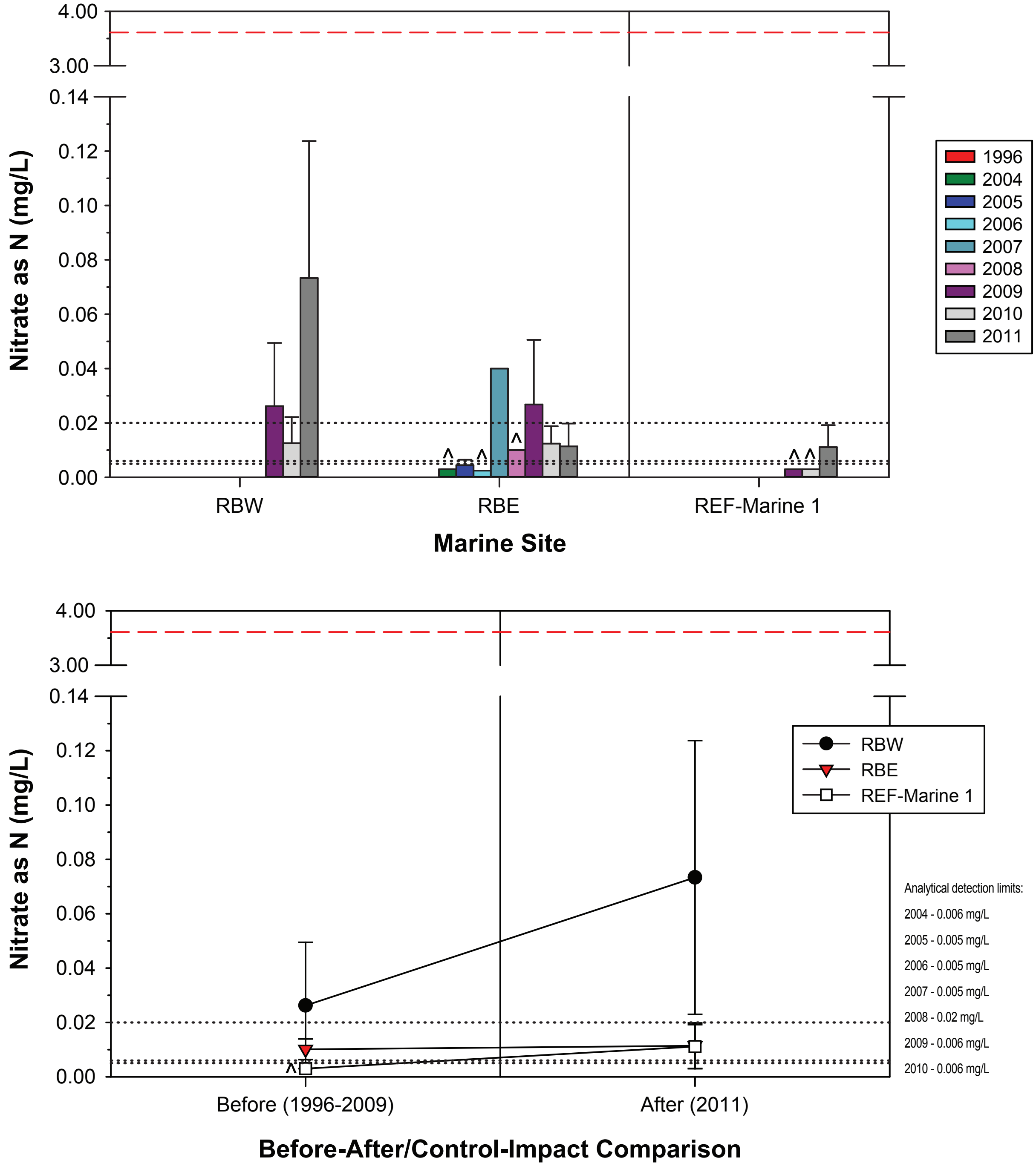

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Sample concentrations that were below the very high detection limits of 0.1, 0.5, or 2.5 mg/L were excluded from plots.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the interim marine CCME guideline for nitrate as N (3.612 mg/L).
Nitrate is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

NEWMONT NORTH AMERICA

Nitrate Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-42

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3.3.3.7 Total Cyanide

Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. At site RBE, the only site for which baseline cyanide data are available, baseline and 2011 cyanide concentrations were usually near or below the detection limit, except some relatively high concentrations measured in 2005 (Figure 3.3-43). The mean 2011 cyanide concentration at site RBE was within the range of baseline concentrations, and the before-after analysis showed that the 2011 mean was not distinguishable from the baseline mean (p = 0.78). Although statistical analysis was not possible for RBW because there was no baseline data for this site, mean 2011 cyanide concentrations were similarly low among all marine exposure and reference sites (Figure 3.3-43). Cyanide was not brought to the Project site in 2011, so there is no reason to expect that cyanide concentrations would increase in either of the marine exposure sites due to Project activity.

3.3.3.8 Radium-226

Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. All radium-226 concentrations measured at marine sites in 2011 were near or below the analytical detection limit of 0.005 Bq/L (Figure 3.3-44). At site RBE, 2011 concentrations were within the range of baseline concentrations, and the before-after analysis found that there was no difference in means between 2011 and baseline years (p = 0.94). Although statistical analysis was not possible for RBW because there was no baseline data for this site, mean 2011 radium-226 concentrations were similarly low among all marine exposure and reference sites (Figure 3.3-43). Therefore, there was no evidence of an increase in radium-226 concentrations in the marine exposure sites as a result of 2011 activities.

3.3.3.9 Total Aluminum

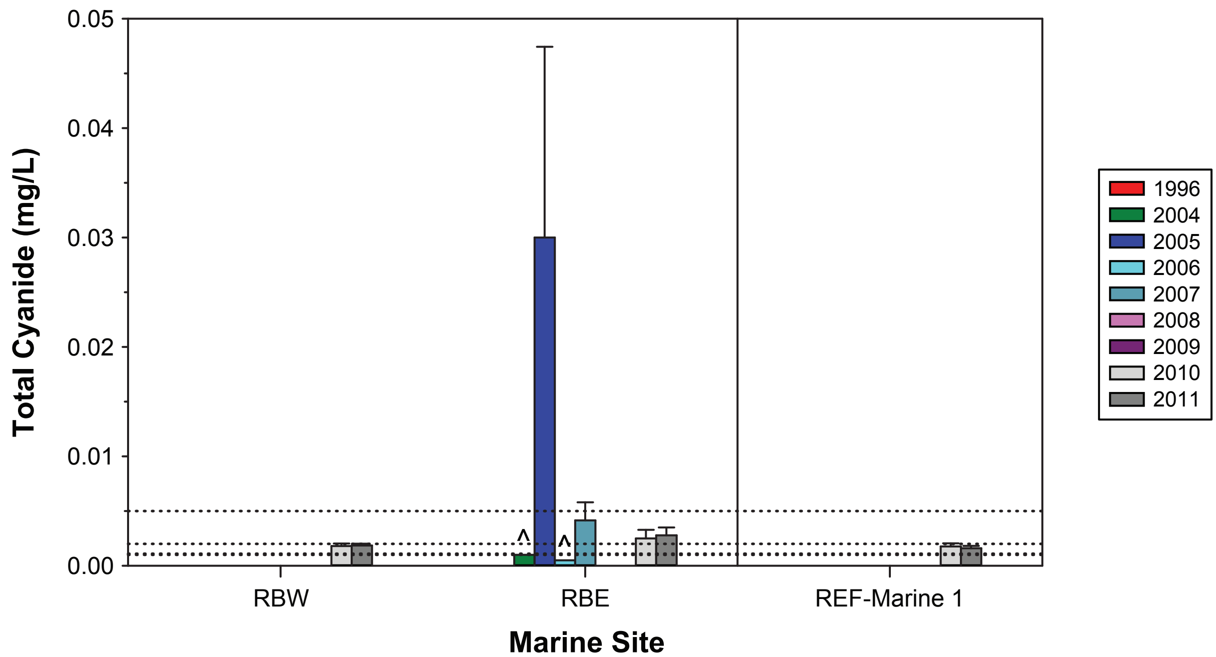
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. At site RBE, the mean 2011 total aluminum concentration was within the range of baseline means (Figure 3.3-45). At site RBW, the 2011 mean was slightly higher than the 2009 mean (Figure 3.3-45). The before-after comparison showed that for both marine exposure sites, the 2011 means were not statistically different from the baseline means (p = 0.086 for RBW and p = 0.65 for RBE). This indicates that there was no effect of Project activities on total aluminum concentrations at the Roberts Bay exposure sites.

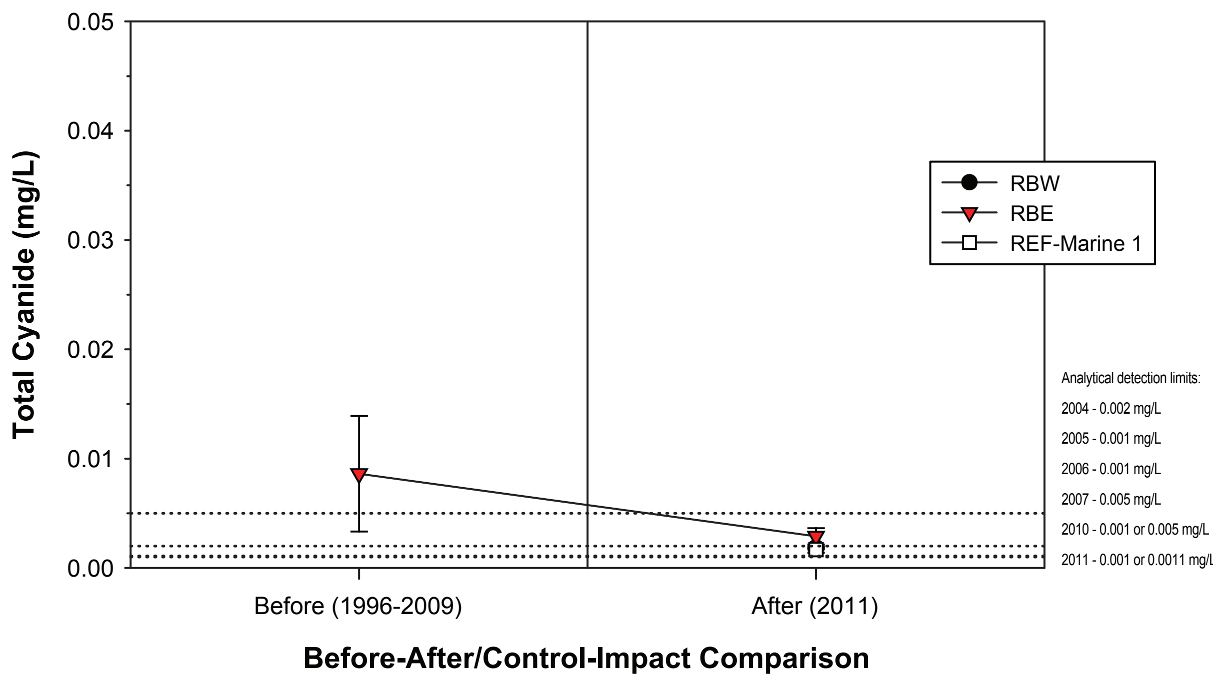
3.3.3.10 Total Arsenic

Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. All total arsenic concentrations measured at marine exposure and reference sites in 2011 were well below the marine CCME guideline of 0.0125 mg/L (Figure 3.3-46). Arsenic concentrations measured at exposure sites in 2011 were similar to historical concentrations measured between 2007 and 2009, but were much lower than the anomalously high arsenic concentrations measured at RBE between 2004 and 2006, which were typically more than an order of magnitude higher than 2011 concentrations (Figure 3.3-46). These unusually high arsenic concentrations were treated as outliers and removed from the dataset for the statistical analyses to increase the ability of statistical tests to detect differences. The before-after comparisons revealed that the 2011 mean arsenic concentrations at RBW and RBE were not distinguishable from baseline means (p = 0.19 for RBW and p = 0.78 for RBE). Therefore, 2011 Project activities did not affect total arsenic concentrations at the marine exposure sites.

3.3.3.11 Total Cadmium

Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. In 2011, all total cadmium concentrations in samples collected from RBW, RBE, and REF-Marine 1 were below the marine CCME guideline of 0.00012 mg/L (Figure 3.3-47). The before-after plot shows





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Samples concentrations that were below the very high detection limits of 0.5 or 5 mg/L were excluded from plots.
^ Indicates that concentrations were below the detection limit in all samples.
Total cyanide is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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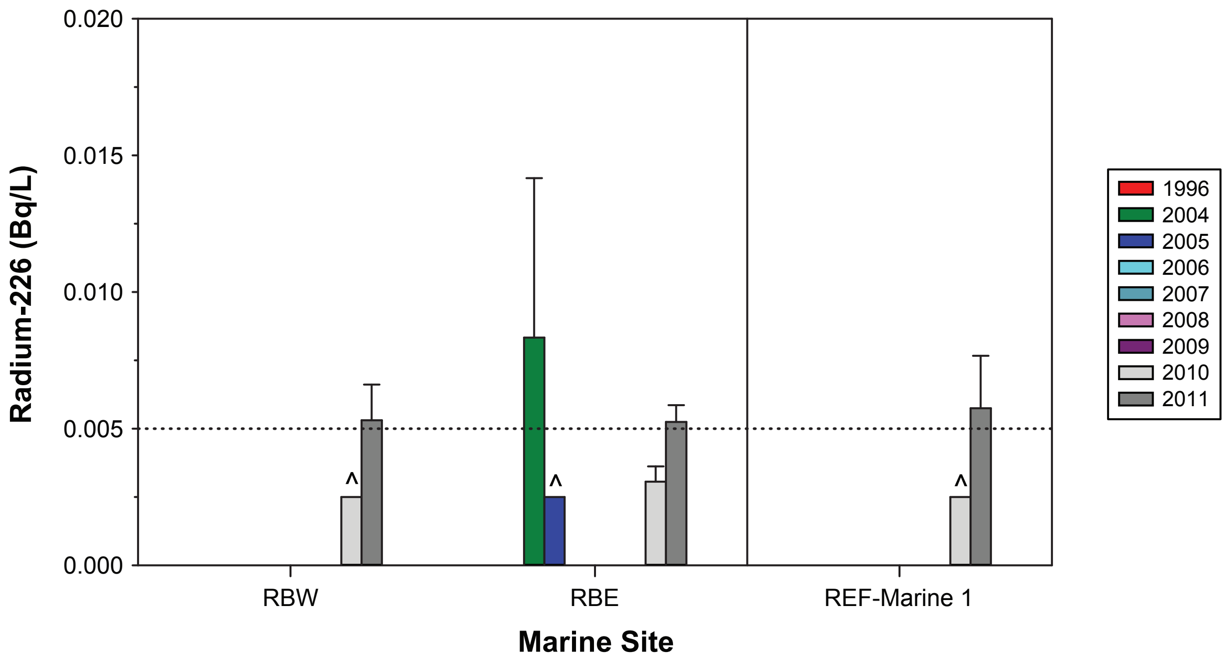
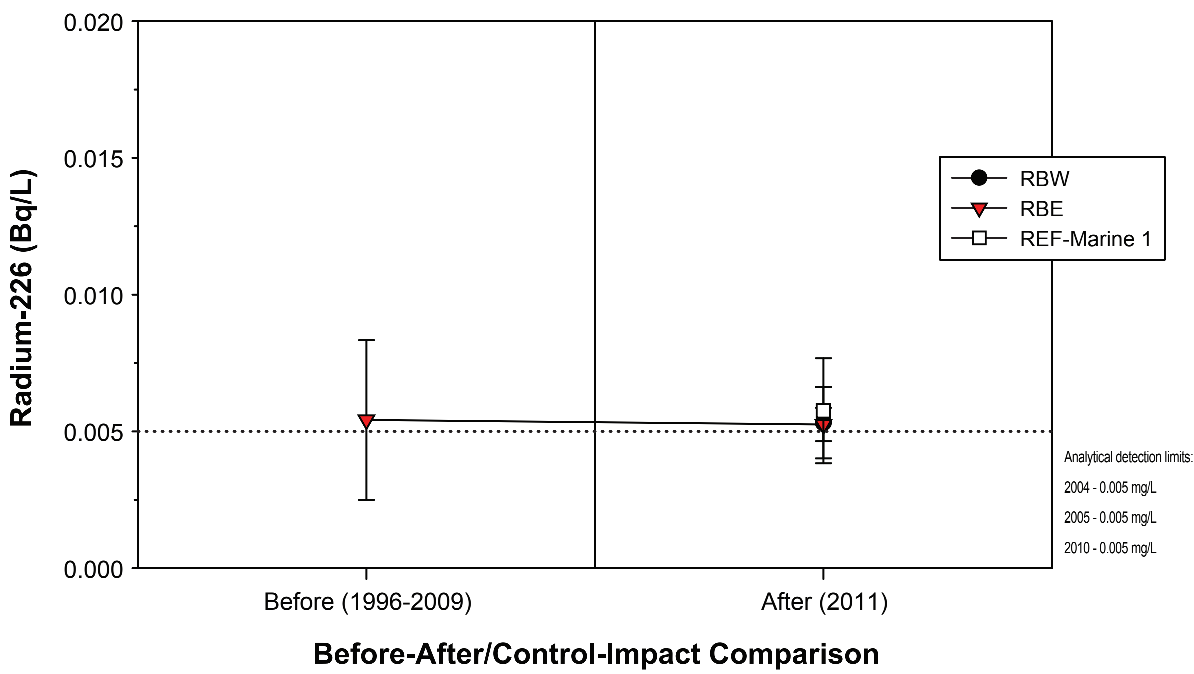
Total Cyanide Concentraton in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-43

Rescan Engineers & Scientists





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Radium-226 is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Radium-226 Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-44

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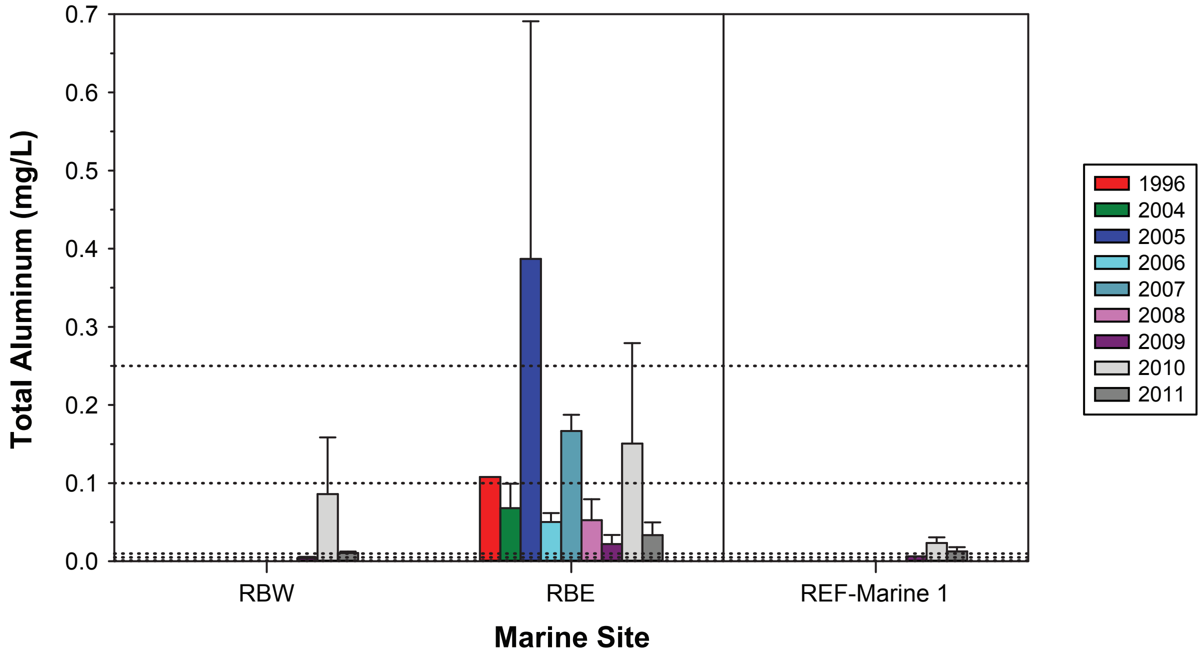

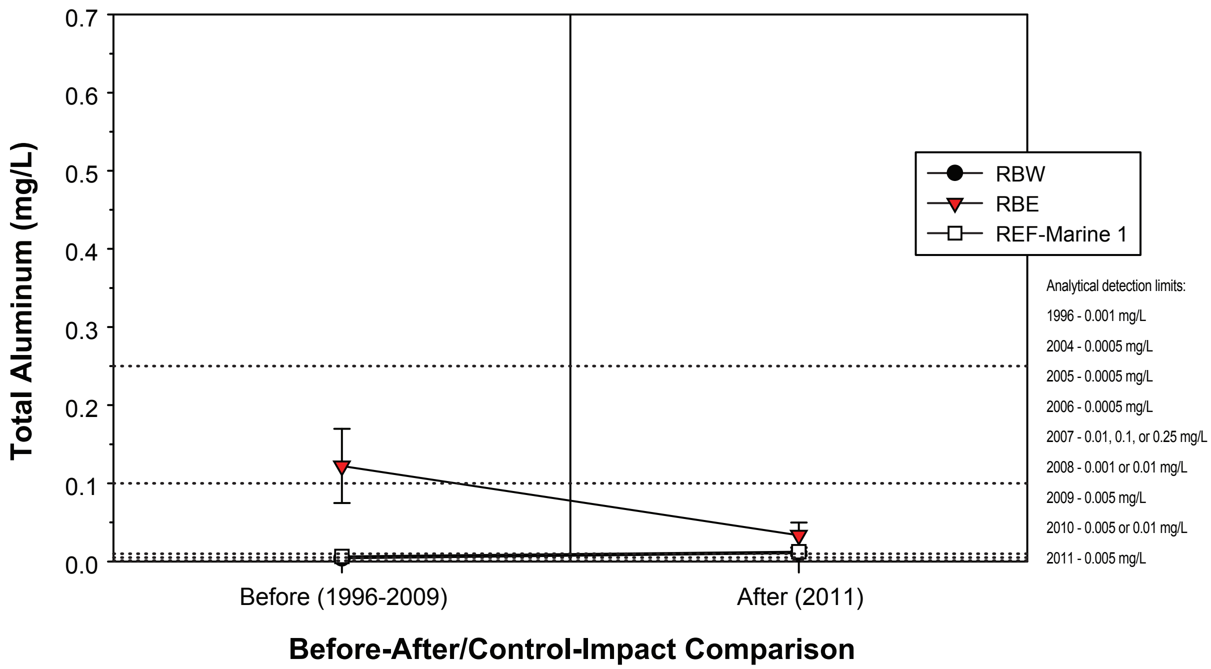

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Aluminum Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-45

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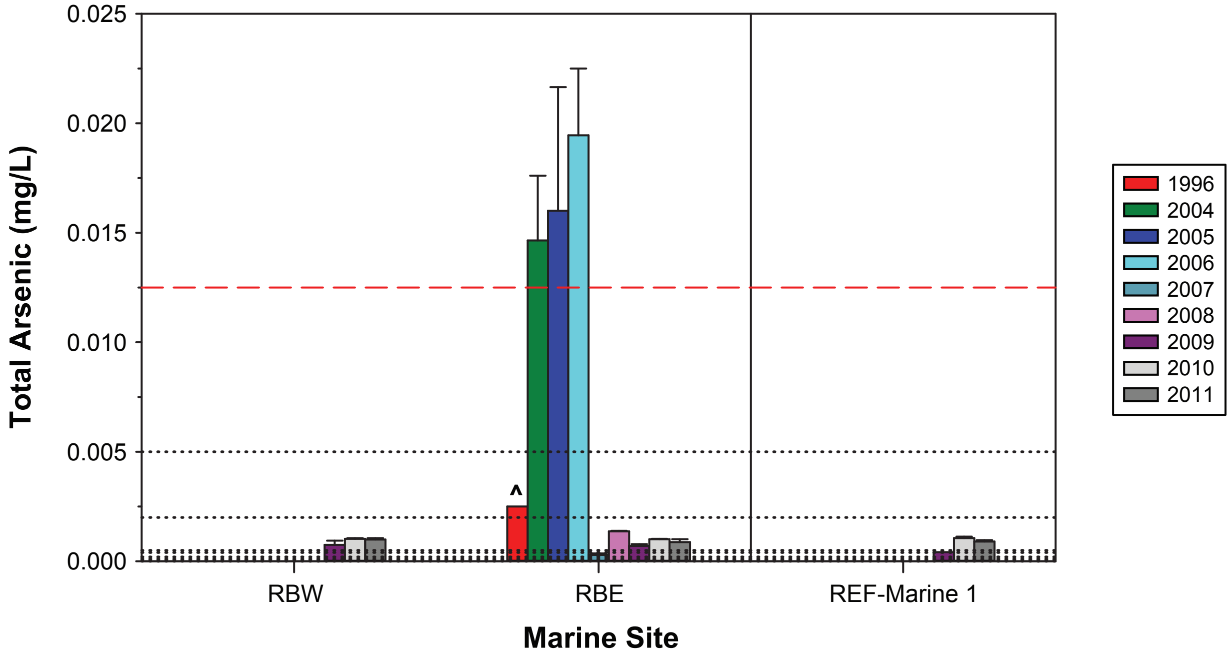

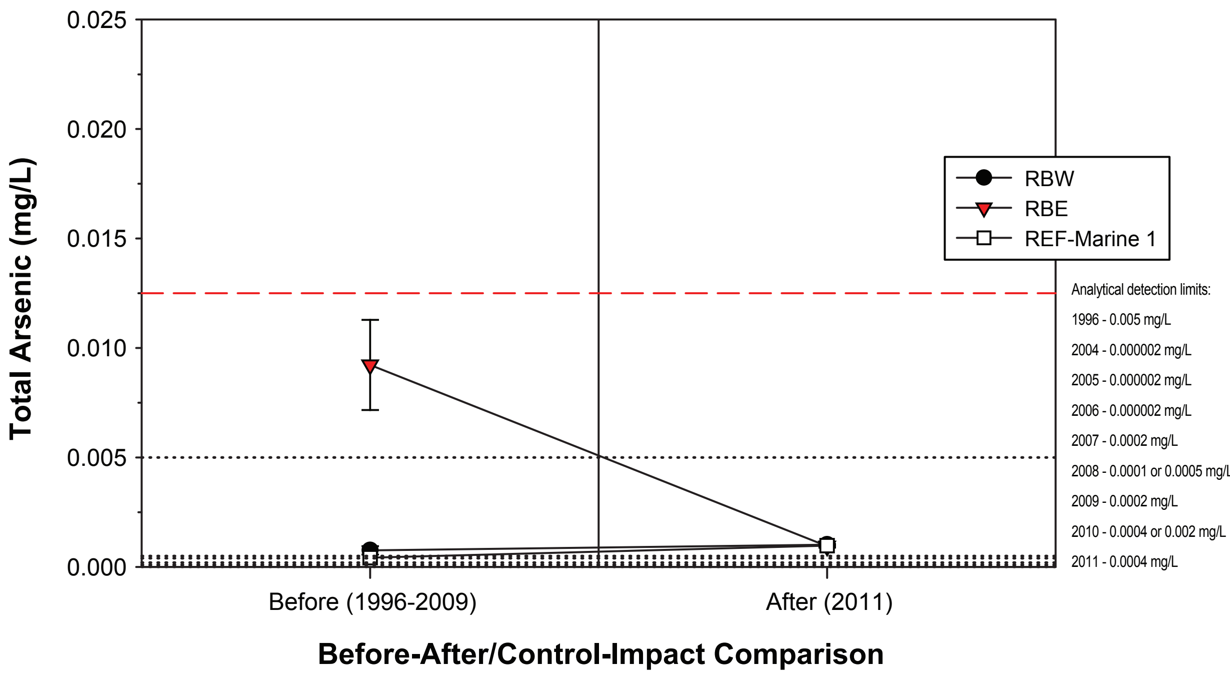

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the interim CCME marine guideline for arsenic (0.0125 mg/L).
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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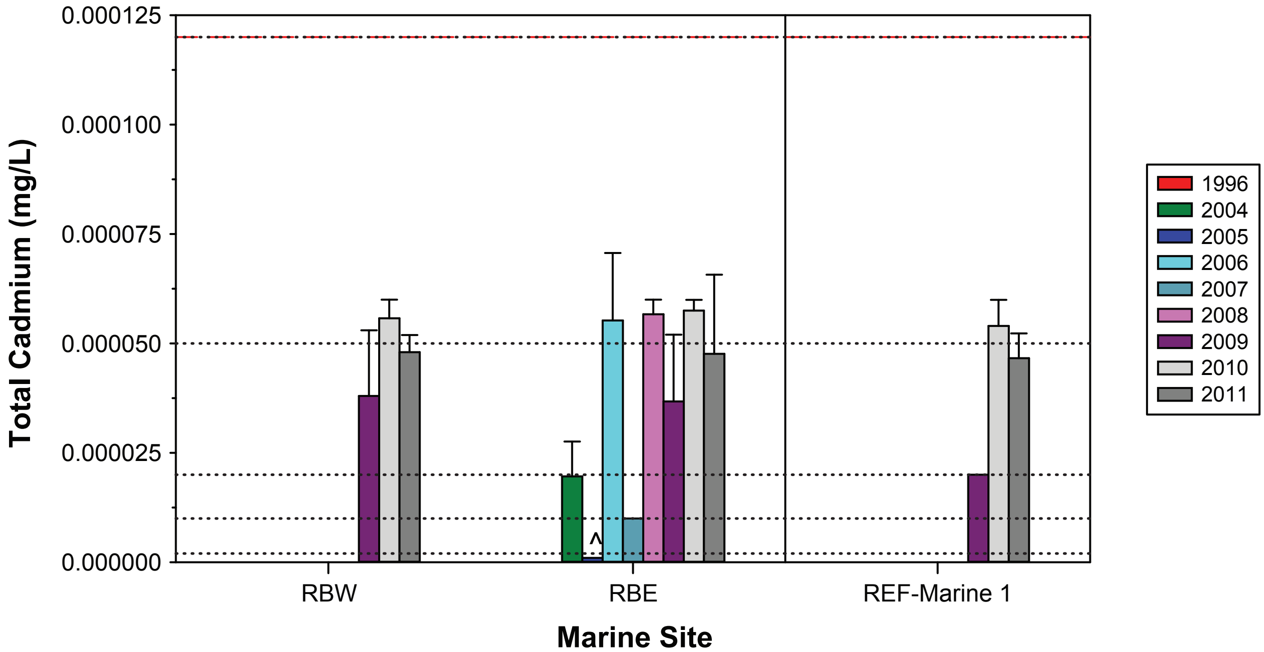
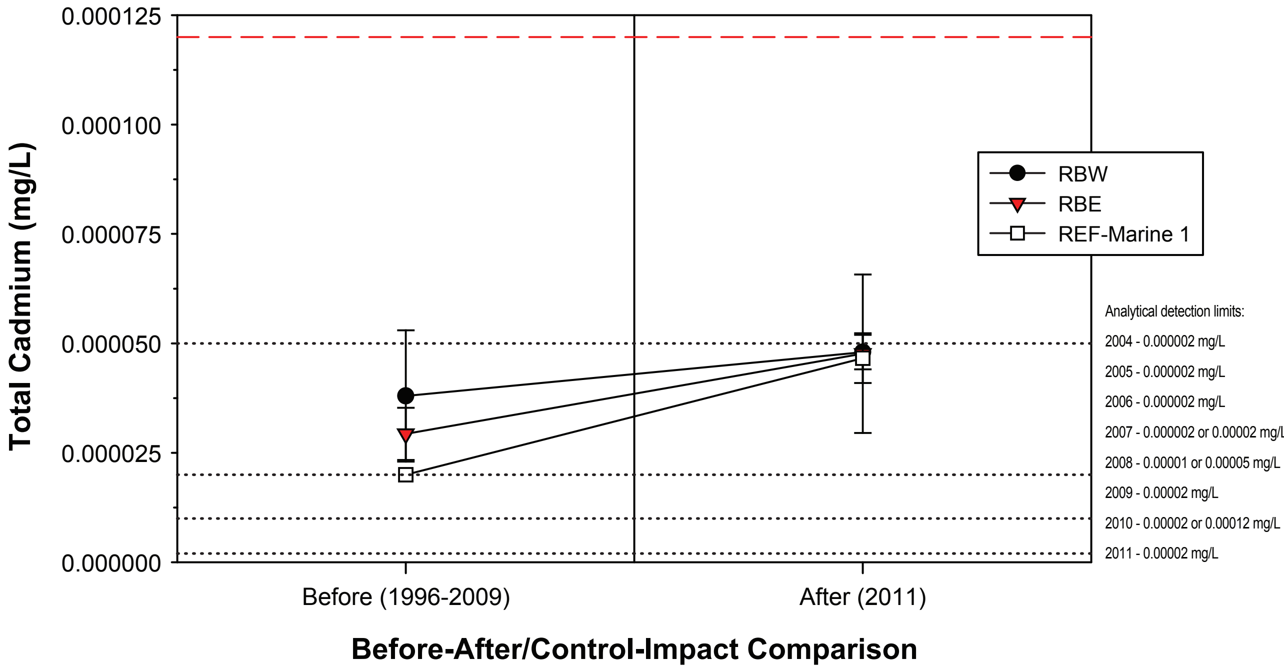
Total Arsenic Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-46

Rescan Engineers & Scientists





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME marine guideline for cadmium (0.00012 mg/L).
The anomalously high total cadmium concentration of 0.00348 mg/L reported for RBE in August 1996 was considered an outlier and was excluded from plots.
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Cadmium Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-47

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that 2011 mean cadmium concentrations increased slightly in both of the exposure sites compared to baseline means (Figure 3.3-47); however, the before-after statistical comparison indicated that these differences were not statistically significant ($p = 0.21$ for RBW and $p = 0.24$ for RBE). Therefore, there was no apparent effect of 2011 activities on total cadmium concentrations at the marine exposure sites.

3.3.3.12 Total Copper

Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Between 1996 and 2009, total copper concentrations at RBE were inter-annually variable. The 2011 mean concentration at RBE was within the range of these historical levels (Figure 3.3-48). At RBW, 2011 total copper concentrations were slightly higher than 2009 concentrations (Figure 3.3-48). The before-after comparison showed that for both RBW and RBE, there was no difference between baseline and 2011 mean copper concentrations ($p = 0.50$ for RBW and $p = 0.62$ for RBE). Therefore, there was no effect of 2011 Project activities on total copper concentrations at sites RBW and RBE in Roberts Bay.

3.3.3.13 Total Iron

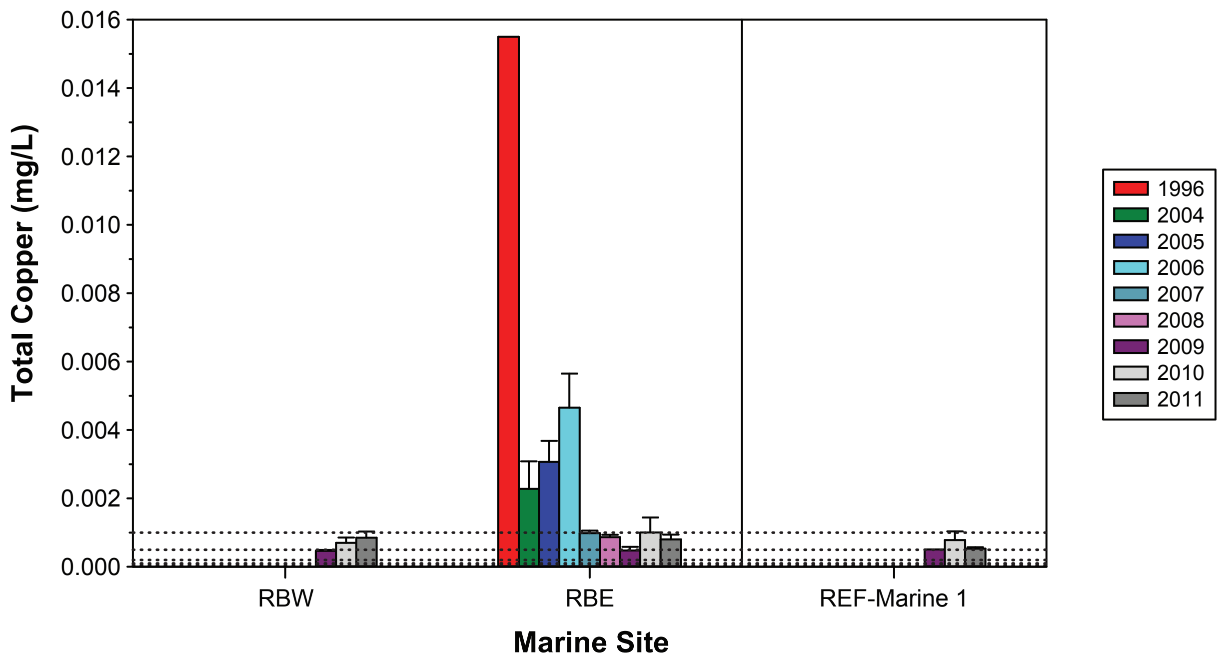
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. At site RBE, 2011 total iron concentrations were within range of the widely variable baseline concentrations (Figure 3.3-49). At site RBW, there was a slight increase in the mean iron concentration in 2011 compared to 2009 (Figure 3.3-49). For both of these Roberts Bay sites, the before-after analysis showed that 2011 means were not distinguishable from baseline means ($p = 0.19$ for RBW and $p = 0.67$ for RBE), indicating that there was no effect of 2011 activities on total iron concentrations at the marine exposure sites.

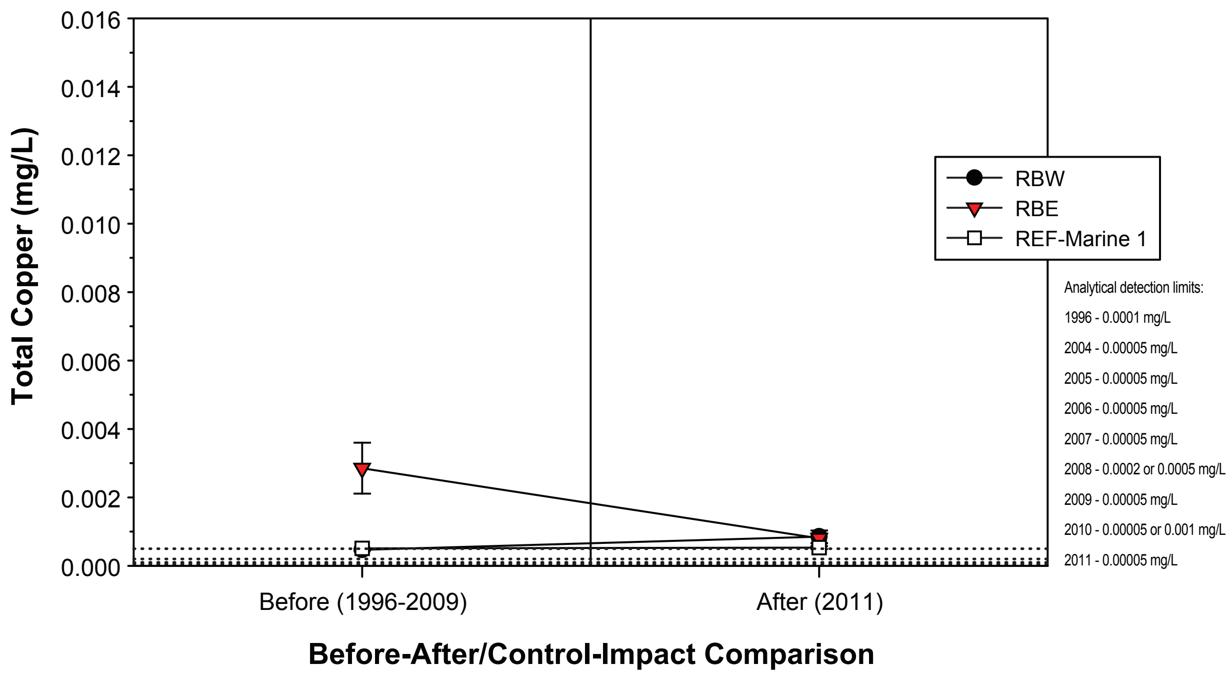
3.3.3.14 Total Lead

Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2011 total lead concentrations at RBW and REF-Marine 1 were higher than in 2009, while 2011 concentrations measured at RBE were within the range of baseline concentrations (Figure 3.3-50). The before-after comparison showed that there was no difference between baseline and 2011 mean total lead concentrations at either marine exposure site ($p = 0.59$ for RBW and $p = 0.87$ for RBE). Therefore, there was no effect of 2011 Project activities on total lead concentrations at RBW and RBE.

3.3.3.15 Total Mercury and Methylmercury

Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. All baseline and 2011 total mercury concentrations were below the marine CCME guideline for inorganic mercury of 0.000016 mg/L (Figure 3.3-51). As was the case for all 2009 total mercury concentrations measured in marine sites, all total mercury concentrations measured in April 2011 were below the detection limit of 0.00001 mg/L. For samples collected between July and September 2011, an ultra-low detection limit of 0.0000005 mg/L was achieved for total mercury samples, and concentrations at exposure sites ranged from 0.0000006 mg/L to 0.0000035 mg/L (Appendix A). Because 2009 was the only year of baseline data available for RBW and REF-Marine 1, total mercury concentrations appear to decrease in 2011 compared to 2009, but this is an artifact of the higher detection limit achieved for 2009 samples (Figure 3.3-51). At RBE, where baseline concentrations between 2004 and 2008 were also measured using ultra-low detection limits, 2011 concentrations were within the range of baseline levels. The before-after comparisons confirmed that the mean 2011 concentrations were statistically indistinguishable from mean baseline concentrations at both exposure sites ($p = 0.30$ for RBW and $p = 0.76$ for RBE), indicating that 2011 activities did not cause an increase in total mercury concentrations.





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Copper Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-48

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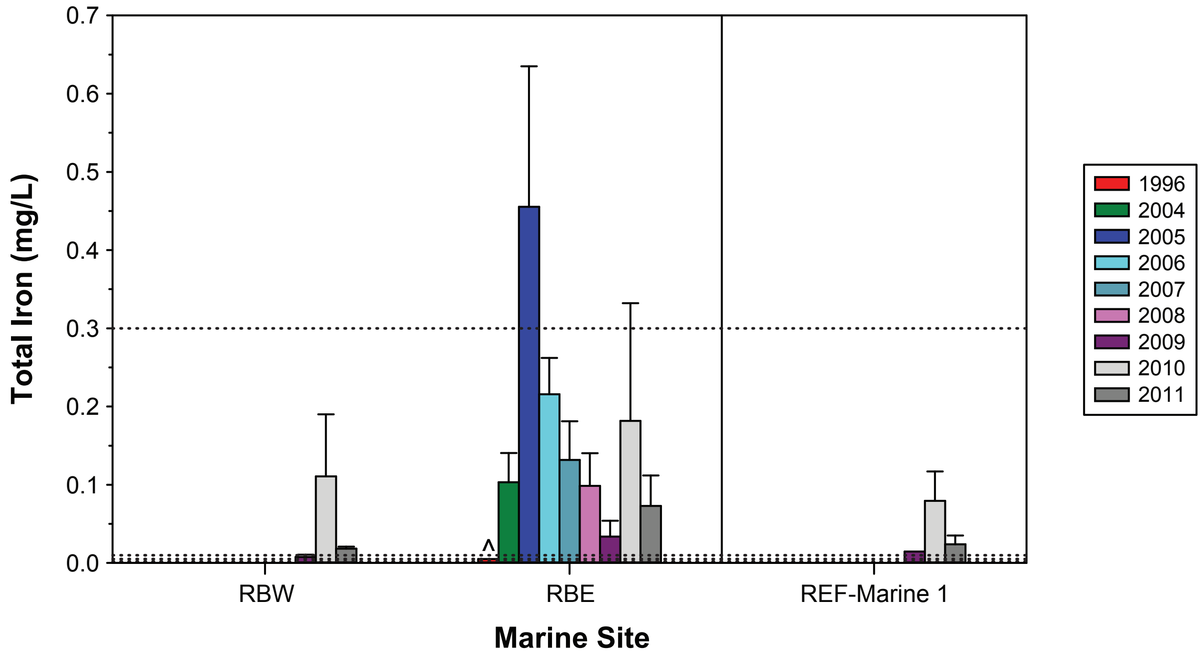

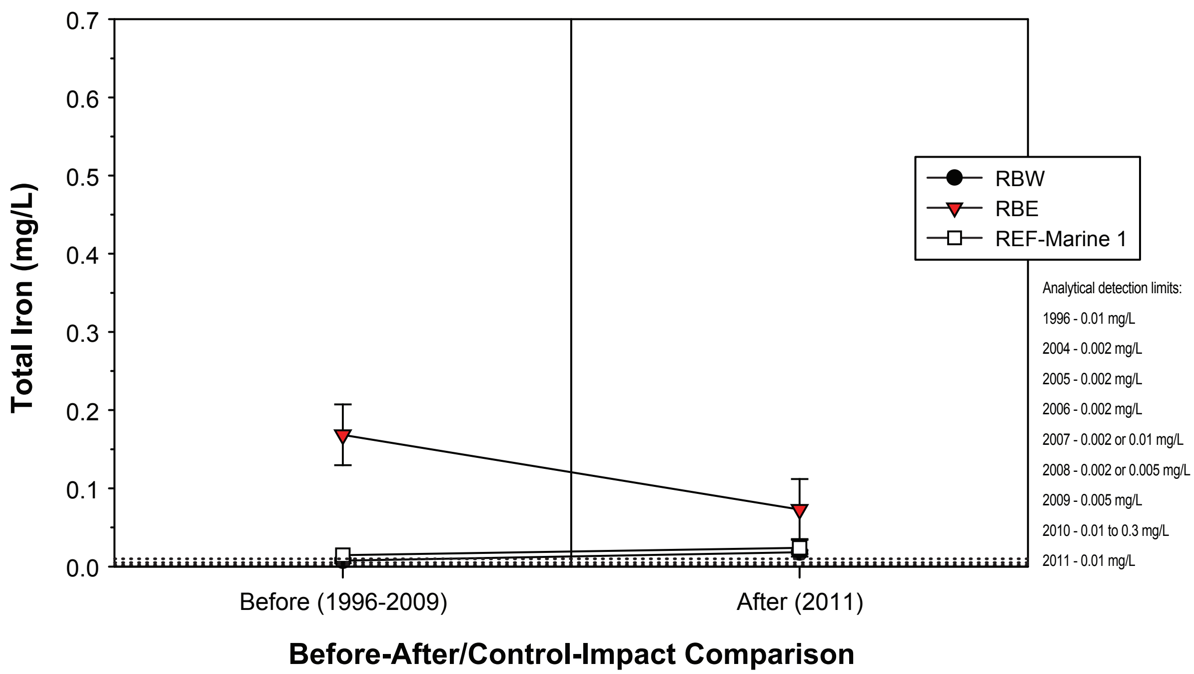

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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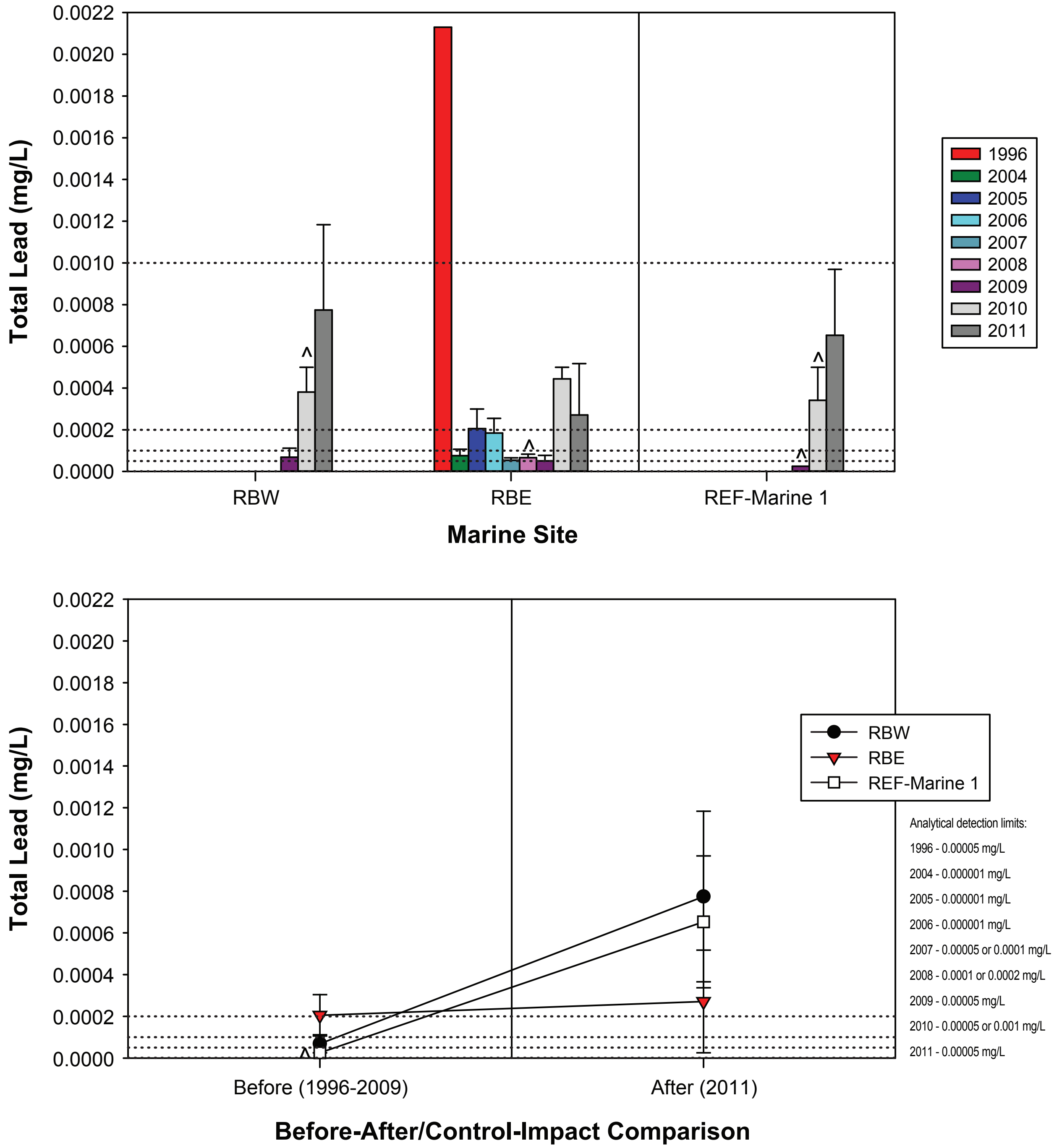
Total Iron Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-49

Rescan Engineers & Scientists



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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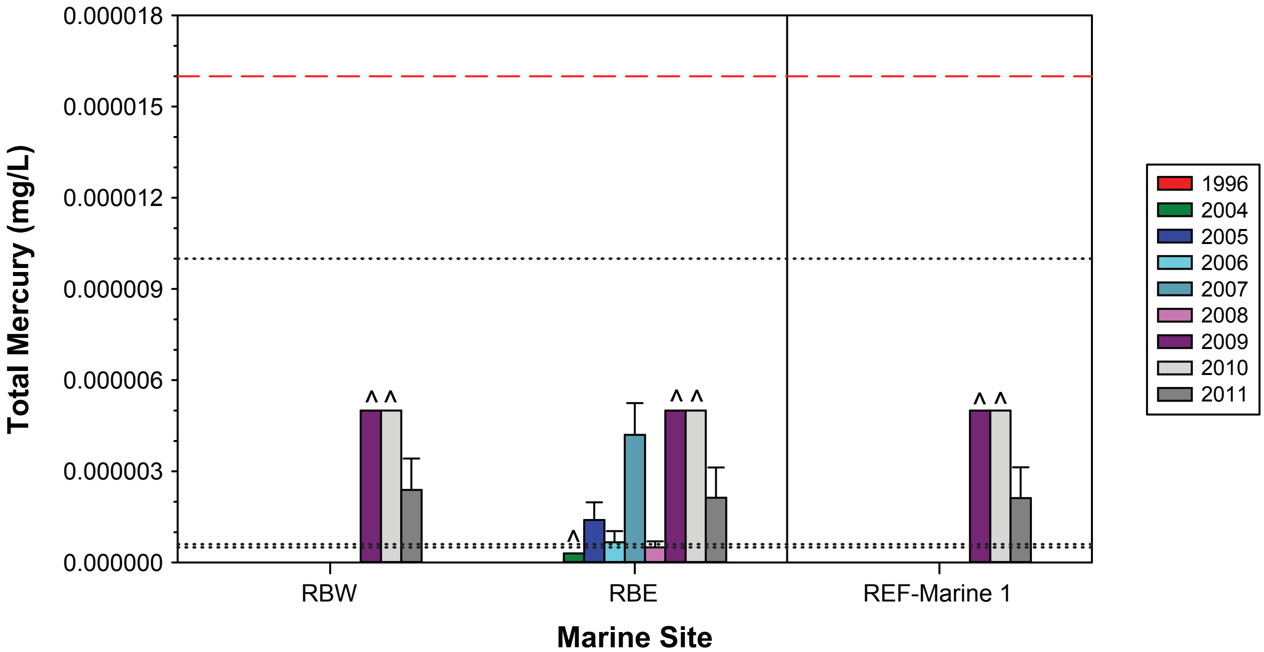
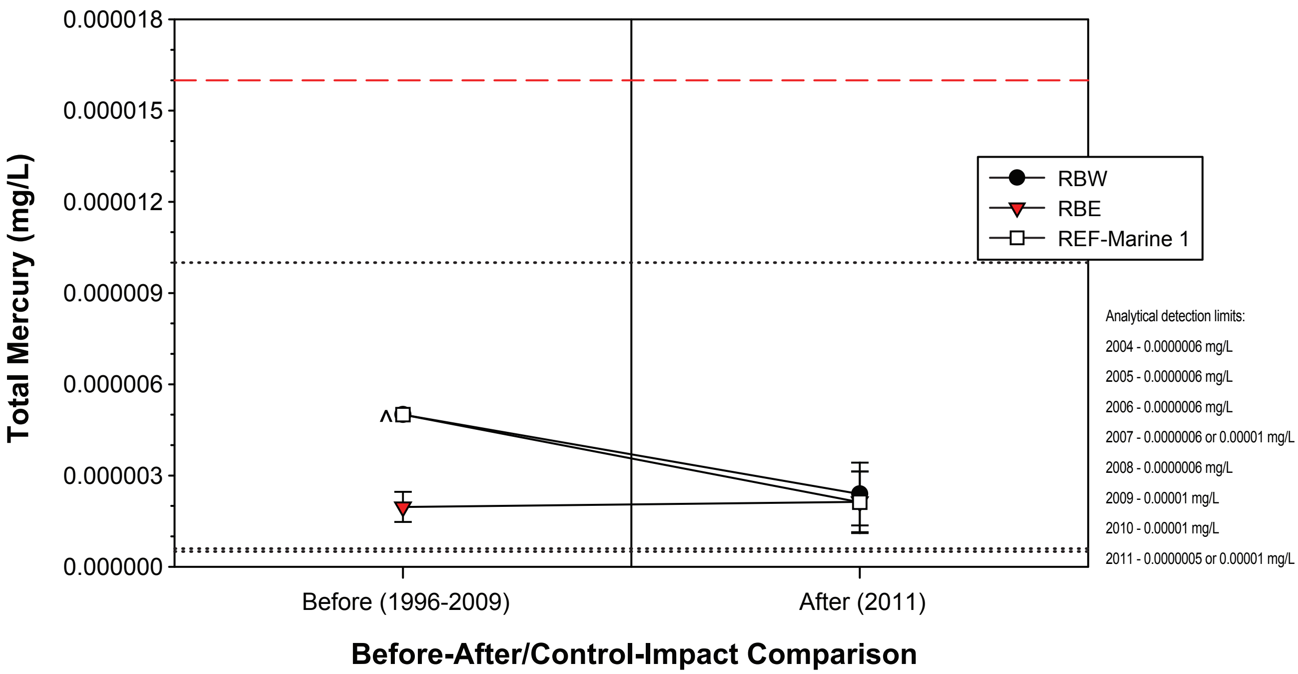
Total Lead Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-50

Rescan Engineers & Scientists





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the interim CCME marine guideline for inorganic mercury (0.000016 mg/L).
Total mercury is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

NEWMONT NORTH AMERICA

Total Mercury Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-51

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Methylmercury, an organic form of mercury that is of concern because of its toxicity and its tendency to biomagnify in upper trophic levels (CCME 2011b), was measured for the first time in Roberts Bay and Ida Bay in 2011. All concentrations measured at marine exposure and reference sites in 2011 were below the analytical detection limit of 0.00005 μg/L (Appendix A). There is no CCME guideline for methylmercury in marine waters.

3.3.3.16 Total Molybdenum

Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER. Mean 2011 total molybdenum concentrations at the two marine exposure sites were similar to baseline levels (Figure 3.3-52). The before-after comparison confirmed that there was no difference between 2011 mean concentrations and baseline means for the Roberts Bay sites ($p = 0.46$ for RBW and $p = 0.42$ for RBE). Therefore, 2011 activities had no apparent effect on total molybdenum concentrations at the marine exposure sites.

3.3.3.17 Total Nickel

Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. Mean 2011 nickel concentrations at the marine exposure sites were similar to baseline concentrations (Figure 3.3-53), and the before-after analysis confirmed that 2011 mean nickel concentrations were not distinguishable from baseline means ($p = 0.52$ for RBW and $p = 0.90$ for RBE). Therefore, there was no effect of 2011 activities on total nickel concentrations at RBW and RBE.

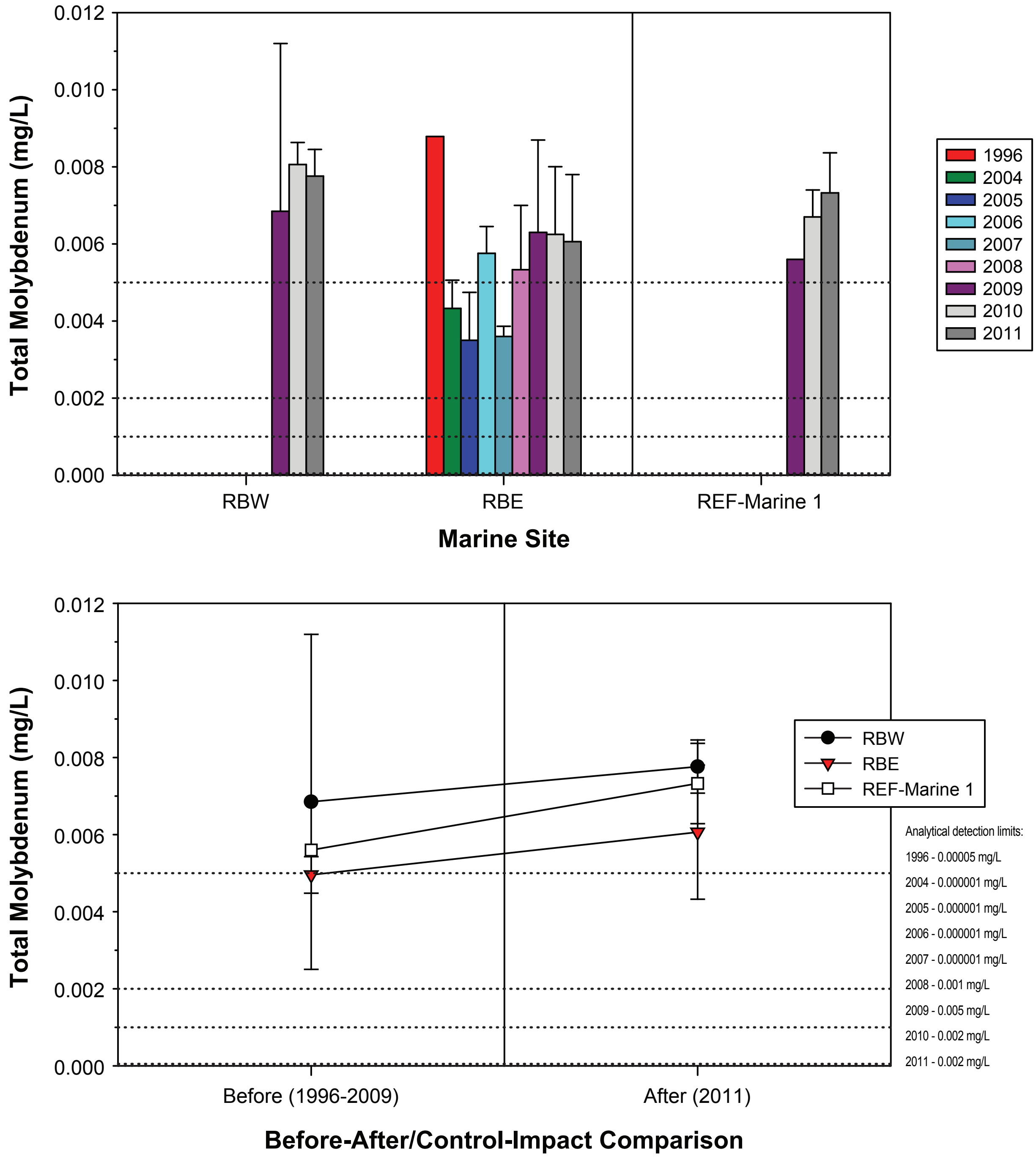
3.3.3.18 Total Zinc

Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER. At site RBW, the mean zinc concentration was higher in 2011 than in 2009, while at RBE, the 2011 mean was within the range of the means for the baseline years (Figure 3.3-54). The before-after comparison showed that there was no significant difference between 2009 and 2011 mean zinc concentrations for either of the Roberts Bay sites ($p = 0.022$ for RBW and $p = 0.62$ for RBE), indicating that 2011 activities did not affect zinc concentrations at the marine exposure sites.

3.4 SEDIMENT QUALITY

As per the MMER, Schedule 5, s. 16(a)(iii), sediment samples are to be collected and analyzed for particle size and total organic carbon (TOC) content to complement the benthic invertebrate community surveys. In this section, the sediment quality data collected from stream, lake, and marine sites in 2011 are compared against available baseline information as well as reference sites to evaluate whether 2011 Project activities caused changes to these sediment quality parameters. Sediment quality parameters for which there are CCME sediment quality guidelines for the protection of aquatic life (CCME 2011a) were also evaluated. CCME guidelines for sediments include interim sediment quality guidelines (ISQGs) and probable effects levels (PELs). The more conservative ISQGs are levels below which adverse biological effects are rarely observed. The higher PELs correspond to concentrations above which negative effects would be expected (CCME 2011a). All sediment quality parameters were compared to applicable CCME guidelines to determine whether concentrations posed a concern for freshwater and marine aquatic life. Site-specific baseline conditions were considered in addition to CCME guidelines to determine whether any detected changes would result in a potential adverse effect to freshwater and marine life.

For both graphical and statistical analyses, half the detection limit was substituted for sediment quality parameters that were below analytical detection limits. Graphs showing sediment quality trends in AEMP waterbodies over time are shown in Figures 3.4-1 to 3.4-27, and all statistical results are presented in Appendix B.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total molybdenum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Molybdenum Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-52

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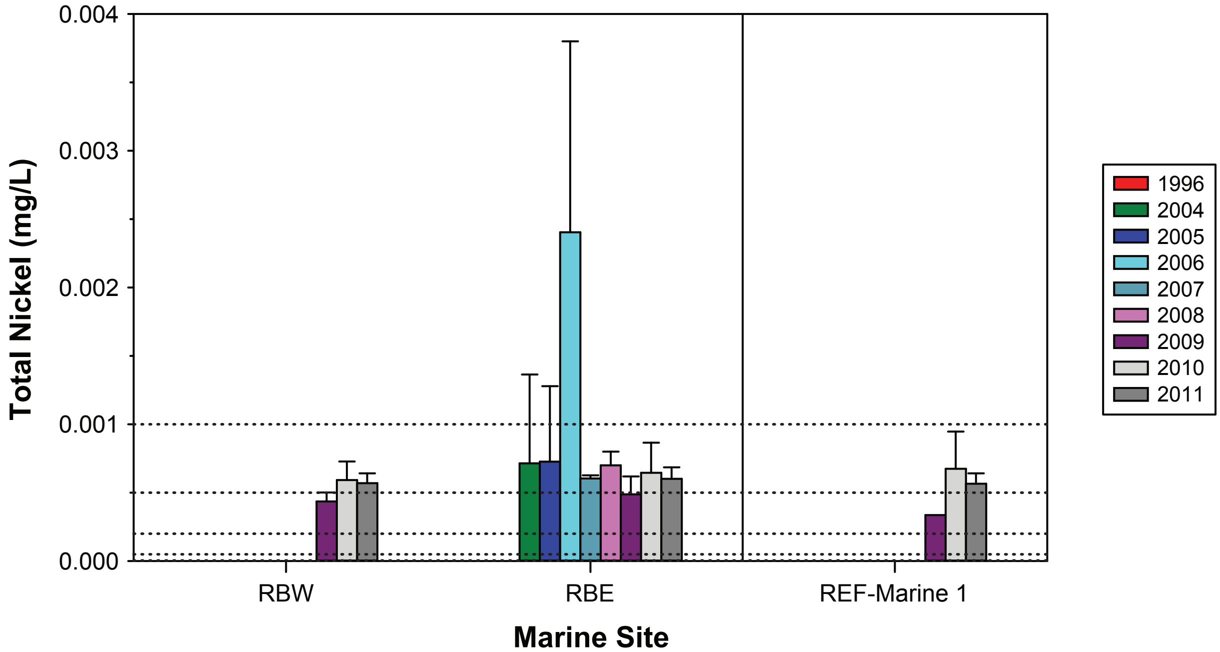

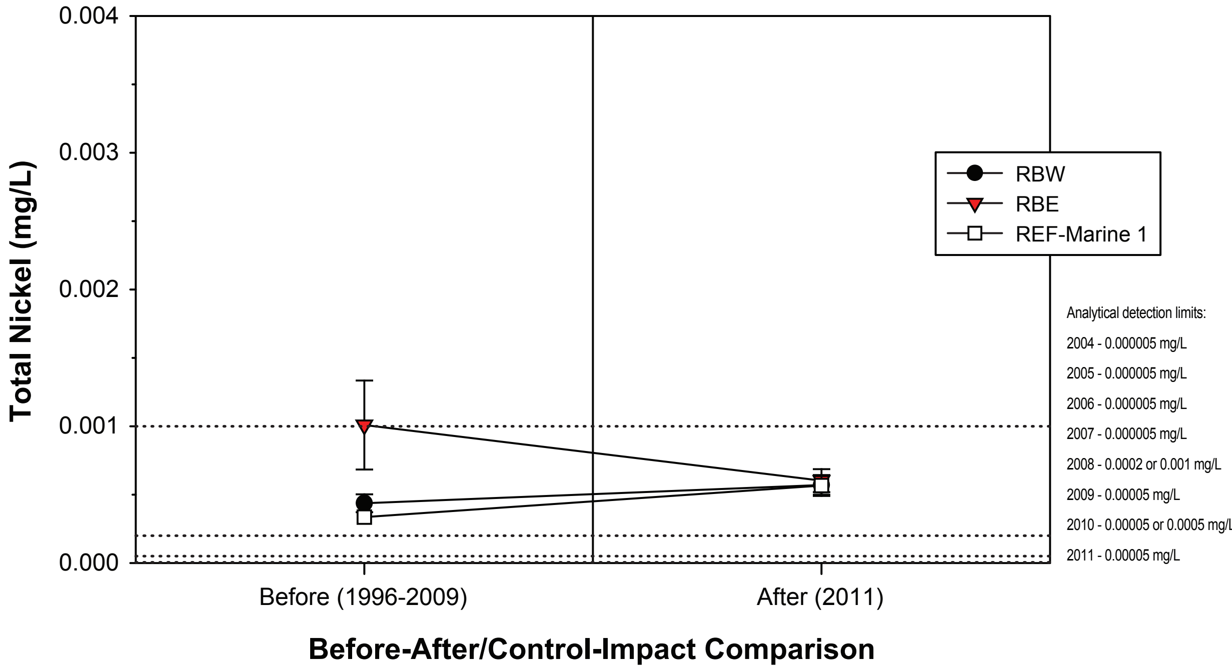

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
The anomalously high total nickel concentration of 0.0215 mg/L reported for RBE in August 1996 was considered an outlier and was excluded from plots.
Total nickel is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Nickel Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-53

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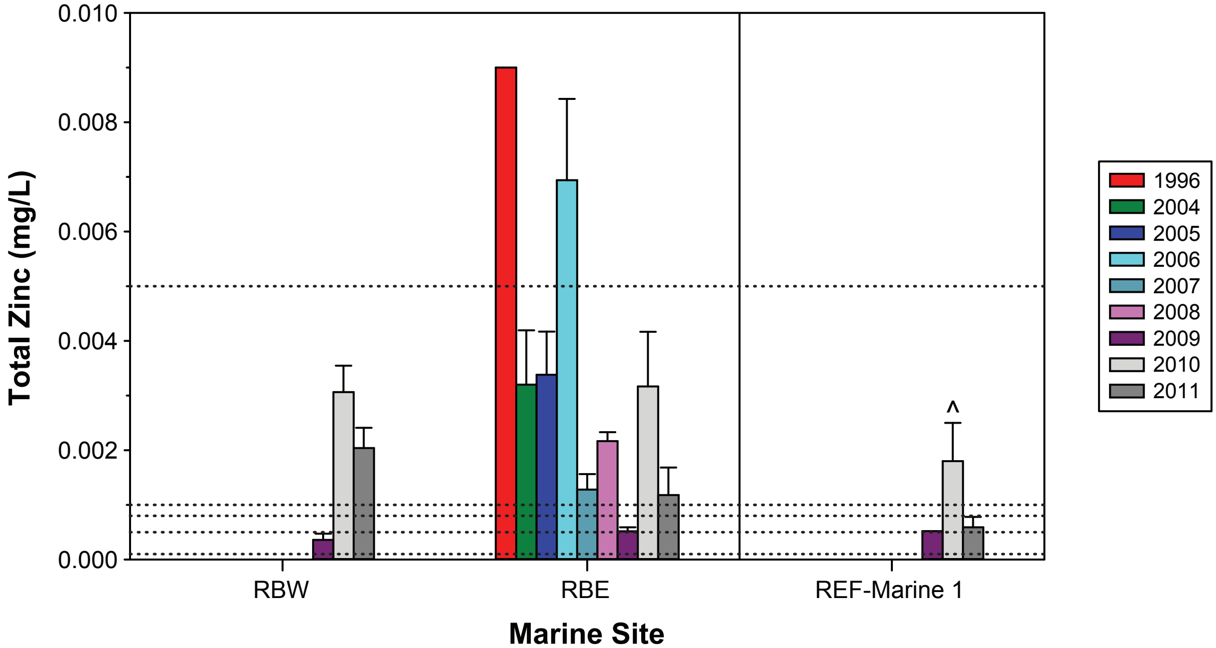

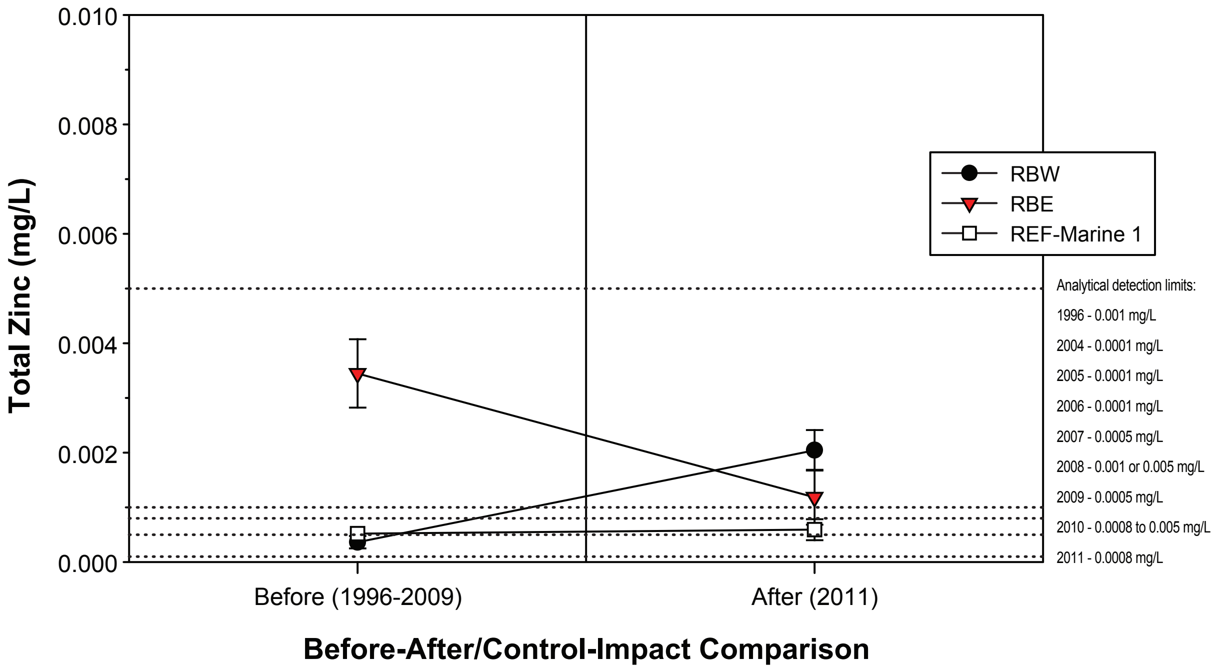

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total zinc is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Zinc Concentration in AEMP Marine Sites, Doris North Project, 1996-2011

Figure 3.3-54

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3.4.1 Streams

Sediment quality samples from streams were collected from three exposure streams (Doris Outflow, Roberts Outflow, and Little Roberts Outflow) and two reference streams (Reference B Outflow and Reference D Outflow). Baseline data for stream sediments are available only from 2009 and only for Doris, Little Roberts, and Reference B outflows. Data from 2011 were compared to 2009 to identify potential changes to sediment parameters. Stream sediment sampling was conducted in August during both years at the sampled sites. For the calculations of annual means for each parameter, all stream sediment replicates collected in a given year were averaged.

3.4.1.1 Particle Size

Particle size is a required sediment parameter to complement the benthic invertebrate surveys as per Schedule 5, s. 16(a)(iii) of the MMER. There were some differences in the particle size composition of stream sediments in 2011 compared to 2009 (Figure 3.4-1). In Doris Outflow, 2011 sediments consisted of a larger proportion of sand and a lower proportion of gravel compared to 2009. In Little Roberts Outflow, the gravel content was higher and the clay and silt content was lower in 2011 than 2009. In Reference B Outflow, the particle size composition of sediments was relatively similar between years, but gravel made up a slightly higher proportion and fine sediments (clay and silt) made up a lower proportion of the sediments in 2011 than in 2009 (Figure 3.4-1).

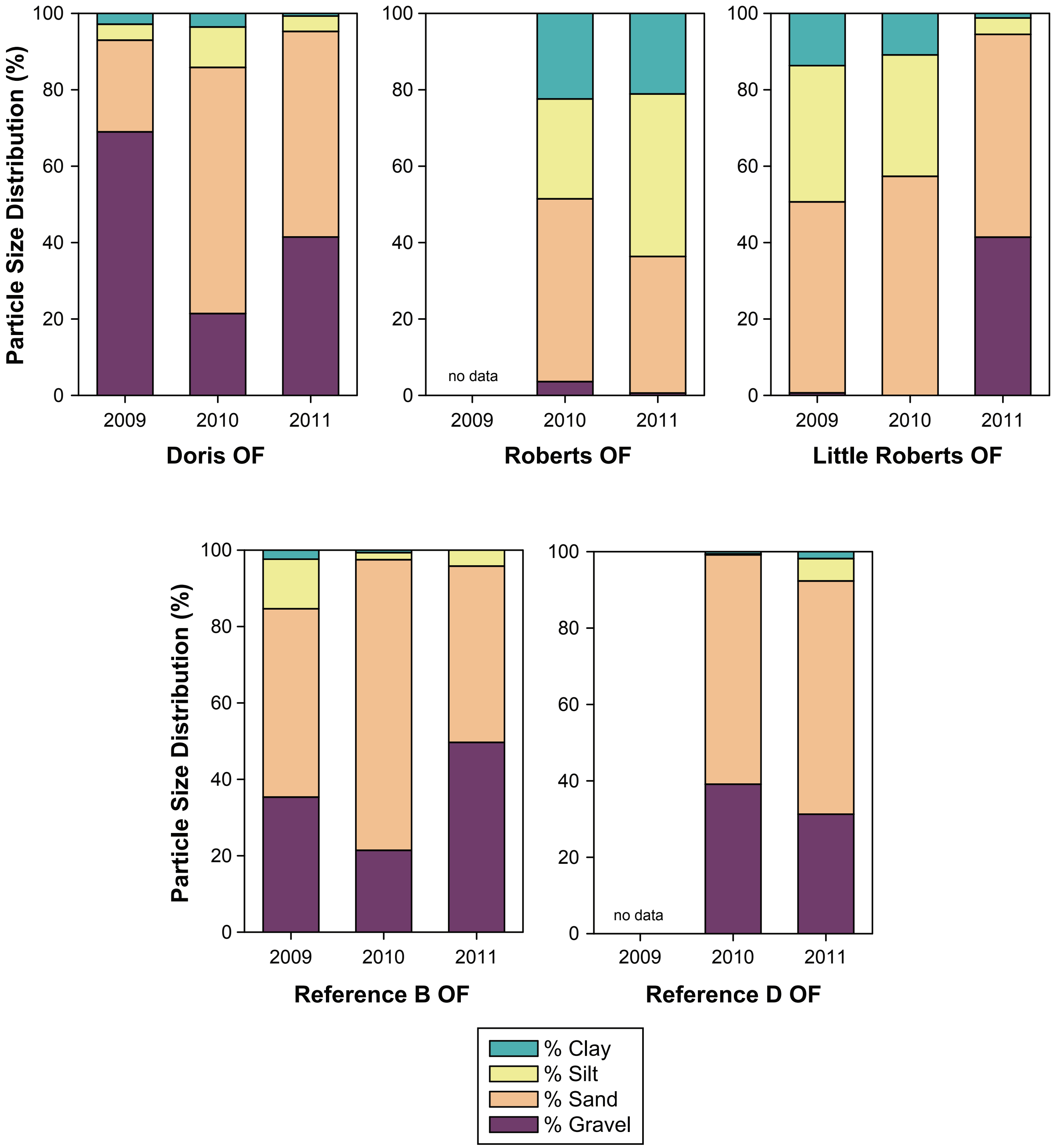
The before-after analysis showed that only some of the observed changes were statistically significant ($p = 0.004$ for the sand content in Doris Outflow and $p < 0.001$ for both the clay and silt content in Little Roberts Outflow). The BACI analysis further revealed that most of these changes were naturally occurring as they were also evident at the reference streams ($p = 0.031$ for sand content in Doris Outflow and $p = 0.013$ for silt content in Little Roberts Outflow), with one exception: the decrease in clay content in Little Roberts Outflow sediments ($p < 0.001$). Variation in sediment particle size composition is unlikely related to 2011 Project activities, and probably reflects natural spatial heterogeneity in stream sediments. However, these differences between 2009 and 2011 may complicate the evaluation of effects, because fine sediments are often associated with higher metal concentrations than coarse sediments (e.g., Lakhan, Cabana, and LaValle 2003).

3.4.1.2 Total Organic Carbon

TOC content is a required sediment parameter that is meant to support the benthic invertebrate surveys as per Schedule 5, s. 16(a)(iii) of the MMER. In both exposure and reference stream sediments, the TOC content was highly variable both inter-annually and among replicates collected within a year (Figure 3.4-2). Although Roberts Outflow TOC concentrations could not be statistically evaluated (because no baseline data were available), the 2011 TOC content of Roberts Outflow sediments was similar to the TOC content of Reference B Outflow sediments. The before-after comparison showed that the mean 2011 TOC content in Doris Outflow sediments was not distinguishable from the 2009 mean ($p = 0.47$), but the 2011 and 2009 means were statistically different for Little Roberts Outflow sediments ($p < 0.001$). The BACI analysis showed that the change in the TOC content observed in Little Roberts Outflow sediments between 2009 and 2011 was parallel to the change that occurred in the reference streams ($p = 0.052$); therefore, there was no apparent effect of 2011 Project activities on sediment TOC content in exposure streams.

3.4.1.3 Total Arsenic

Mean 2011 sediment arsenic concentrations were highest at Roberts Outflow (4.4 mg/kg) and were generally similar among the remaining exposure and reference streams (ranging from 0.86 to 1.4 mg/kg; Figure 3.4-3). All mean arsenic concentrations in 2009 and 2011 were below the CCME ISQG of 5.9 mg/kg



Notes: Stacked bars represent the mean of replicate samples.
Particle size distribution of sediments is a required parameter as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

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Particle Size Distribution in AEMP Stream Sediments, Doris North Project, 2009-2011

Figure 3.4-1

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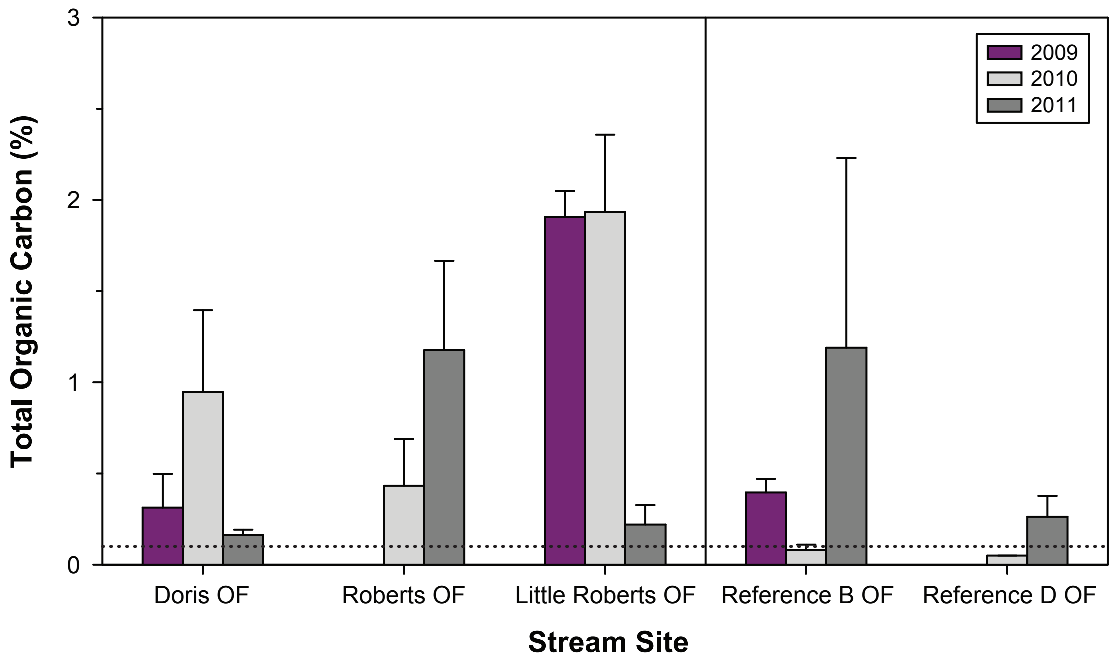

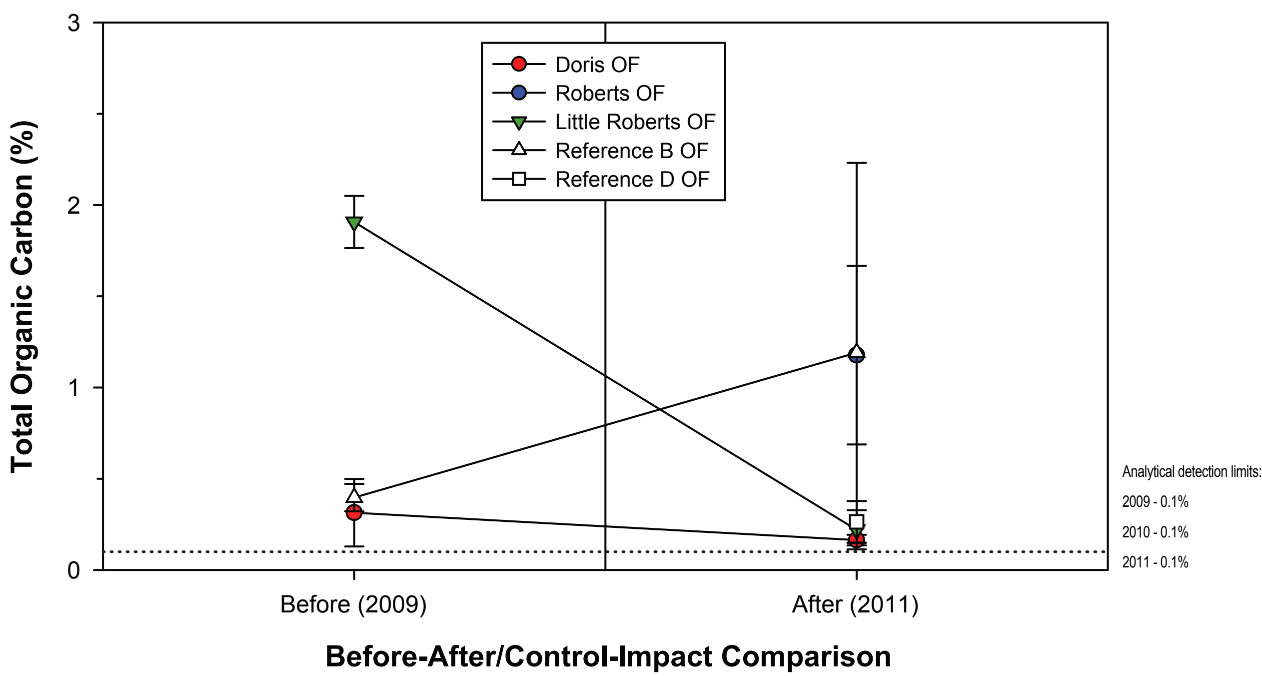

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Total organic carbon content of sediments is a required parameter as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

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Total Organic Carbon Concentration in AEMP Stream Sediments, Doris North Project, 2009-2011

Figure 3.4-2

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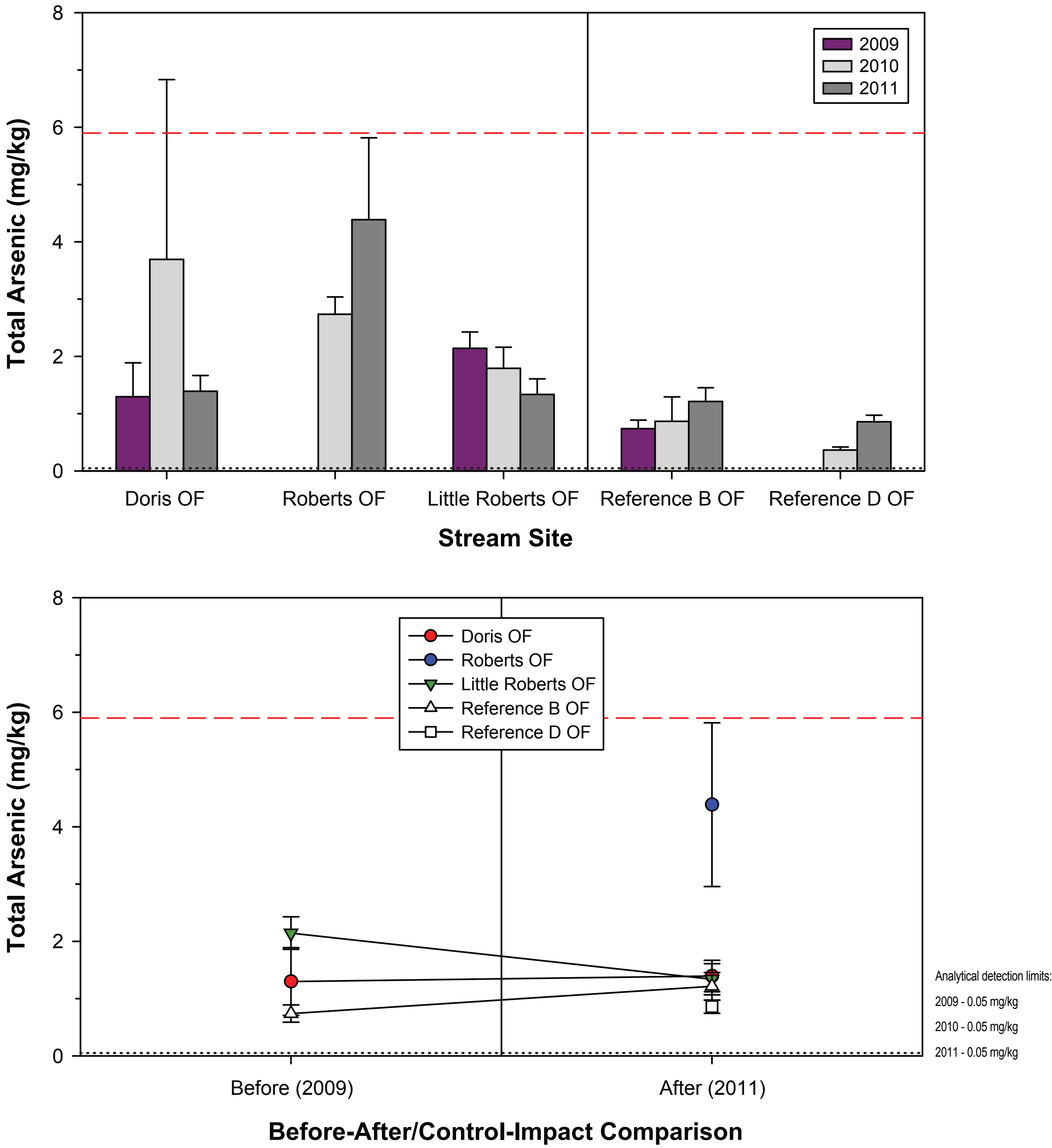

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for arsenic (5.9 mg/kg); the probable effects level (PEL) for arsenic (17 mg/kg) is not shown.

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Total Arsenic Concentration in AEMP Stream Sediments, Doris North Project, 2009-2011

Figure 3.4-3

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and the PEL of 17 mg/kg. In Doris Outflow, mean total arsenic concentrations were similar between 2009 and 2011. In Little Roberts Outflow, the mean concentration was lower in 2011 than in 2009 (Figure 3.4-3). The before-after comparison showed that there were no significant differences between 2009 and 2011 mean total arsenic concentrations at Doris Outflow ($p = 0.74$) or Little Roberts Outflow ($p = 0.024$). Therefore, 2011 activities did not adversely affect arsenic concentrations in these exposure streams.

3.4.1.4 Total Cadmium

In both Doris Outflow and Little Roberts Outflow, total cadmium concentrations in sediments were below the analytical detection limits of 0.1 mg/kg (2009) and 0.05 mg/kg (2011) in all samples collected in 2009 and 2011 (Figure 3.4-4). In Roberts Outflow sediments, 2011 total cadmium concentrations were slightly higher than the 2011 detection limit, averaging 0.083 mg/kg (Figure 3.4-4). All 2009 and 2011 total cadmium concentrations measured in stream sediments were well below the CCME ISQG of 0.6 mg/kg and the PEL of 3.5 mg/kg, and there was no indication that 2011 Project activities had any effect on cadmium concentrations in exposure stream sediments.

3.4.1.5 Total Chromium

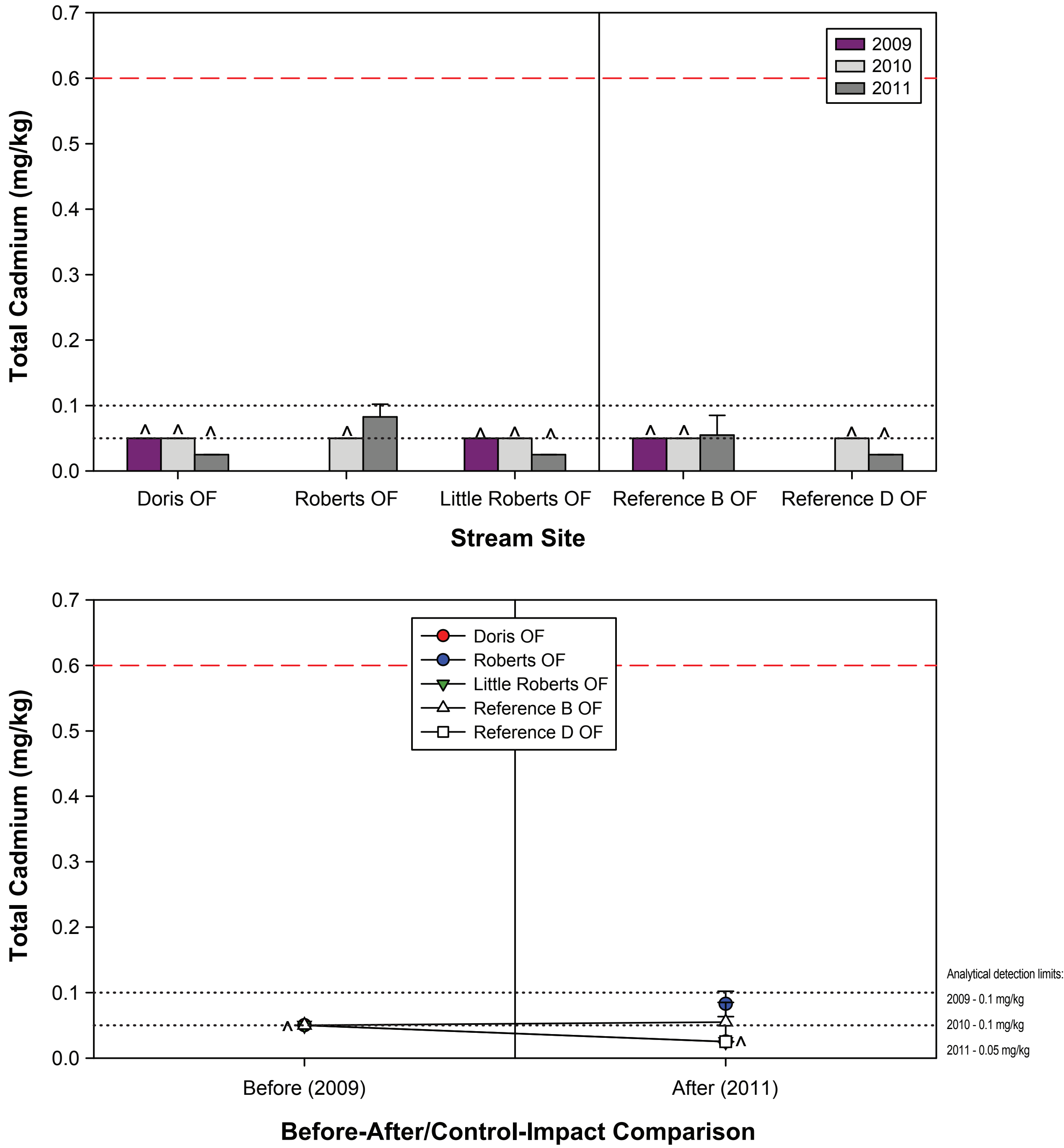
Mean 2011 chromium concentrations in Doris Outflow and Little Roberts Outflow sediments were higher than mean 2009 concentrations (Figure 3.4-5). In all three exposure streams, mean 2011 concentrations were higher than the CCME ISQG of 37.3 mg/kg, and in Little Roberts Outflow, the mean 2011 concentration was also higher than the CCME PEL of 90 mg/kg (Figure 3.4-5). The before-after analysis failed to find evidence of a difference in mean chromium concentrations between 2009 and 2011 for either Doris Outflow ($p = 0.14$) or Little Roberts Outflow ($p = 0.25$), likely because of the high degree of variability among replicate samples collected in 2011. Therefore, there was no apparent effect of 2011 Project activities on sediment chromium levels in exposure streams.

3.4.1.6 Total Copper

Mean 2011 sediment copper concentrations were highest at Roberts Outflow (20.6 mg/kg) and were generally similar among the remaining exposure and reference streams (ranging from 8.6 to 11.8 mg/kg; Figure 3.4-6). All mean copper concentrations in 2009 and 2011 were below the CCME ISQG of 35.7 mg/kg and the PEL of 197 mg/kg. In both Doris Outflow and Little Roberts Outflow, mean total copper concentrations were lower in 2011 than in 2009, indicating that Project activities did not cause an increase in copper concentrations in the sediments of these exposure streams. The before-after analysis showed that mean 2011 copper concentrations in exposure stream sediments were not statistically distinguishable from 2009 means ($p = 0.78$ for Doris Outflow, $p = 0.015$ for Little Roberts Outflow). Therefore, 2011 activities had no effect on sediment copper concentrations in these exposure streams (Figure 3.4-6).

3.4.1.7 Total Lead

In all three exposure streams, 2011 lead concentrations in sediments were well below the CCME ISQG of 35 mg/kg and the PEL of 91.3 mg/kg (Figure 3.4-7). In both Doris Outflow and Little Roberts Outflow, mean 2011 total lead concentrations in sediments were lower in 2011 than in 2009 (Figure 3.4-7). The before-after comparison showed that this decrease was statistically significant for Little Roberts Outflow ($p = 0.003$), but not for Doris Outflow ($p = 0.42$). The BACI analysis for Little Roberts Outflow showed that a similar decrease in the mean lead concentration in 2011 compared to 2009 did not occur at the reference streams ($p = 0.001$). The apparent decrease in the lead concentration in Little Roberts Outflow sediments may be related to the lower proportion of silt and clay in 2011 sediment samples compared to 2009 samples (because fine sediments are often associated with higher concentrations of metals). Nevertheless, a decrease in sediment lead concentration is not of concern, and there were no apparent adverse effects of 2011 activities on lead concentrations in stream sediments.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for cadmium (0.6 mg/kg); the probable effects level (PEL) for cadmium (3.5 mg/kg) is not shown.

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Total Cadmium Concentration in AEMP Stream Sediments, Doris North Project, 2009-2011

Figure 3.4-4

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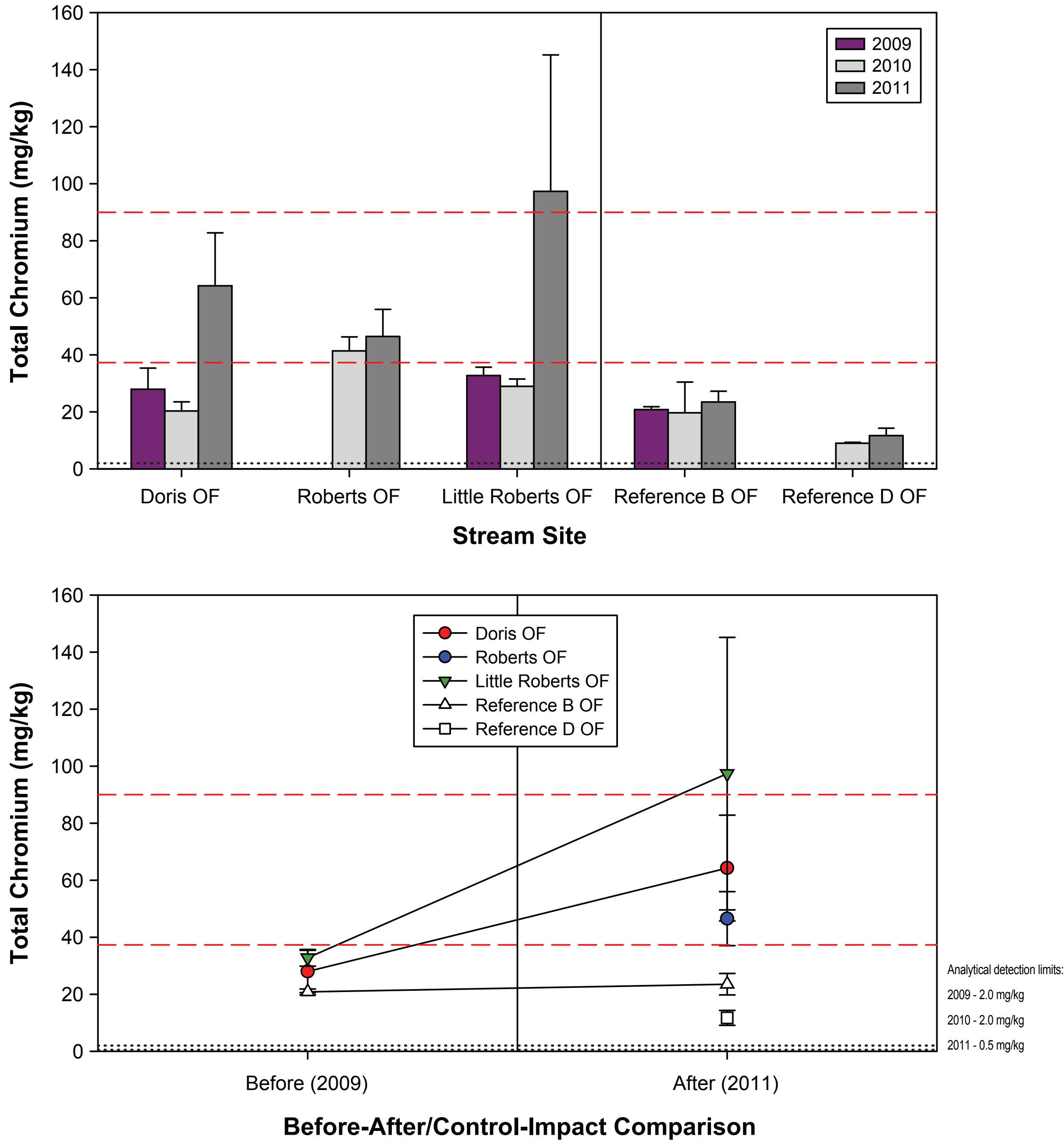

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG)
for chromium (37.3 mg/kg) and the probable effects level (PEL) for chromium (90 mg/kg).

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Total Chromium Concentration in AEMP Stream Sediments, Doris North Project, 2009-2011

Figure 3.4-5

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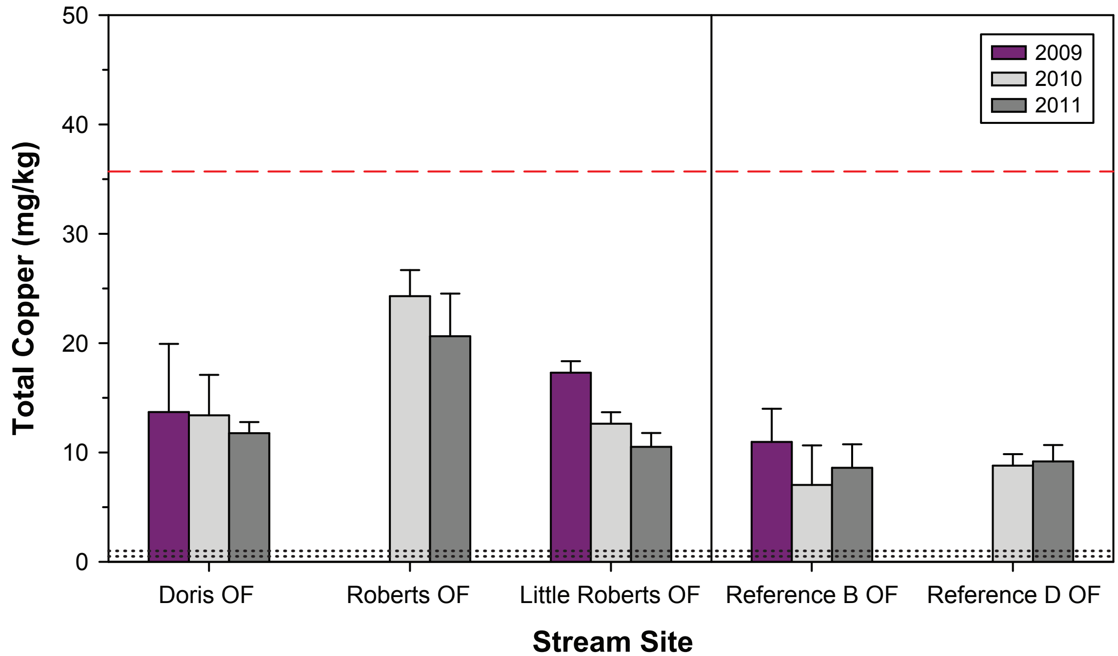

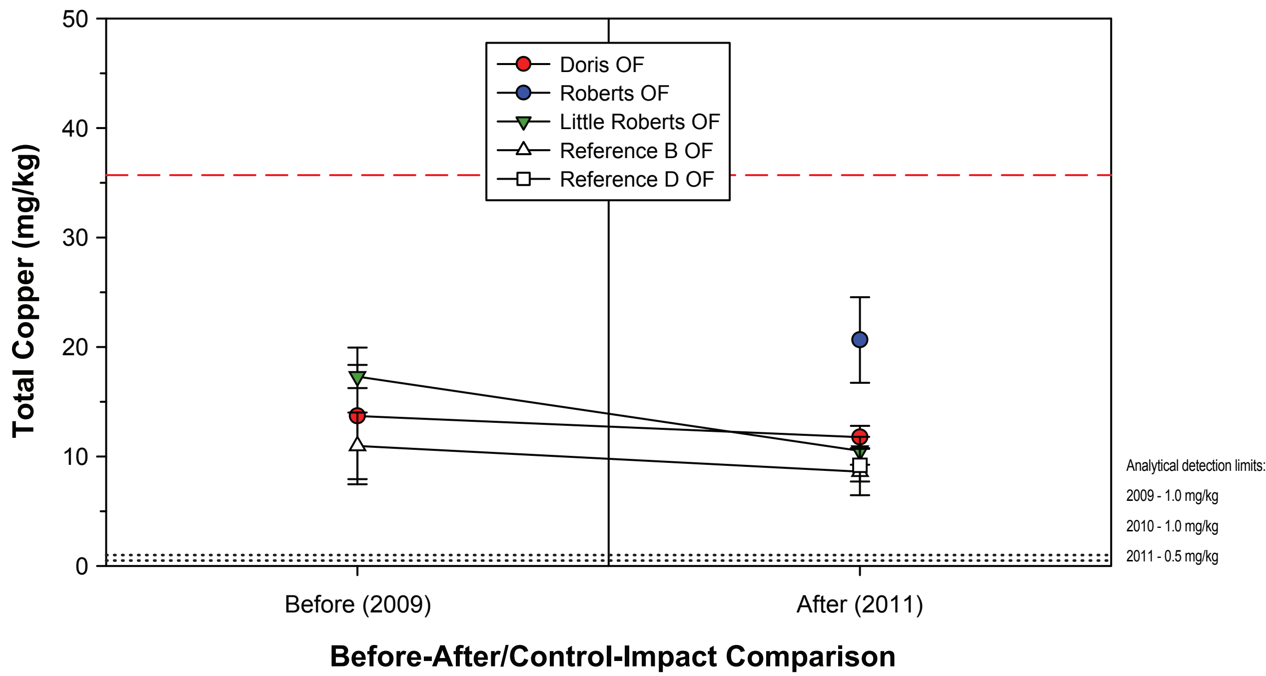

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG)
for copper (35.7 mg/kg); the probable effects level (PEL) for copper (197 mg/kg) is not shown.

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Total Copper Concentration in AEMP Stream Sediments, Doris North Project, 2009-2011

Figure 3.4-6

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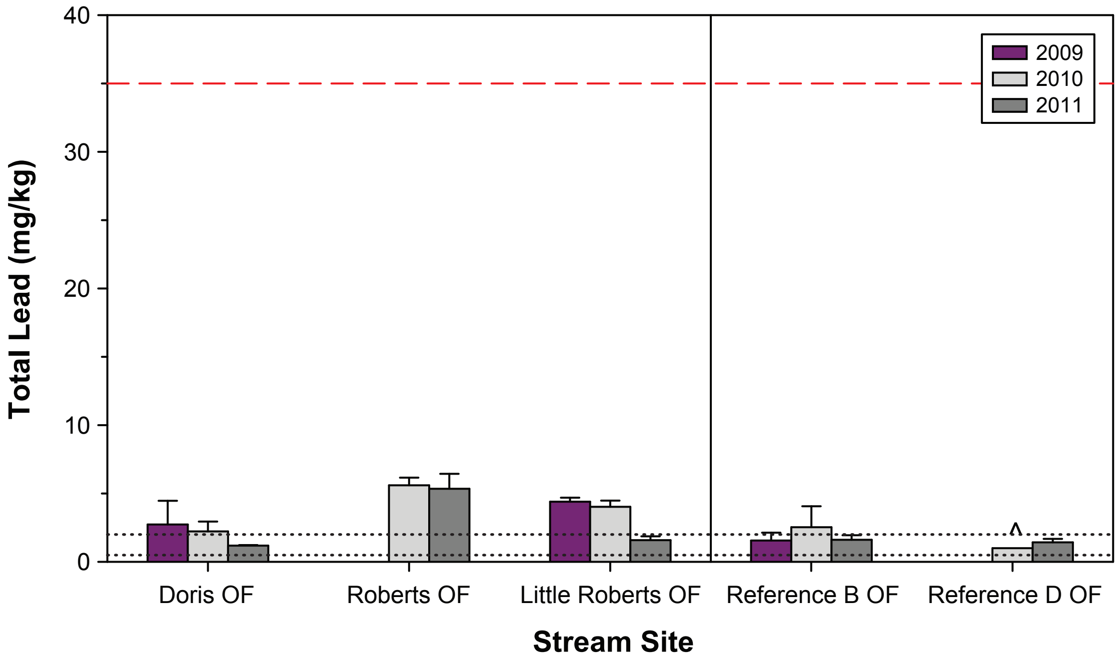

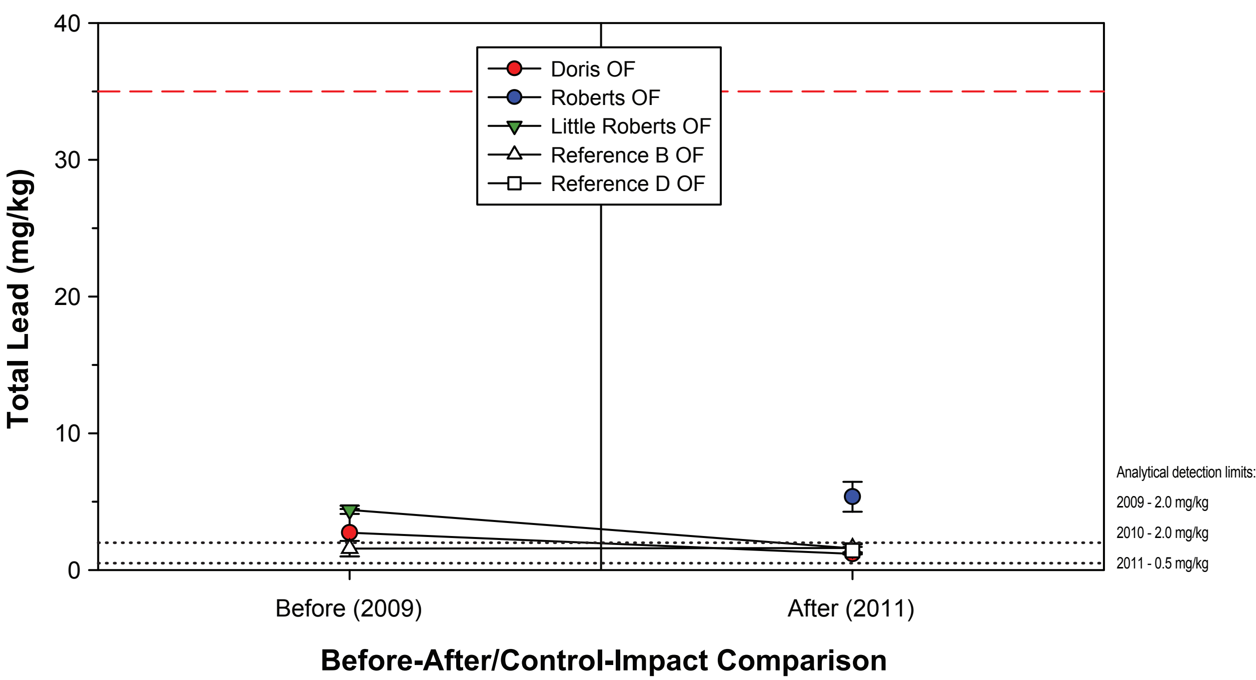

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for lead (35 mg/kg); the probable effects level (PEL) for lead (91.3 mg/kg) is not shown.

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Total Lead Concentration in AEMP Stream Sediments, Doris North Project, 2009-2011

Figure 3.4-7

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3.4.1.8 Total Mercury

All 2011 total mercury concentrations measured in Doris Outflow and Little Roberts Outflow sediments were below the analytical detection limit of 0.005 mg/kg, and the mean 2011 concentration in Roberts Outflow sediments was slightly higher than this detection limit (0.0086 mg/kg; Figure 3.4-8). All 2011 total mercury concentrations measured in exposure and reference stream sediments were well below the CCME ISQG of 0.17 mg/kg and the PEL of 0.486 mg/kg (Figure 3.4-8). Compared to mean 2009 concentrations, mean 2011 total mercury concentrations were lower in both Doris Outflow and Little Roberts Outflow. A decrease in sediment mercury levels is not of concern; therefore, 2011 activities did not adversely affect total mercury concentrations in the sediments of exposure streams. As suggested for lead concentrations, the significant decrease (before-after analysis: $p = 0.004$; BACI analysis: 0.002) in total mercury concentrations in Little Roberts Outflow sediments may be related to the lower proportion of silt and clay in 2011 sediment samples compared to 2009 samples. Statistical analysis results are not presented for Doris Outflow because of the high proportion of concentrations in the dataset that were below detection limits (83%).

3.4.1.9 Total Zinc

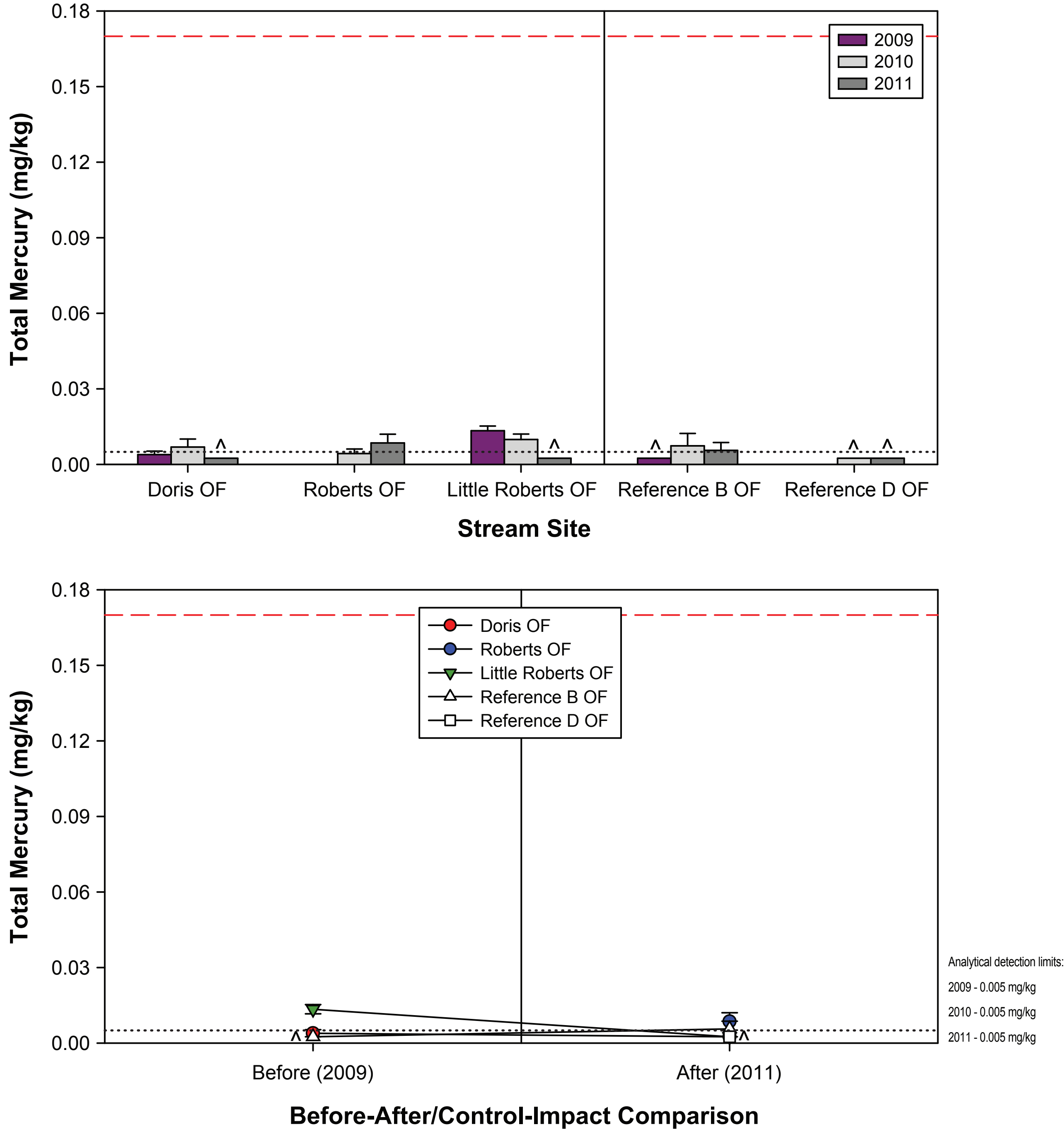
In all three exposure streams, 2011 zinc concentrations in sediments were well below the CCME ISQG of 123 mg/kg and the PEL of 315 mg/kg (Figure 3.4-9). Compared to 2009 mean zinc concentrations, 2011 mean concentrations were slightly higher in Doris Outflow and lower in Little Roberts Outflow (Figure 3.4-9). However, The before-after comparison indicated that mean 2011 zinc concentrations in exposure stream sediments were not distinguishable from 2009 means ($p = 0.50$ for Doris Outflow and $p = 0.017$ for Little Roberts Outflow). Consequently, there was no evidence that 2011 Project activities had an effect on zinc concentrations in the AEMP exposure stream sediments.

3.4.2 Lakes

AEMP sediment quality samples were collected from three exposure sites (Doris Lake North, Doris Lake South, and Little Roberts Lake) and two reference sites (Reference Lake B and Reference Lake D) in 2011. Sediment samples have been collected in the Doris North area since 1996; however, most of the historical data are not directly comparable to 2011 data because of differences in sampling locations, depth strata, and sampling methodology (Appendix B). Sediment quality data from 1997 and 2009 were used for before-after comparisons for Doris Lake South and Little Roberts Lake, and data from 2009 were used for before-after comparisons for Doris Lake North. 1997 sediment sampling was conducted in July, and 2009 and 2011 sediment sampling was conducted in August. No baseline sediment quality data were available for the reference lakes; therefore, no BACI analyses were possible for the lake exposure sites. For the calculations of annual means for each parameter, all lake sediment replicates collected in a given year were averaged.

3.4.2.1 Particle Size

The AEMP lakes were dominated by fine sediments in 2011 (Figure 3.4-10). Silt made up the largest proportion of the sediment composition in the two reference lakes and in Little Roberts Lake, and silt and clay each made up approximately half of the sediment composition in Doris Lake North and Doris Lake South (Figure 3.4-10). In all three exposure lakes, the particle size composition was similar between 2009 and 2011; however, the before-after analysis indicated that the silt content increased significantly in Little Roberts Lake between 2009 and 2011 ($p < 0.001$), while the clay content decreased significantly ($p < 0.001$). Variation in sediment particle size composition is unlikely related to 2011 Project activities, and probably reflects natural spatial heterogeneity in lake sediments.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG)
for mercury (0.17 mg/kg); the probable effects level (PEL) for mercury (0.486 mg/kg) is not shown.

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Total Mercury Concentration in AEMP Stream Sediments, Doris North Project, 2009-2011

Figure 3.4-8

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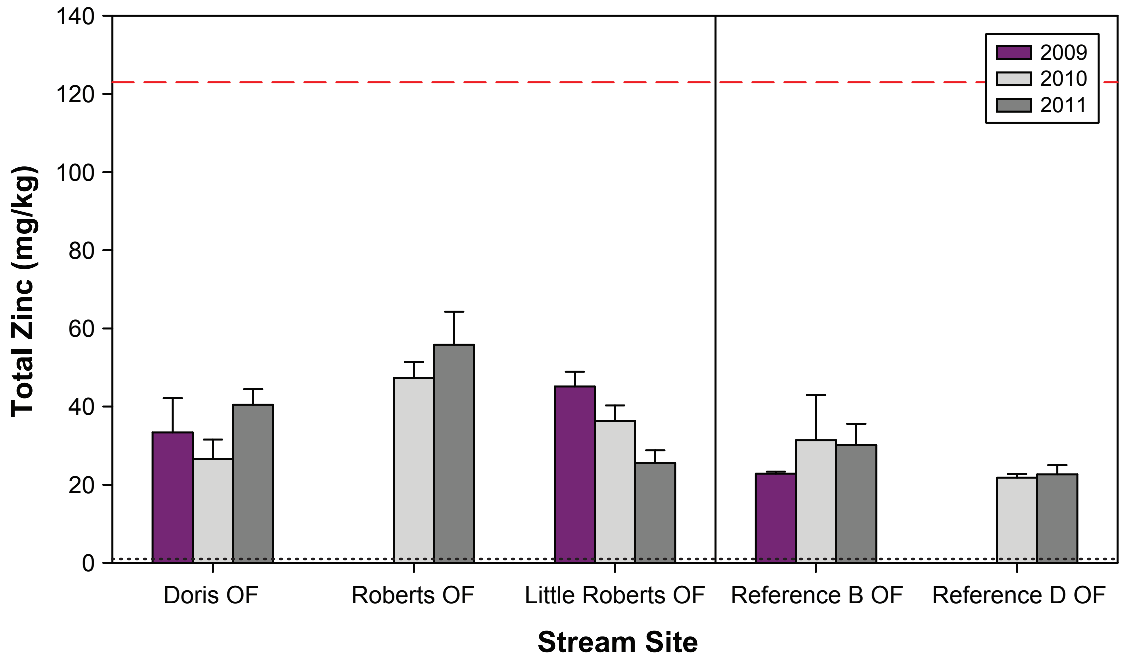

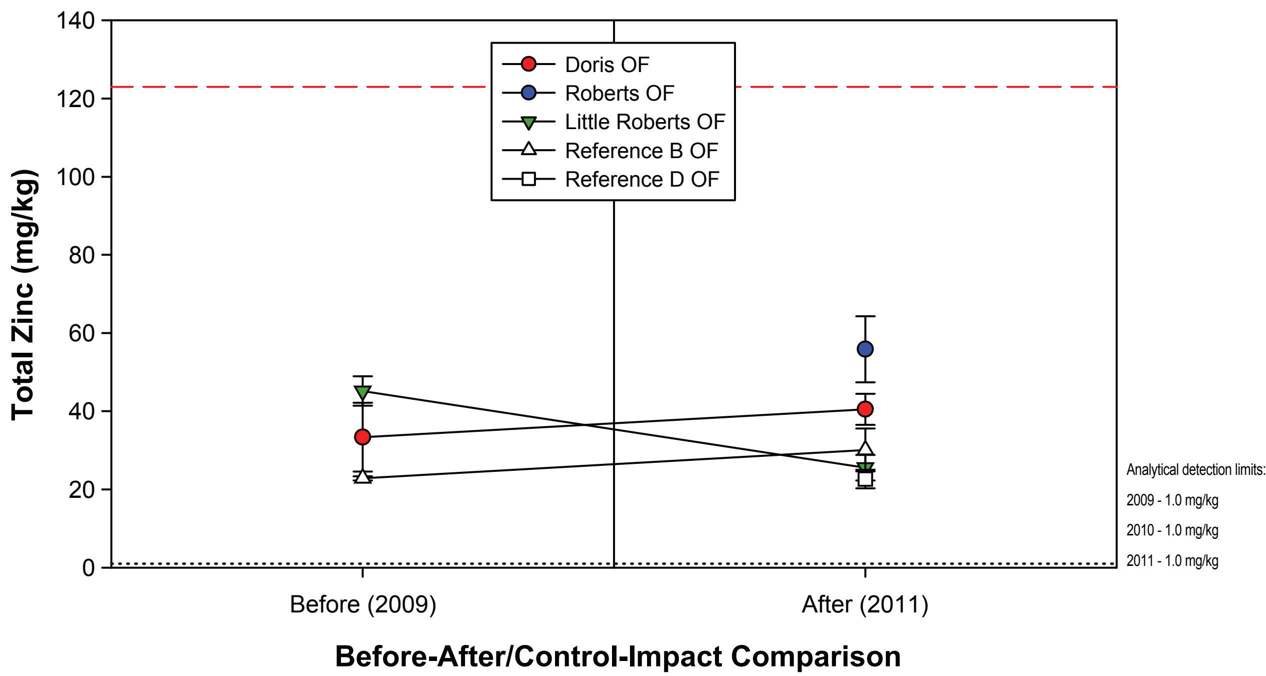

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for zinc (123 mg/kg); the probable effects level (PEL) for zinc (315 mg/kg) is not shown.

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Total Zinc Concentration in AEMP Stream Sediments, Doris North Project, 2009-2011

Figure 3.4-9

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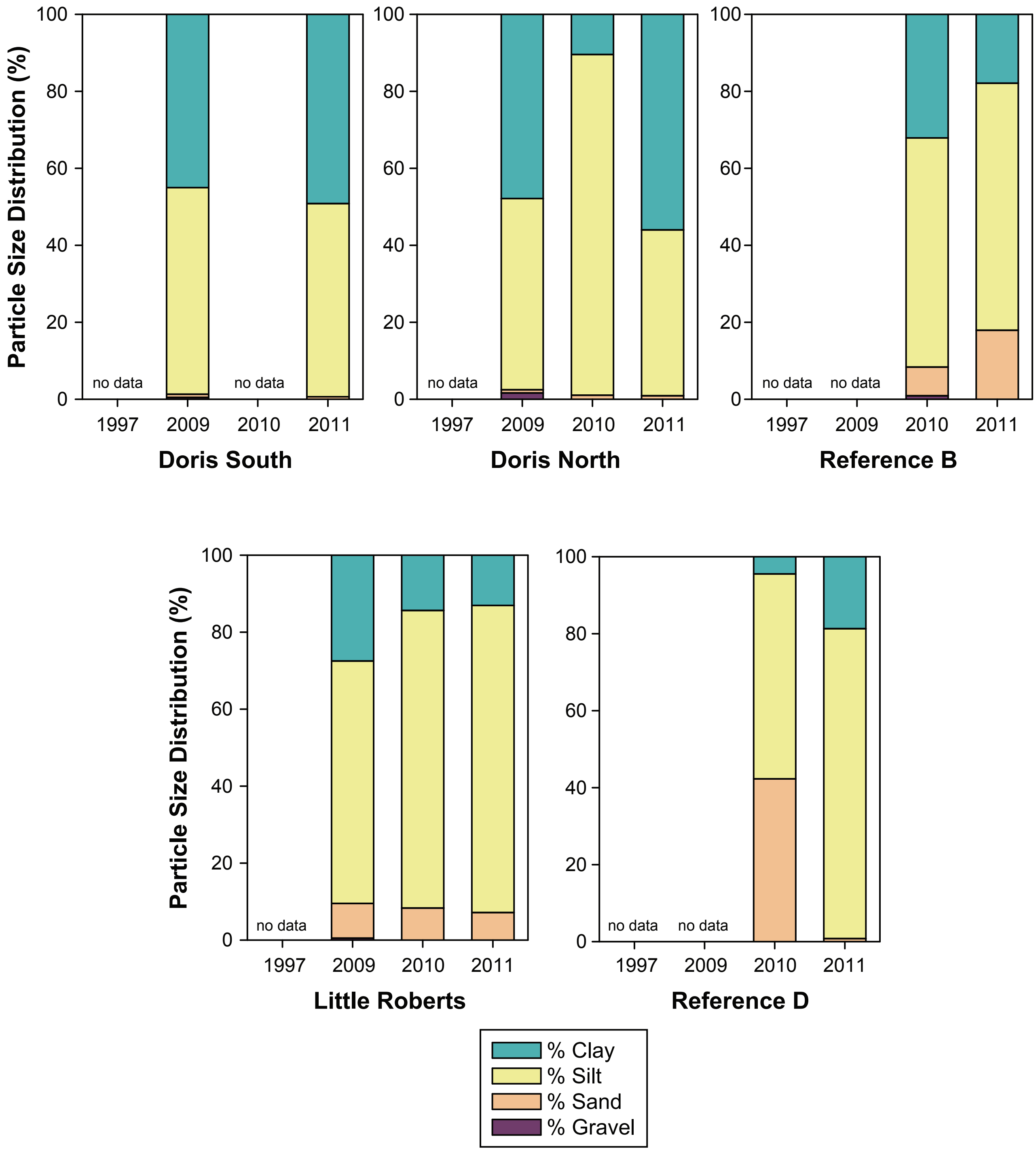

Notes: Stacked bars represent the mean of replicate samples.
Particle size distribution of sediments is a required parameter as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

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Particle Size Distribution in AEMP Lake Sediments, Doris North Project, 1997-2011

Figure 3.4-10

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3.4.2.2 Total Organic Carbon

The mean 2011 TOC concentrations in Doris Lake North and Doris Lake South sediments were nearly identical to baseline TOC levels (Figure 3.4-11). In Little Roberts Lake, the mean 2011 sediment TOC content was similar to 1997 but lower than 2009 (Figure 3.4-11). The before-after comparison confirmed that there was no significant difference between mean baseline and mean 2011 TOC levels in the sediments of any exposure lake ($p = 0.74$ for Doris Lake South, $p = 0.65$ for Doris Lake North, and $p = 0.57$ for Little Roberts Lake). Therefore, there was no effect of 2011 Project activities on the TOC content of exposure lake sediments.

3.4.2.3 Total Arsenic

Total arsenic concentrations in lake sediments were inter-annually variable (Figure 3.4-12). In both Doris Lake South and Little Roberts Lake, mean 2011 concentrations were higher than mean baseline levels, while in Doris Lake North, the mean 2011 arsenic concentration was lower than the mean 2009 concentration (Figure 3.4-12). The mean 2011 total arsenic concentration in Doris Lake South (22.7 mg/kg) exceeded the CCME ISQG of 5.9 mg/kg and the PEL of 17 mg/kg. Mean baseline total arsenic concentrations at this lake site also exceeded the ISQG but not the PEL (though one replicate from 2009 did exceed the PEL). At all other lake sites, mean 2011 concentrations were below the CCME ISQG and PEL guidelines. The before-after comparison indicated that baseline and 2011 mean arsenic levels were not statistically different in either Doris Lake South ($p = 0.12$), Doris Lake North ($p = 0.076$) or Little Roberts Lake ($p = 0.34$). Consequently, there were no 2011 Project effects on arsenic levels in the AEMP exposure lake sediments.

3.4.2.4 Total Cadmium

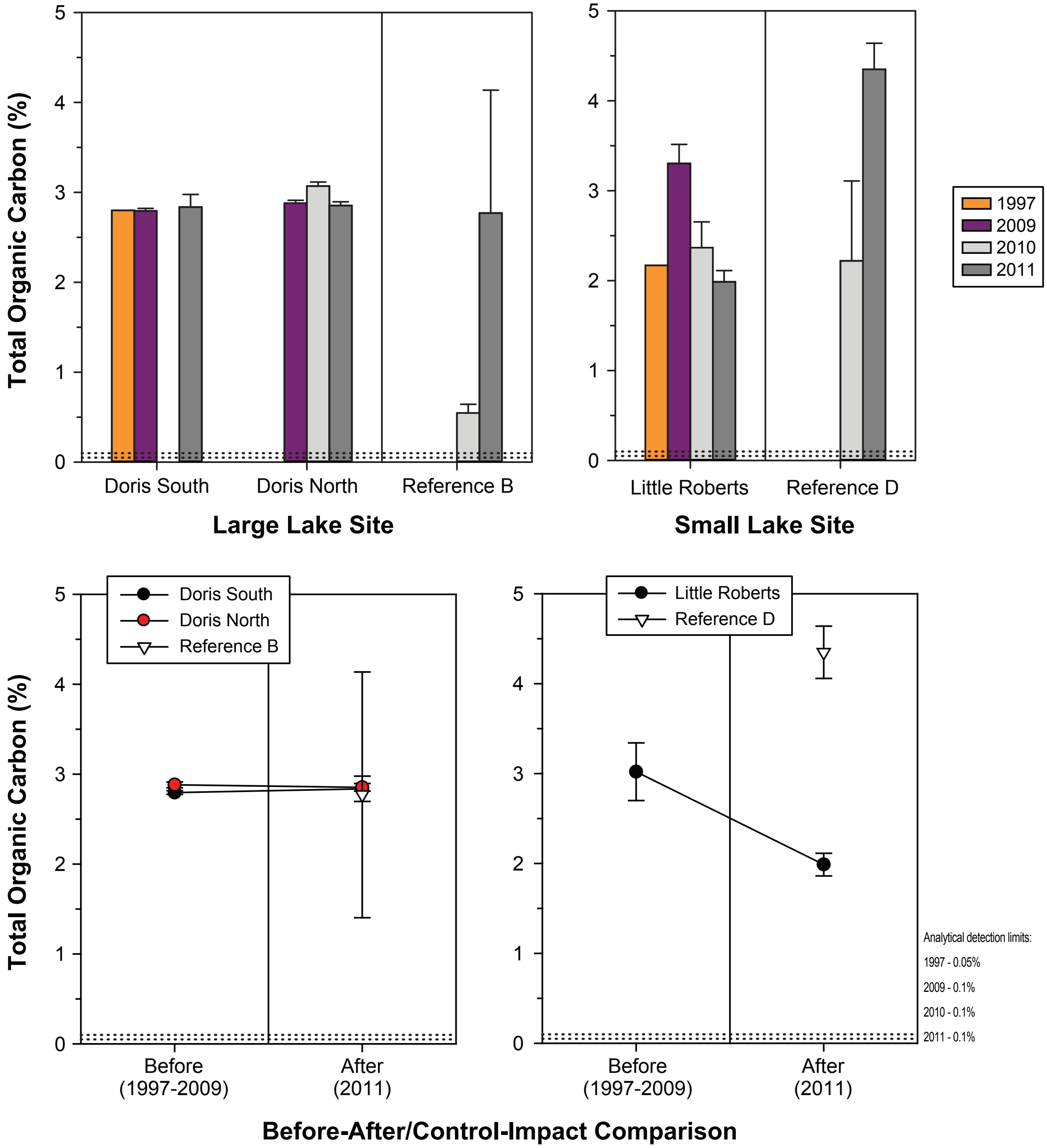
Mean 2011 cadmium levels in Doris Lake South and Little Roberts Lake sediments were within the range of baseline means, while the mean 2011 cadmium concentration in Doris Lake North sediments was slightly lower than the 2009 mean (Figure 3.4-13). All baseline and 2011 mean cadmium concentrations in exposure and reference lake sediments were below the CCME ISQG of 0.6 mg/kg and the PEL of 3.5 mg/kg (Figure 3.4-13). Based on the before-after analysis, there were no significant changes in mean sediment cadmium concentrations between baseline years and 2011 in the exposure lakes ($p = 0.87$ for Doris Lake South, $p = 0.012$ for Doris Lake North, and $p = 0.93$ for Little Roberts Lake). Therefore, 2011 activities had no apparent effect on cadmium concentrations in the exposure lake sediments.

3.4.2.5 Total Chromium

Sediment chromium levels were naturally high in the exposure and reference lake sediments, as 2011 concentrations were always above the CCME ISQG of 37.3 mg/kg (Figure 3.4-14). Baseline chromium levels also commonly exceeded this guideline. All chromium concentrations measured in 2011 were below the CCME PEL of 90 mg/kg. In the exposure lakes, 2011 concentrations were similar to baseline concentrations, and the before-after confirmed that there was no difference in means between baseline years and 2011 ($p = 0.73$ for Doris Lake South, $p = 0.76$ for Doris Lake North, and $p = 0.77$ for Little Roberts Lake). Therefore, there was no evidence of an effect of 2011 activities on total chromium concentrations in exposure lake sediments.

3.4.2.6 Total Copper

Mean baseline and 2011 copper concentrations were slightly higher than the CCME ISQG of 35.7 mg/kg in both Doris Lake South and Doris Lake North, but were well below the PEL of 197 mg/L. In Little Roberts Lake, mean baseline and 2011 concentrations were below both ISQG and PEL guidelines (Figure 3.4-15). At all three exposure lake sites, the before-after plot showed that mean 2011 sediment copper concentrations were slightly lower than baseline means (Figure 3.4-15). The before-after



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG)
Total organic carbon content of sediments is a required parameter as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

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Total Organic Carbon Concentration in AEMP Lake Sediments, Doris North Project, 1997-2011

Figure 3.4-11

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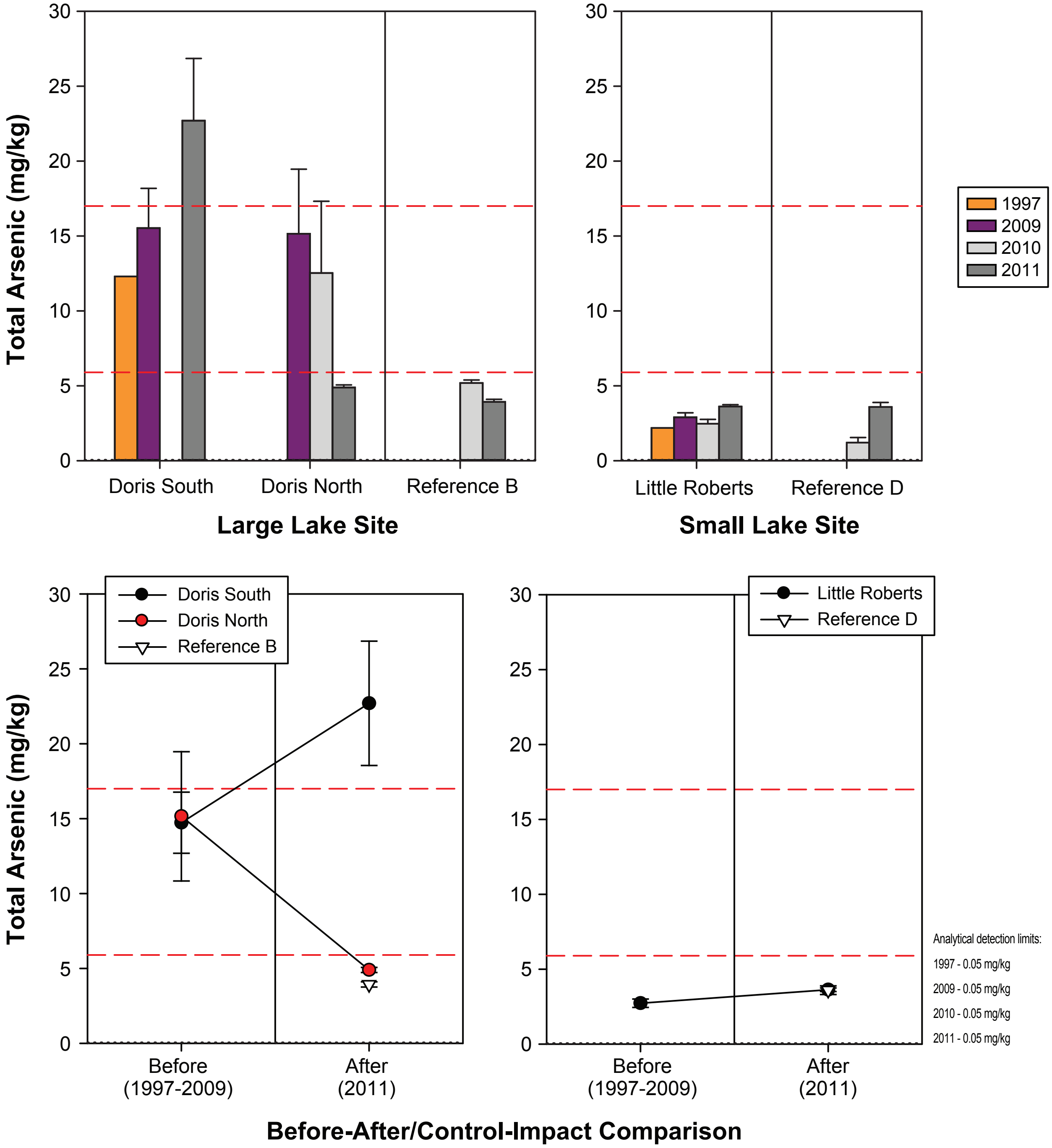

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for arsenic (5.9 mg/kg) and the probable effects level (PEL) for arsenic (17 mg/kg).

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Total Arsenic Concentration in AEMP Lake Sediments, Doris North Project, 1997-2011

Figure 3.4-12

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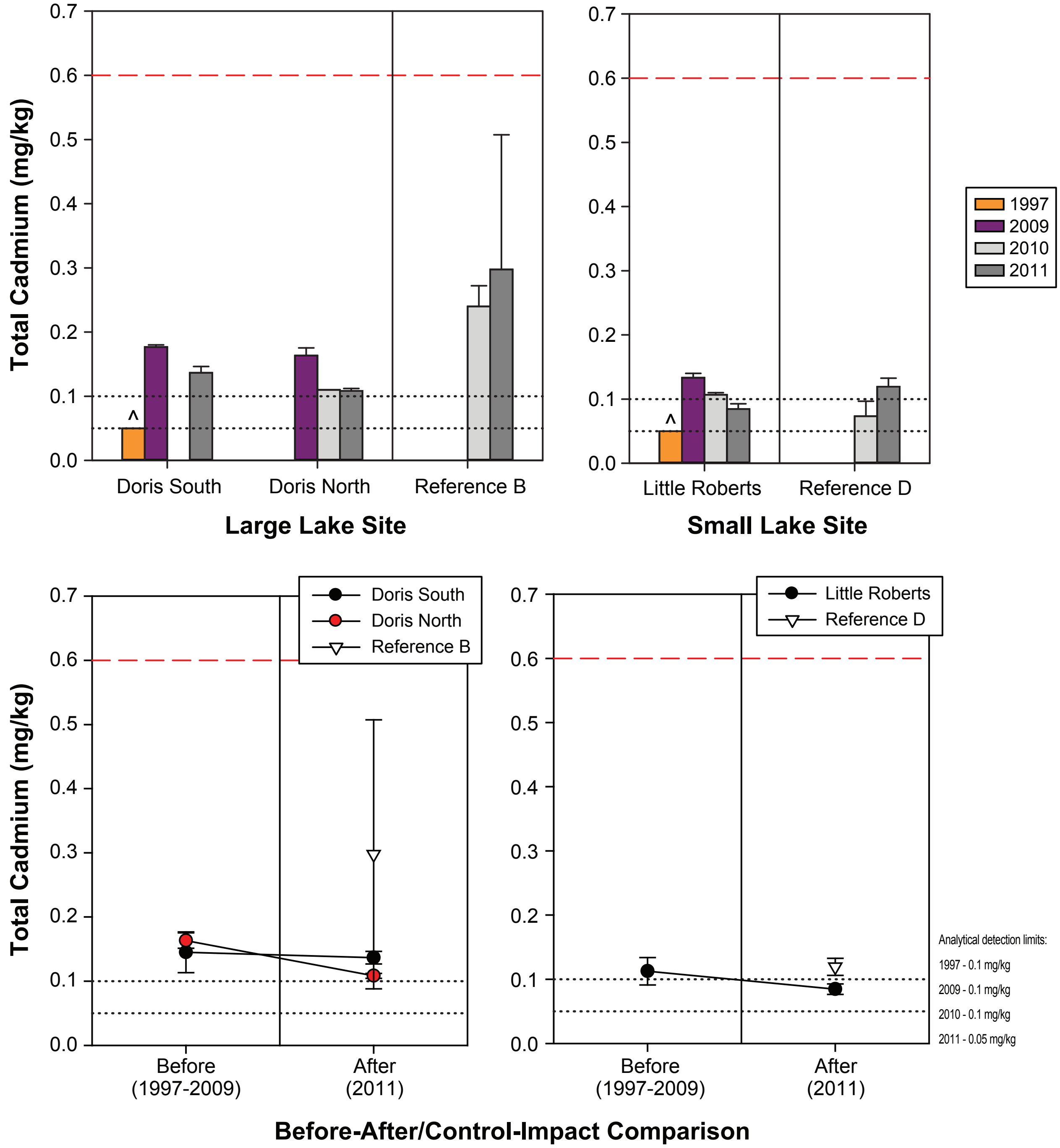

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for cadmium (0.6 mg/kg); the probable effects level (PEL) for cadmium (3.5 mg/kg) is not shown.
^ Indicates that concentrations were below the detection limit in all samples.

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Total Cadmium Concentration in AEMP Lake Sediments, Doris North Project, 1997-2011

Figure 3.4-13

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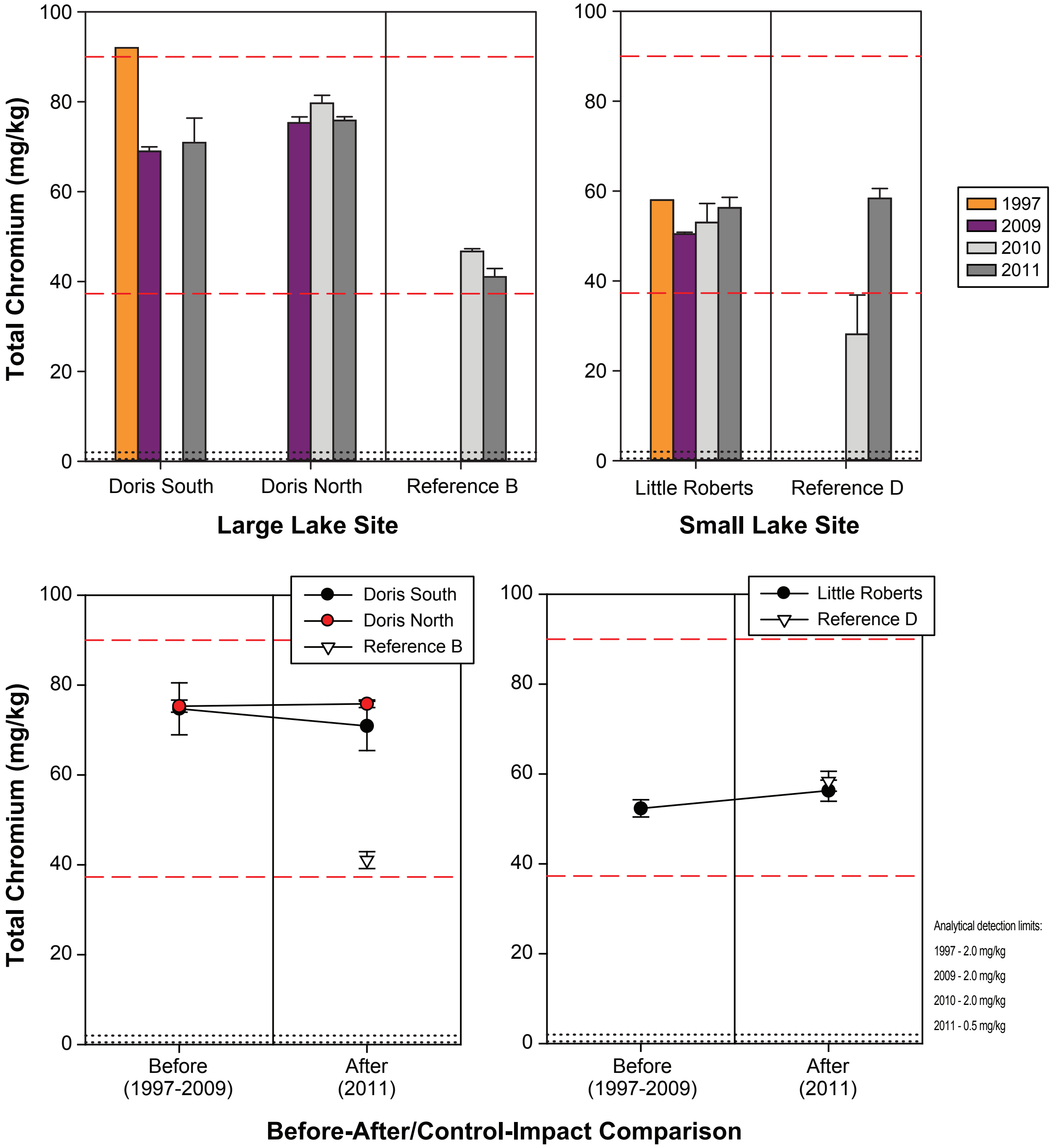

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for chromium (37.3 mg/kg) and the probable effects level (PEL) for chromium (90 mg/kg).

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Total Chromium Concentration in AEMP Lake Sediments, Doris North Project, 1997-2011

Figure 3.4-14

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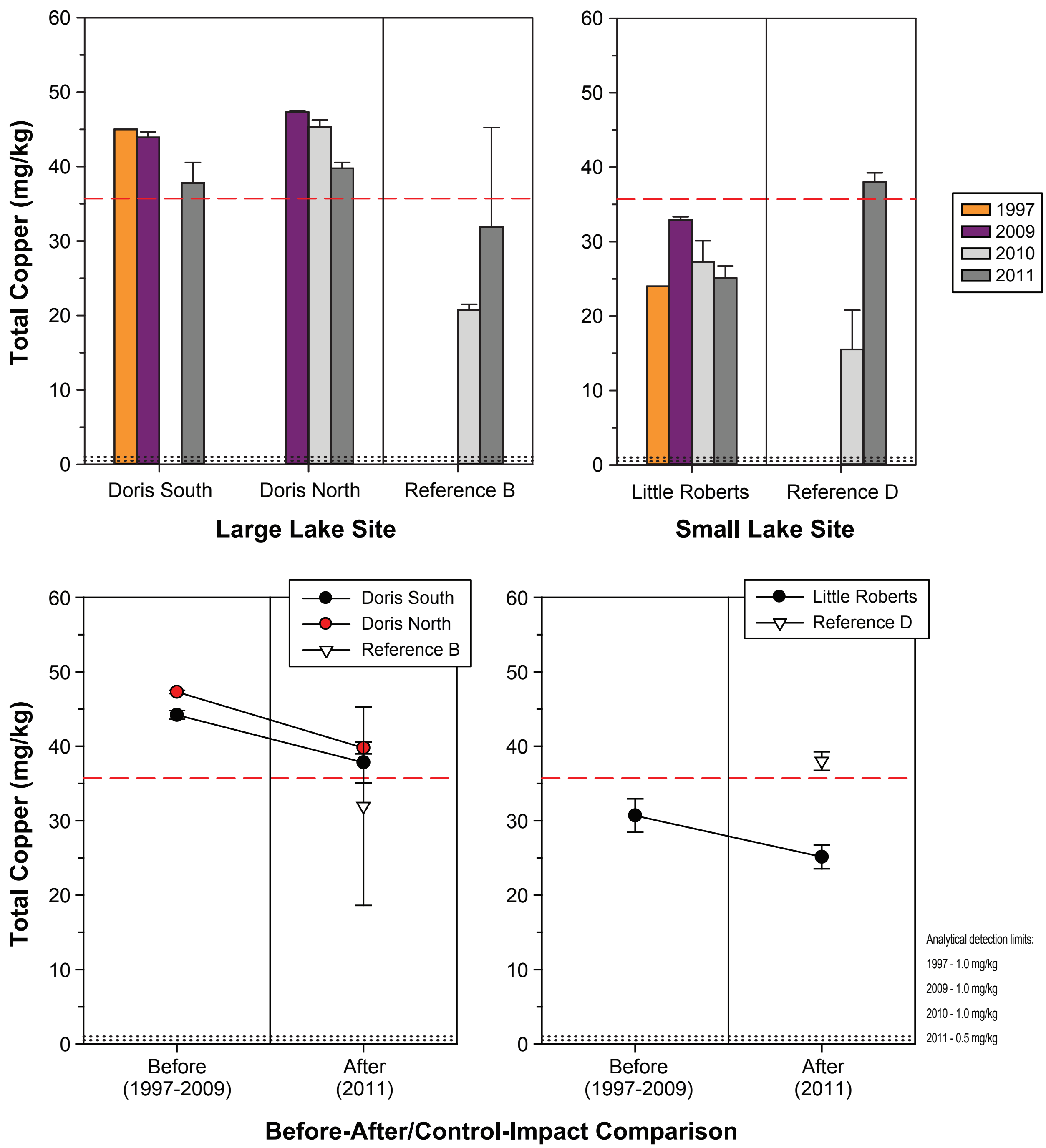

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for copper (35.7 mg/kg); the probable effects level (PEL) for copper (197 mg/kg) is not shown.

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Total Copper Concentration in AEMP Lake Sediments, Doris North Project, 1997-2011

Figure 3.4-15

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analysis indicated that this decrease was statistically significant for Doris Lake North sediments ($p < 0.001$), but that there was no significant difference between baseline and 2011 means for Doris Lake South ($p = 0.045$) and Little Roberts Lake ($p = 0.73$) sediments. A decrease in total copper concentrations in Doris Lake North sediments is not of concern; therefore, 2011 activities did not adversely affect copper concentrations in the sediments of exposure lakes.

3.4.2.7 Total Lead

Mean sediment lead concentrations decreased slightly in all exposure lakes between baseline years and 2011, and remained well below the CCME ISQG of 35 mg/kg and the PEL of 91.3 mg/kg (Figure 3.4-16). The before-after comparison showed that the mean 2011 lead concentration in Doris Lake North sediments was significantly lower than the 2009 mean ($p < 0.001$), but that the 2011 means were not significantly different from the baseline means in both Doris Lake South ($p = 0.31$) and Little Roberts Lake ($p = 0.099$). A decrease in sediment lead concentrations in Doris Lake North is not of concern; therefore, 2011 activities did not adversely affect lead concentrations in the sediments of exposure lakes.

3.4.2.8 Total Mercury

In all exposure lakes, sediment mercury concentrations measured in 2011 were similar to baseline concentrations, and were well below the CCME ISQG of 0.17 mg/kg and the PEL of 0.486 mg/kg (Figure 3.4-17). The before-after comparison confirmed that 2011 mean concentrations were not statistically different from baseline means in any exposure lake ($p = 0.97$ for Doris Lake South, $p = 0.012$ for Doris Lake North, and $p = 0.81$ for Little Roberts Outflow). There was no indication that 2011 activities had an effect on sediment mercury concentrations in exposure lakes.

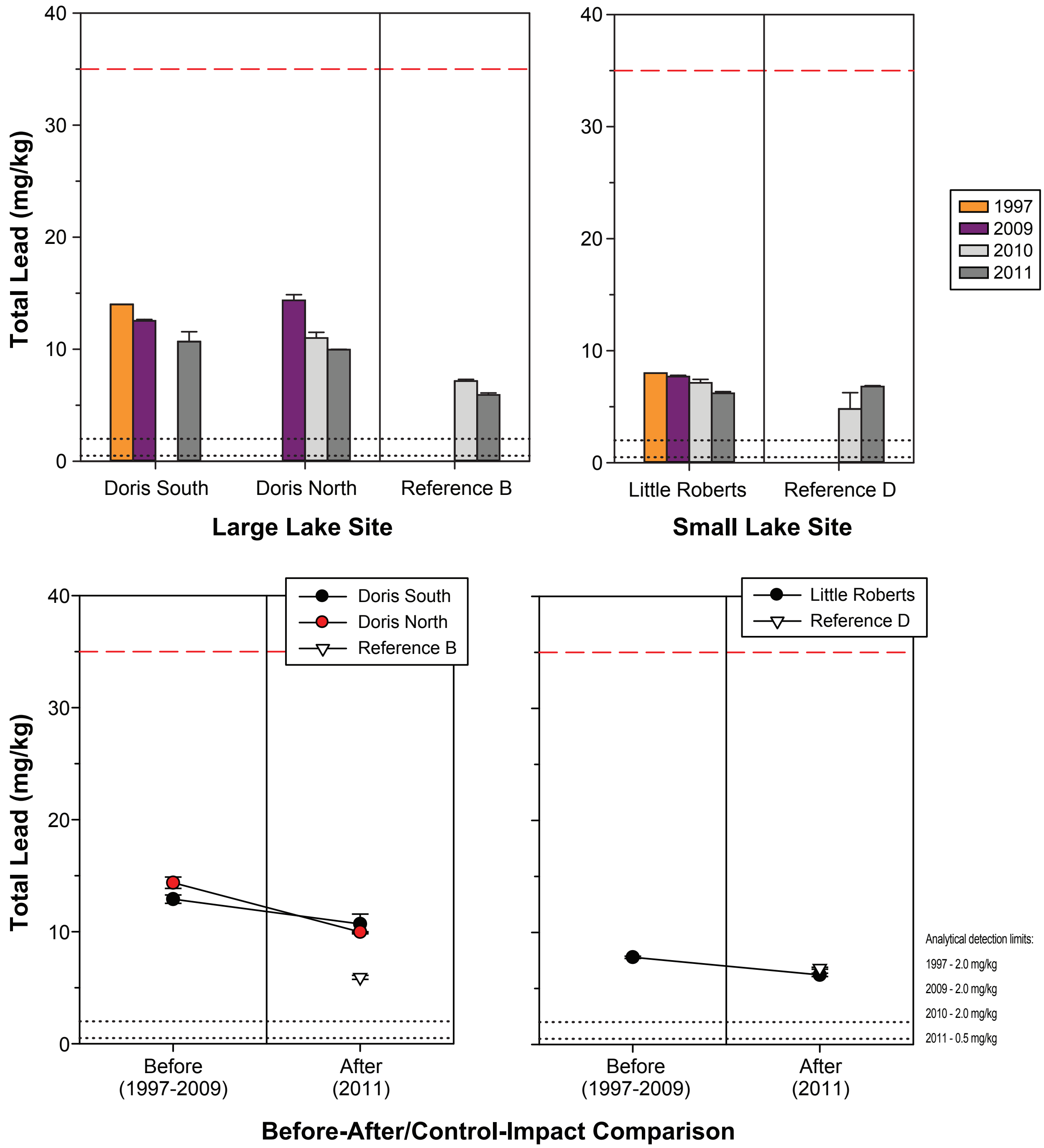
3.4.2.9 Total Zinc

Mean zinc concentrations in the sediments of the exposure lake sites were similar between baseline years and 2011, and 2011 zinc concentrations were always below the CCME ISQG of 123 mg/kg and the PEL of 315 mg/kg (Figure 3.4-18). Although the 2009 mean sediment zinc concentration of 105 mg/kg was similar to the 2011 mean of 98.5 mg/kg for Doris Lake North (Figure 3.4-18), the before-after analysis showed that this difference was statistically significant ($p = 0.006$). However, a decrease in sediment zinc levels is not of concern. At the other exposure lake sites, the before-after analysis failed to find evidence of a difference between baseline and 2011 means ($p = 0.67$ for Doris Lake South and $p = 0.90$ for Little Roberts Lake). Thus, there were no apparent adverse effects of 2011 activities on zinc concentrations in the sediments of the exposure lakes.

3.4.3 Marine

Sediment quality samples from the marine environment were collected from two exposure sites in Roberts Bay (RBW and RBE) and one reference site in Ida Bay (REF-Marine 1). Baseline sediment quality data were collected in Roberts Bay in 1997, 2002, and 2009; however, not all of the baseline data were directly comparable to the 2011 samples either because they were not collected in the immediate vicinity of the AEMP sampling sites or they were collected from different depth strata than 2011 samples (Appendix B). There was no suitable baseline data available for RBE, but there was one year of historical data available for each RBW (2002) and REF-Marine 1 (2009).

Because the available baseline data are from two different years, a change in any parameter at the exposure site, RBW, from 2002 to 2011 cannot be directly compared to the change at the reference station, REF-Marine 1, between 2009 and 2011. Any change at REF-Marine 1 can only be used to show the inherent inter-annual variability that occurs in the AEMP sediment parameters. Also, caution must be exercised when interpreting changes at RBW since there is a nine-year gap between the collection of before and after data. Because no suitable baseline sediment data were collected near RBE, no statistical analyses could be performed for this exposure site.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for lead (35 mg/kg); the probable effects level (PEL) for lead (91.3 mg/kg) is not shown.

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Total Lead Concentration in AEMP Lake Sediments, Doris North Project, 1997-2011

Figure 3.4-16

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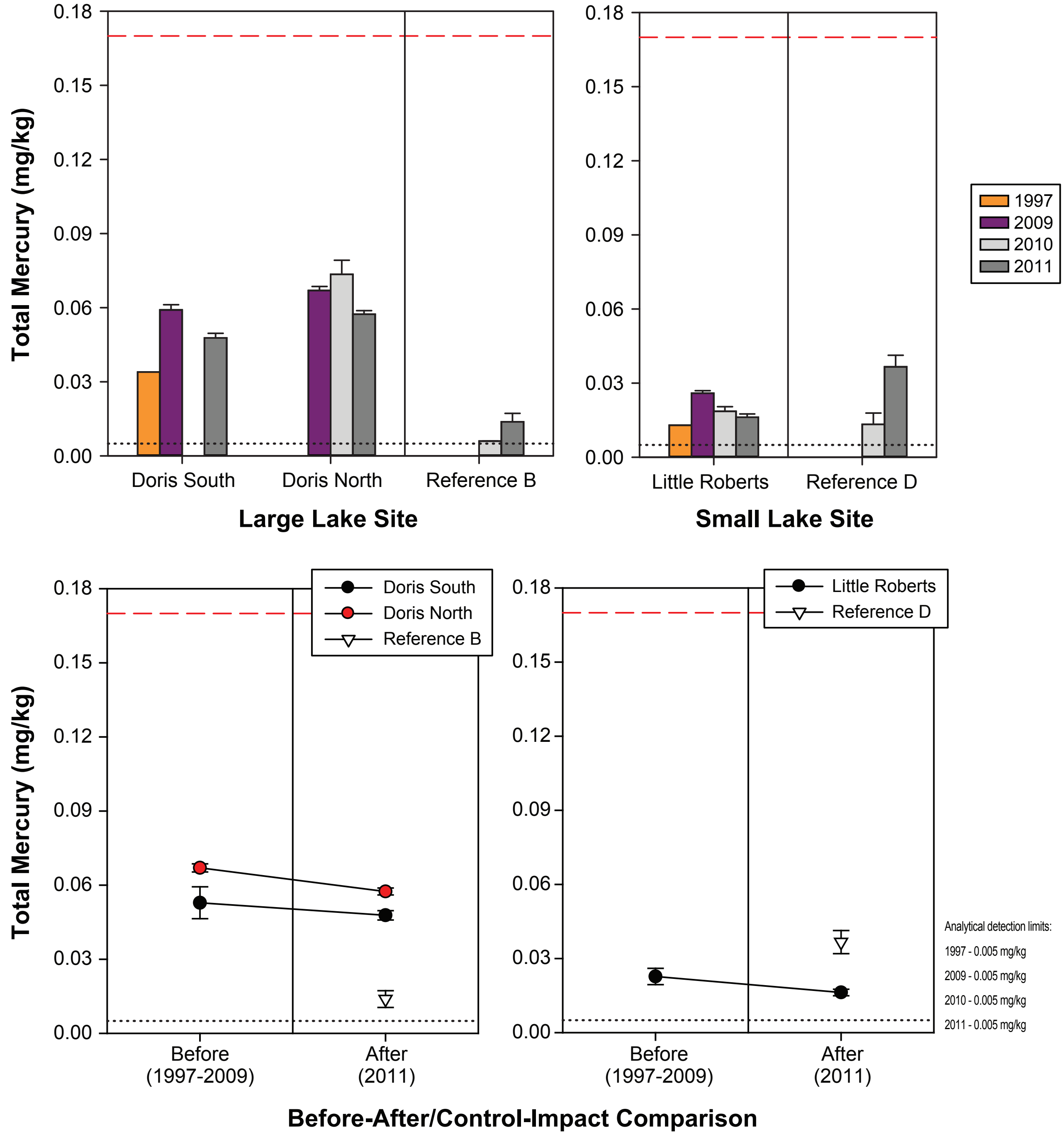


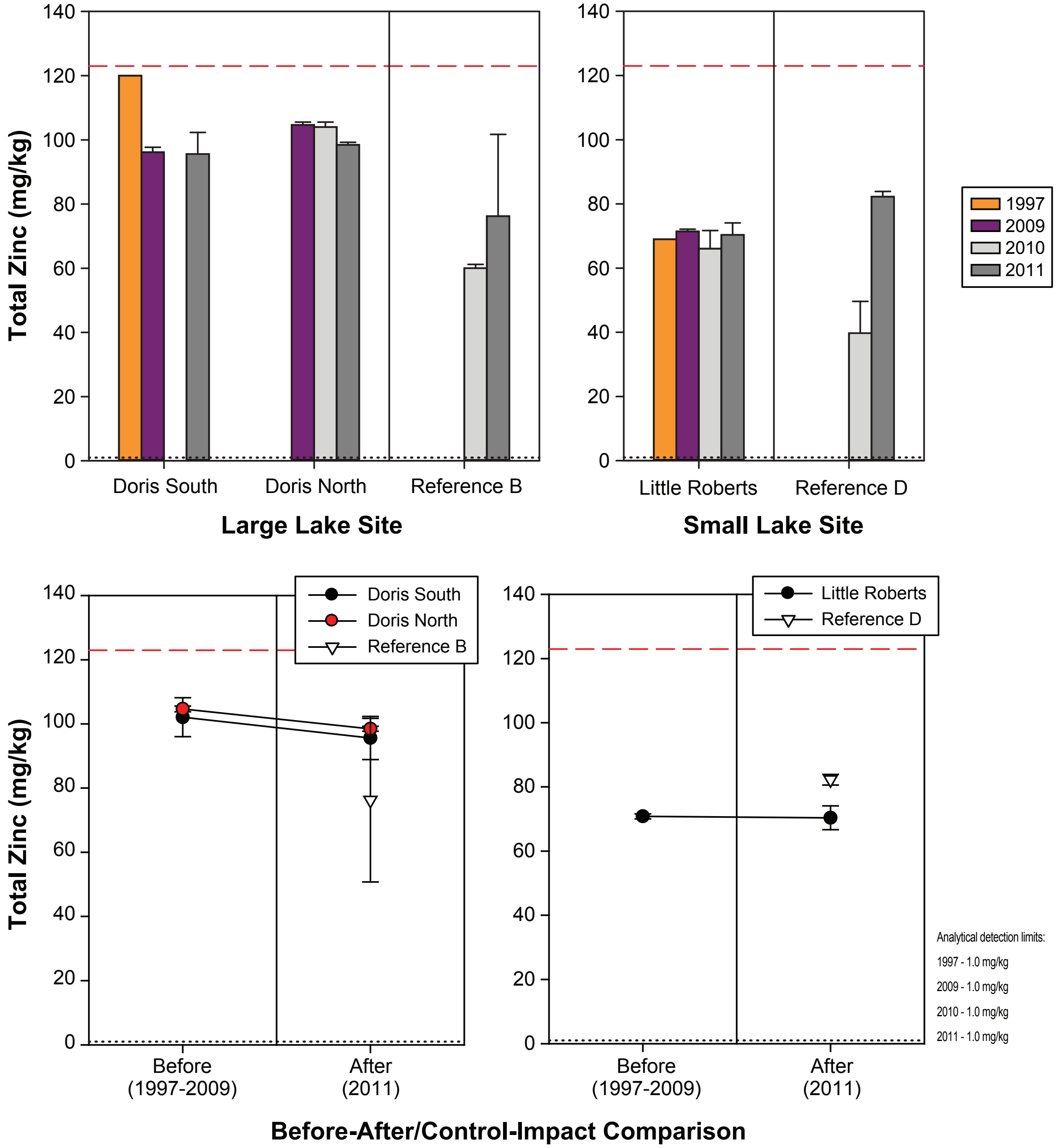
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for mercury (0.17 mg/kg); the probable effects level (PEL) for mercury (0.486 mg/kg) is not shown.

NEWMONT NORTH AMERICA

Total Mercury Concentration in AEMP Lake Sediments, Doris North Project, 1997-2011

Figure 3.4-17

Rescan Engineers & Scientists



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guideline (ISQG) for zinc (123 mg/kg); the probable effects level (PEL) for zinc (315 mg/kg) is not shown.

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Total Zinc Concentration in AEMP Lake Sediments, Doris North Project, 1997-2011

Figure 3.4-18

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3.4.3.1 Particle Size

In 2011, the sediment composition at the three AEMP marine sites was largely made up of sand and silt, with some clay (Figure 3.4-19). At site RBW, there were minor changes in the 2011 particle size composition of sediments compared to 2002 (Figure 3.4-19). The before-after comparison showed that the clay content decreased significantly from 19.7% in 2002 to 8.5 % in 2011 ($p < 0.001$), the silt content remained relatively consistent (27.5% in 2002 to 31.1% in 2011; $p = 0.054$), and the sand content increased significantly from 52.3% in 2002 to 60.4% in 2011 ($p = 0.002$). Variation in sediment particle size composition is unlikely related to 2011 Project activities, and probably reflects natural spatial heterogeneity in marine sediments.

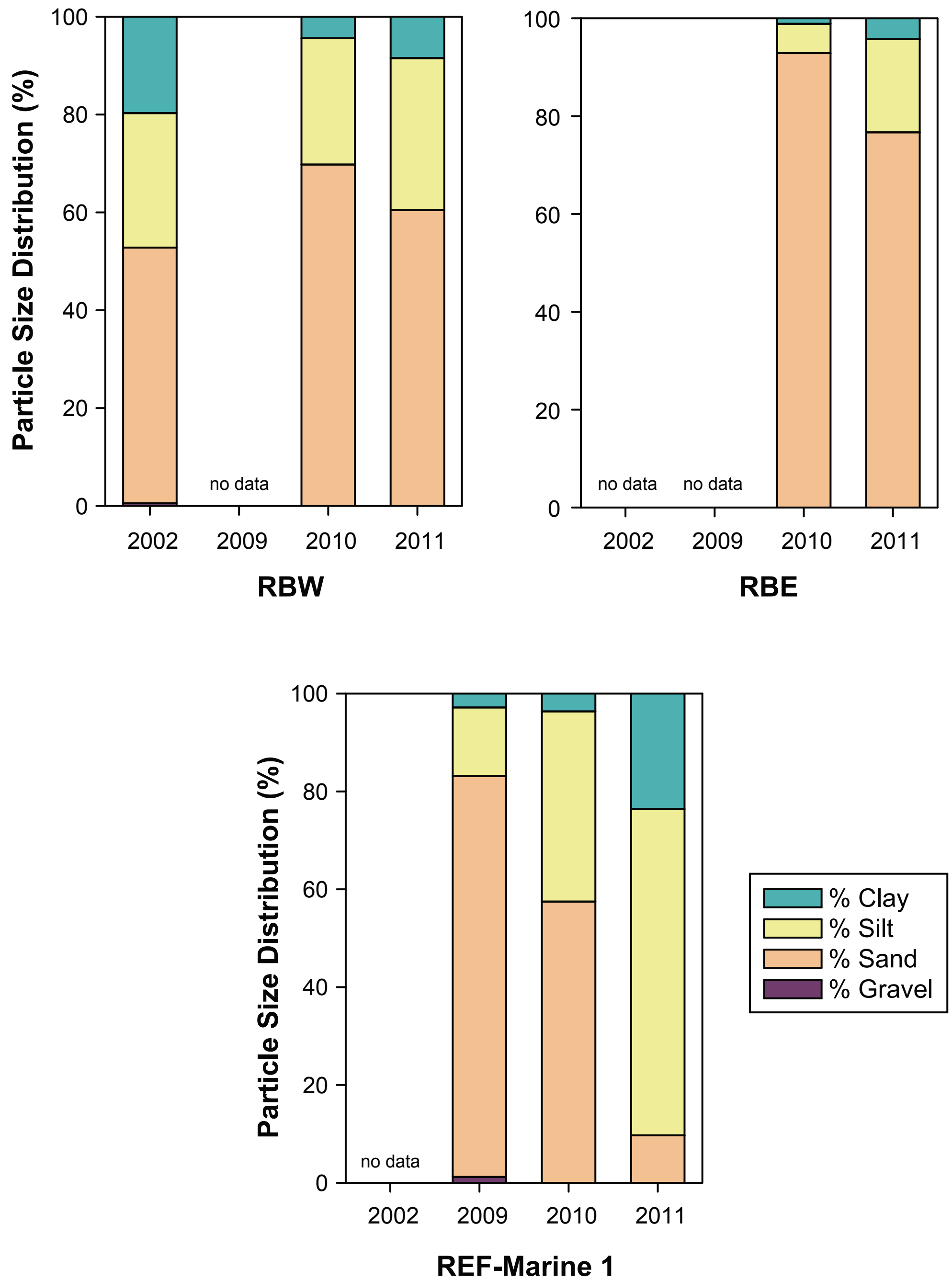
At site REF-Marine 1, there was a clear difference in the sediment composition in 2011 compared to 2009, as 2011 samples consisted of finer sediments than 2009 samples (Figure 3.4-19). The before-after analysis showed that the clay content increased significantly from 3.3% to 23.6% ($p < 0.001$) between 2009 and 2011, the silt content increased significantly from 14.0% to 66.7% ($p < 0.001$), and the sand content decreased significantly from 82.0% to 9.6% ($p < 0.001$). This had important implications for the before-after comparisons of metals because metal concentrations tend to be higher in fine sediments than in coarse sediments (e.g., Lakhan, Cabana, and LaValle 2003). As described in the following sections, mean concentrations of TOC and all evaluated metals increased significantly at REF-Marine 1 in 2011 compared to 2009. Consequently, the results of the BACI analysis for RBW become difficult to interpret because before-after trends at RBW are compared to the before-after trends at REF-Marine 1, which always increased.

3.4.3.2 Total Organic Carbon

The mean TOC content in sediments from RBW appeared to increase from 2002 to 2011 (Figure 3.4-20); however, this was an artifact of the five-fold higher analytical detection limit for TOC in 2002 (0.5%) compared to 2011 (0.1%). TOC concentrations measured in 2002 were all below the detection limit (< 0.5%), while the mean TOC content measured in 2011 (0.36%) was also lower than the 2002 detection limit. The before-after comparison indicated that there was a significant increase in the mean sediment TOC content at RBW between 2002 and 2011 ($p < 0.001$), but this can be entirely explained by the variability in detection limits and the substitution of half the detection limit for values that were below the detection limit. Sediment samples from the sand-dominated RBE contained very little TOC, as all concentrations were near or below the detection limit of 0.1% and were lower than the TOC content in samples from either RBW or REF-Marine 1 (Figure 3.4-20). There was no evidence that 2011 Project activities had any effect on the proportion of TOC in the exposure site sediments.

3.4.3.3 Total Arsenic

Mean arsenic concentrations in sediments from RBW increased from 1.9 mg/kg in 2002 to 3.4 mg/kg in 2011 (Figure 3.4-21). This increase was statistically significant ($p < 0.001$) based on the before-after analysis. However, mean arsenic concentrations also increased significantly at REF-Marine 1 from 2009 (0.6 mg/kg) to 2011 (5.2 mg/kg; $p < 0.001$). The BACI interaction effect was statistically significant ($p < 0.001$), because the increase that occurred at REF-Marine 1 was greater than that the increase that occurred at RBW. This suggests that the change in arsenic concentrations that occurred in sediments from RBW in 2011 was within the range of natural variability that can be expected, and was unrelated to 2011 Project activities. At RBE, the mean 2011 arsenic concentration in sediments (1.5 mg/kg) was lower than concentrations in sediments from the other AEMP sites (Figure 3.4-21). All 2011 concentrations were well below the CCME ISQG of 7.24 mg/kg and the PEL of 41.6 mg/kg. There was no evidence that 2011 activities affected sediment arsenic concentrations at the marine exposure sites.



Notes: Stacked bars represent the mean of replicate samples.
Particle size distribution of sediments is a required parameter as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

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Particle Size Distribution in AEMP Marine Sediments, Doris North Project, 2002-2011

Figure 3.4-19

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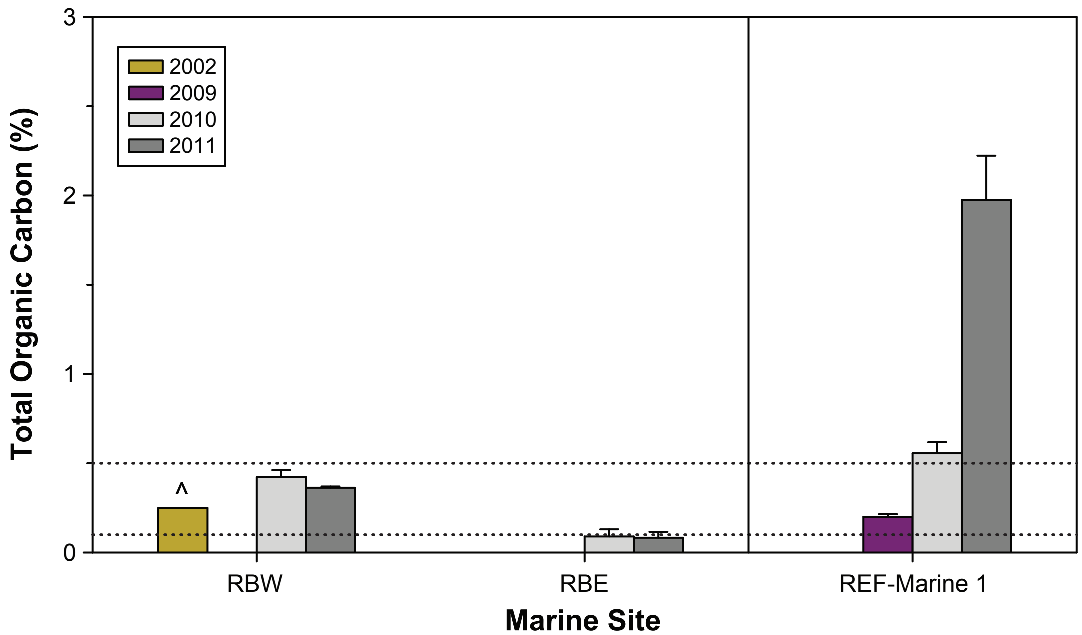

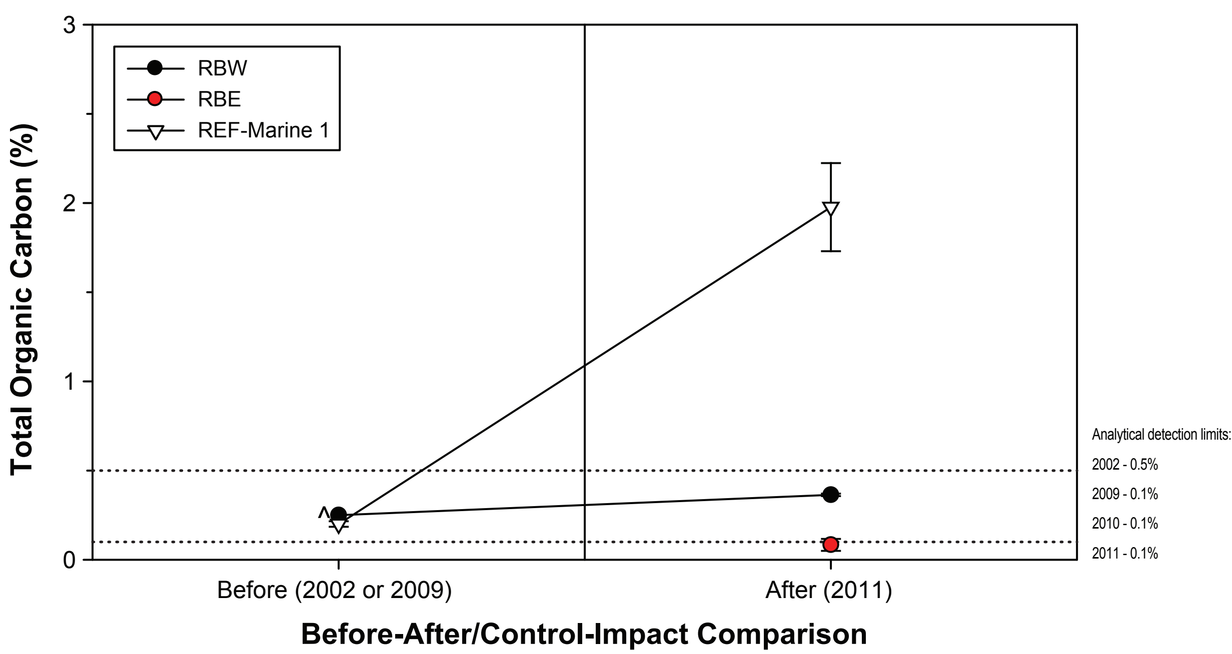

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Total organic carbon content of sediments is a required parameter as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

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Total Organic Carbon Concentration in AEMP Marine Sediments, Doris North Project, 2002-2011

Figure 3.4-20

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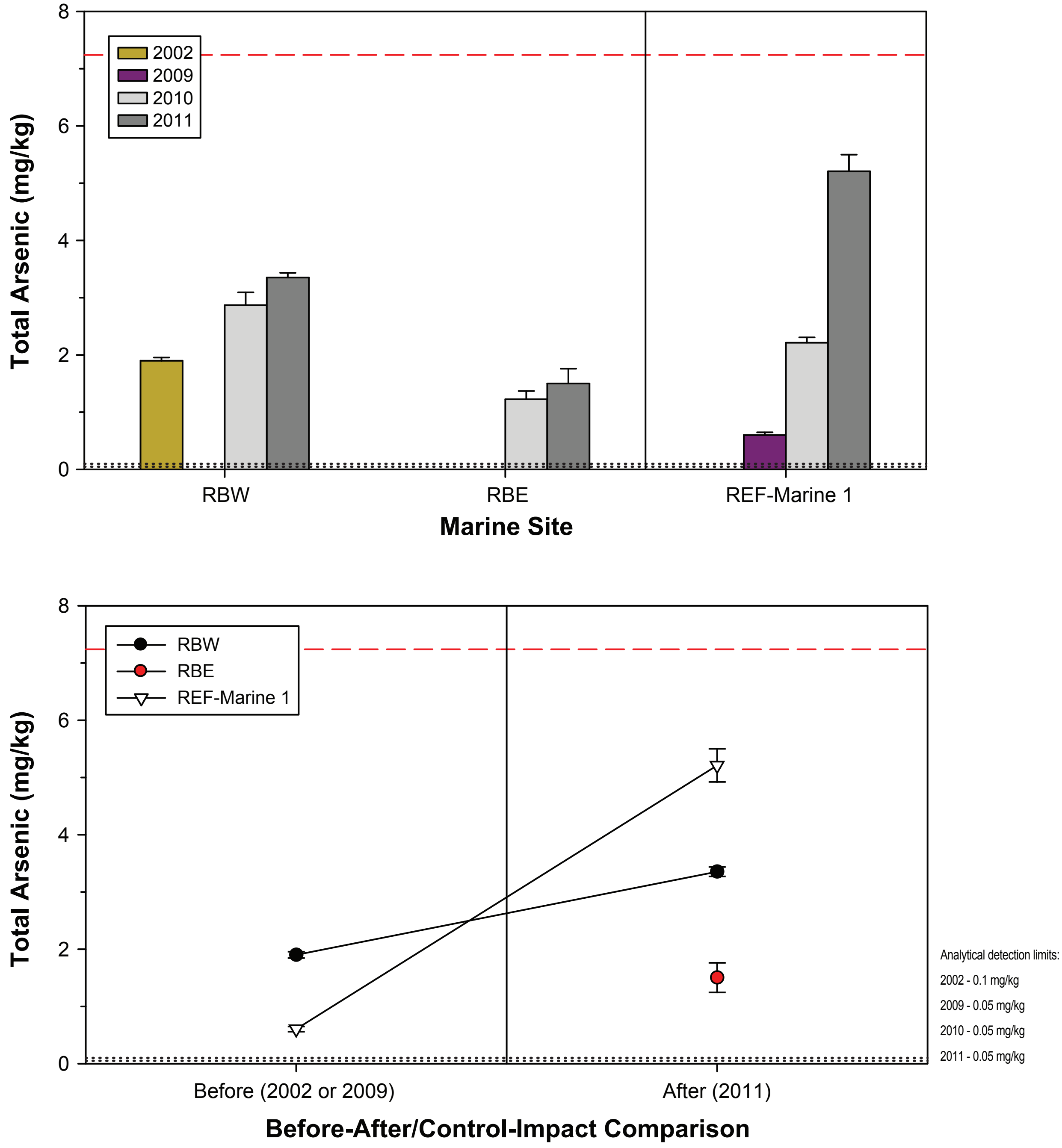

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for arsenic (7.24 mg/kg); the probable effects level (PEL) for arsenic (41.6 mg/kg) is not shown.

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Total Arsenic Concentration in AEMP Marine Sediments, Doris North Project, 2002-2011

Figure 3.4-21

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3.4.3.4 Total Cadmium

Total cadmium concentrations were below the detection limit (< 0.05 mg/kg) in all sediment samples collected from RBW and RBE in 2011, but were detectable in samples from REF-Marine 1 (mean: 0.13 mg/kg; Figure 3.4-22). All 2011 concentrations were well below the CCME ISQG of 0.7 mg/kg and the PEL of 4.2 mg/kg. There was no indication that 2011 activities had any effect on cadmium concentrations in sediments at the marine exposure sites.

3.4.3.5 Total Chromium

Mean chromium concentrations in RBW sediments increased slightly but significantly from 18.2 mg/kg in 2002 to 22.4 mg/kg in 2011 (before-after: $p = 0.003$; Figure 3.4-23). A significant and considerably larger increase from 9.4 mg/kg in 2009 to 38.4 mg/kg in 2011 (before-after: $p < 0.001$) occurred in sediments from REF-Marine 1 (Figure 3.4-23). The BACI interaction effect was statistically significant ($p < 0.001$), because the increase that occurred at REF-Marine 1 was greater than that the increase that occurred at RBW. This suggests that the change in chromium concentrations that occurred in sediments from RBW in 2011 was within the range of natural variability that can be expected, and was unrelated to 2011 Project activities. At RBE, the mean 2011 chromium concentration in sediments (13.9 mg/kg) was lower than concentrations in sediments from the other AEMP sites (Figure 3.4-23). All 2011 concentrations were below the CCME ISQG of 52.3 mg/kg and the PEL of 160 mg/kg. There was no evidence of an effect of 2011 activities on sediment chromium concentrations at the marine exposure sites in Roberts Bay.

3.4.3.6 Total Copper

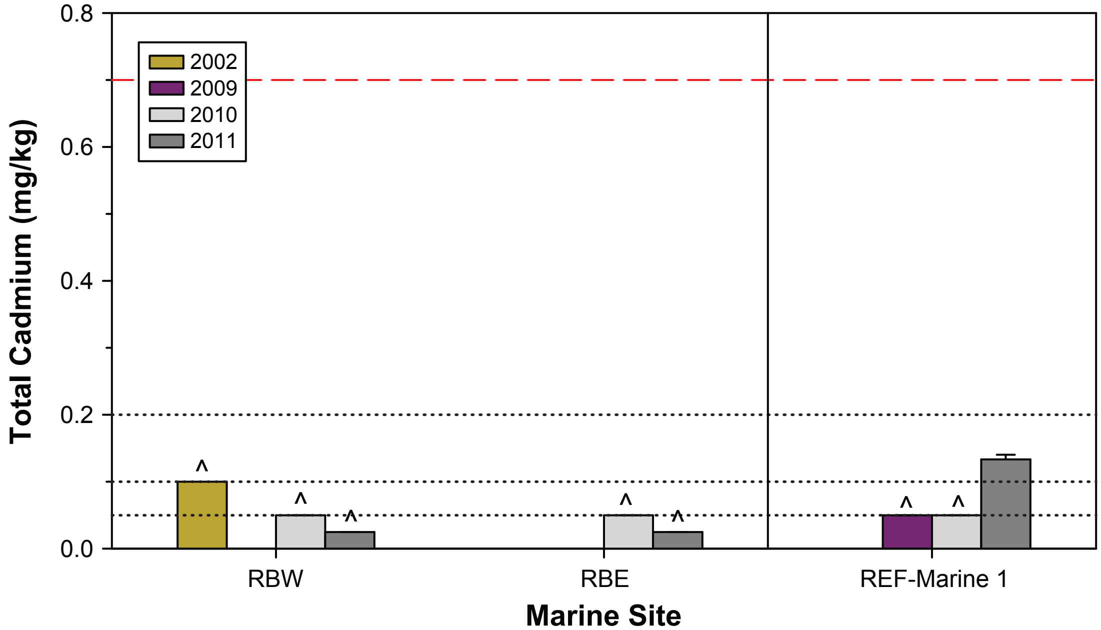
Mean copper concentrations in sediments from RBW increased from 8.4 mg/kg in 2002 to 14.6 mg/kg in 2011 (Figure 3.4-24). This increase was statistically significant ($p < 0.001$) based on the before-after analysis. However, mean copper concentrations also increased significantly at REF-Marine 1 from 2009 (4.9 mg/kg) to 2011 (18.1 mg/kg; $p < 0.001$). The BACI interaction effect was statistically significant ($p < 0.001$), because the increase that occurred at REF-Marine 1 was greater than that the increase that occurred at RBW. This suggests that the change in copper concentrations that occurred in sediments from RBW in 2011 was within the range of natural variability that can be expected, and was unrelated to 2011 Project activities. At RBE, the mean 2011 copper concentration in sediments (9.9 mg/kg) was lower than concentrations in sediments from the other AEMP sites (Figure 3.4-24). All 2011 concentrations from the marine exposure sites were below the CCME ISQG of 18.7 mg/kg and the PEL of 108 mg/kg. There was no indication that 2011 Project activities affected sediment copper concentrations at the marine exposure sites.

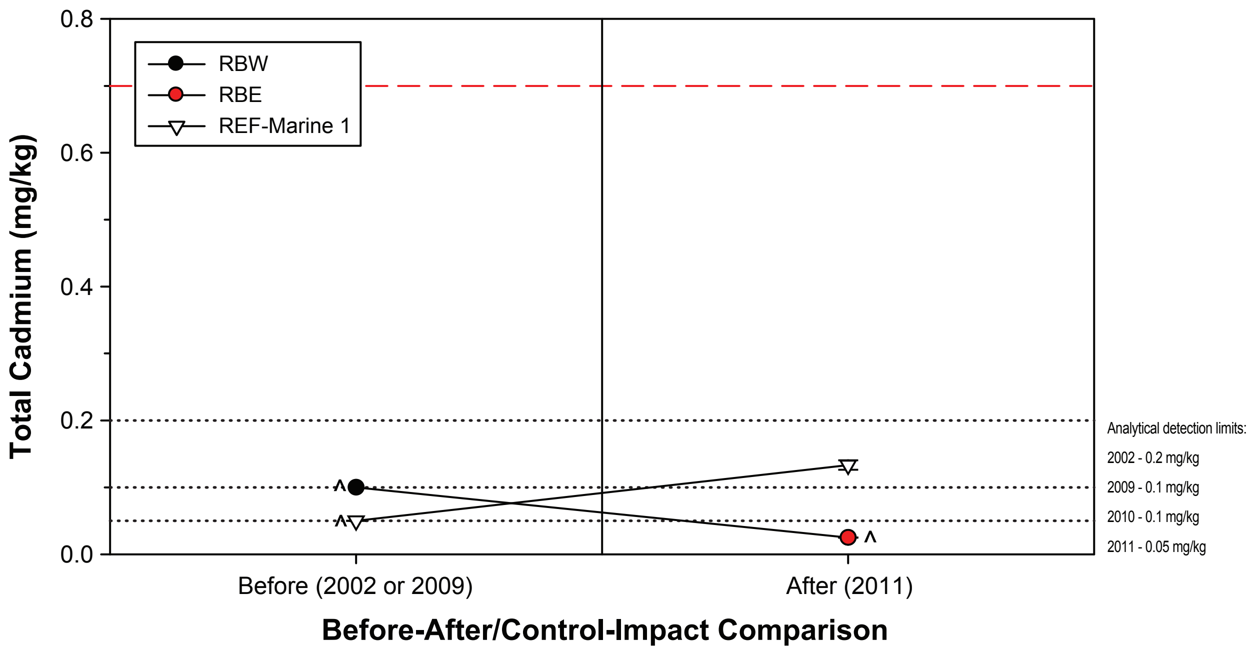
3.4.3.7 Total Lead

The mean 2011 lead concentration in RBW sediments (2.8 mg/kg) was similar to the 2002 mean (2.6 mg/kg; Figure 3.4-25), and the before-after analysis found no evidence of a difference in means ($p = 0.66$). As observed for all other 2011 sediment metal concentrations, sediments from RBE had the lowest mean concentration of lead (1.6 mg/kg), while sediments from REF-Marine 1 had the highest (5.4 mg/kg; Figure 3.4-25). All 2011 sediment lead concentrations were well below the CCME ISQG of 30.2 mg/kg and the PEL of 112 mg/kg (Figure 3.4-25). There was no apparent effect of 2011 activities on sediment lead concentrations at the marine exposure sites.

3.4.3.8 Total Mercury and Methylmercury

Total mercury concentrations were below the detection limit (< 0.005 mg/kg) in all sediment samples collected from the exposure sites in Roberts Bay in 2011, but were detectable in samples collected from REF-Marine 1 in 2011 (mean: 0.014 mg/kg; Figure 3.4-26). Total mercury concentrations in all





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for cadmium (0.7 mg/kg); the probable effects level (PEL) for cadmium (4.2 mg/kg) is not shown.

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Total Cadmium Concentration in AEMP Marine Sediments, Doris North Project, 2002-2011

Figure 3.4-22

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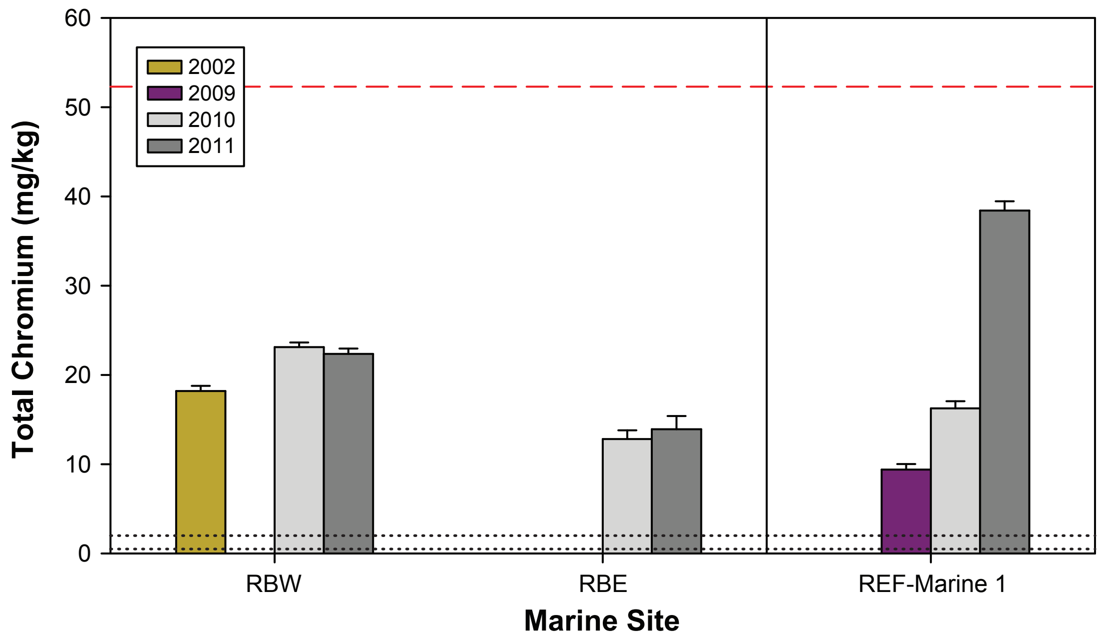

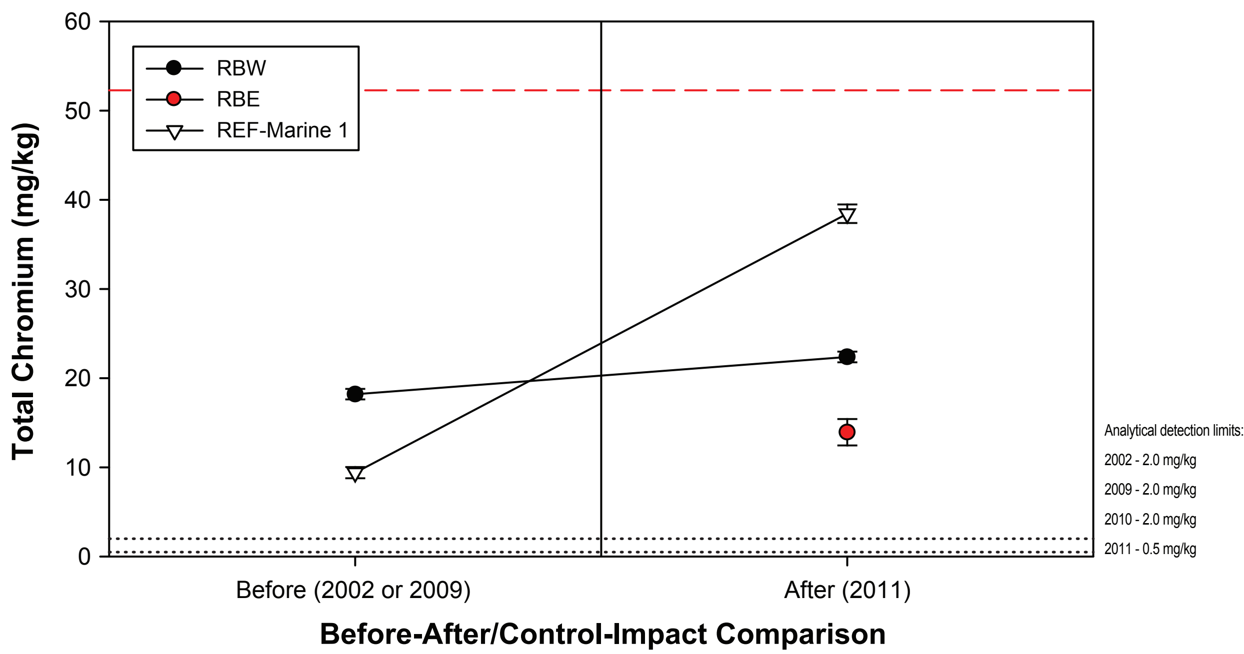

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for chromium (52.3 mg/kg); the probable effects level (PEL) for chromium (160 mg/kg) is not shown.

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Total Chromium Concentration in AEMP Marine Sediments, Doris North Project, 2002-2011

Figure 3.4-23

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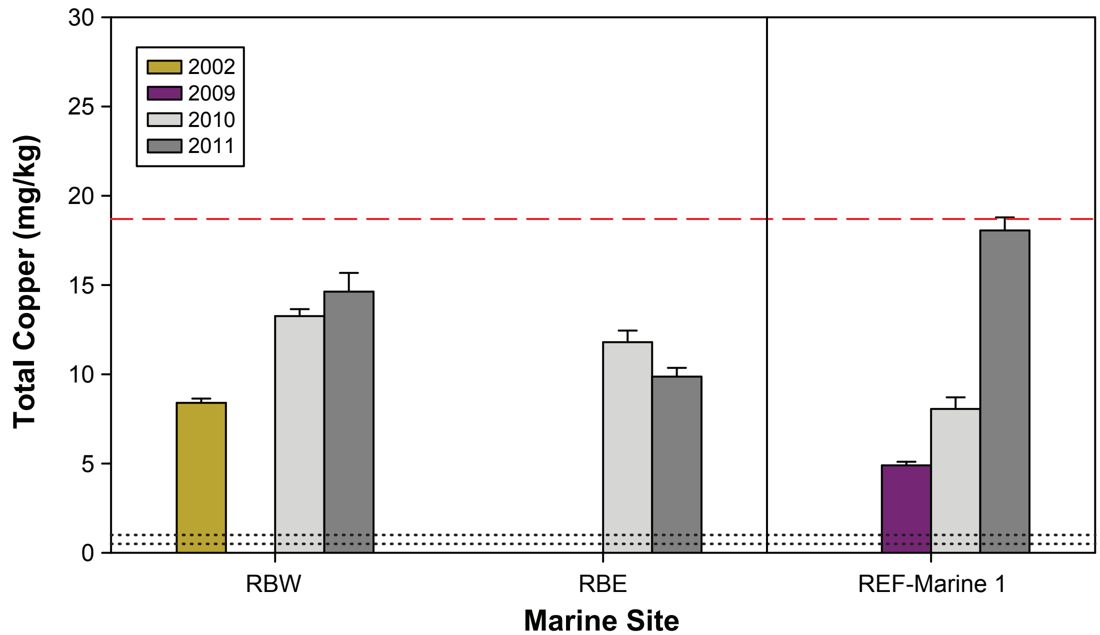

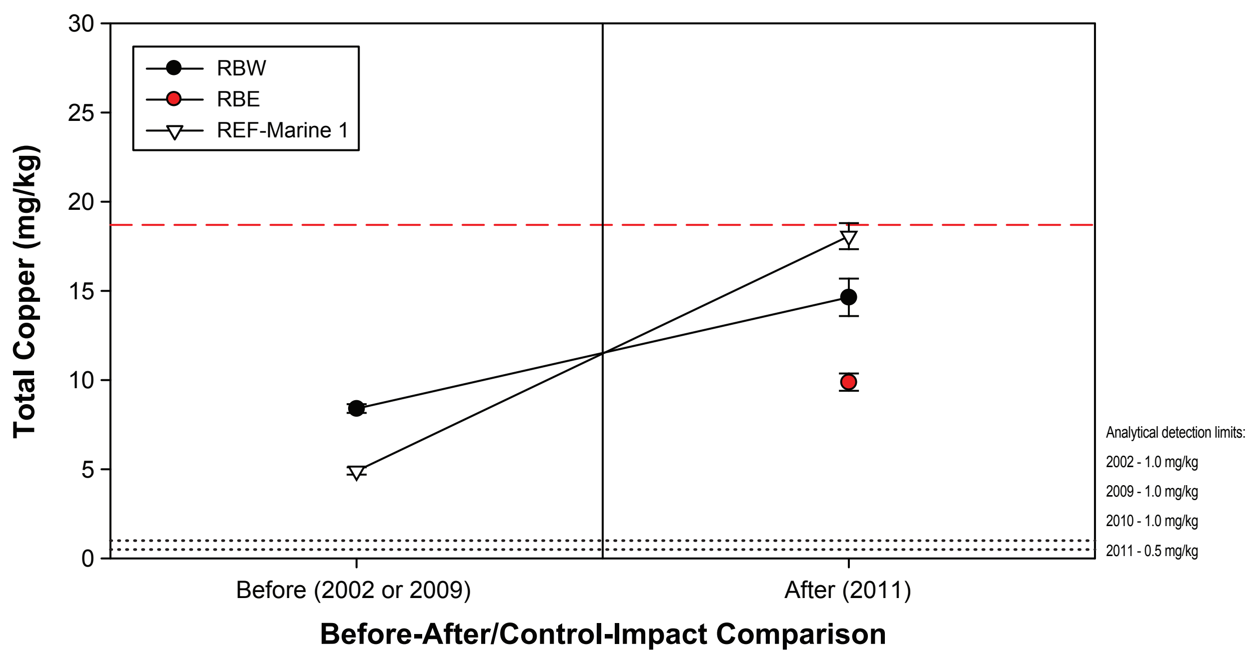

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for copper (18.7 mg/kg); the probable effects level (PEL) for copper (108 mg/kg) is not shown.

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Total Copper Concentration in AEMP Marine Sediments, Doris North Project, 2002-2011

Figure 3.4-24

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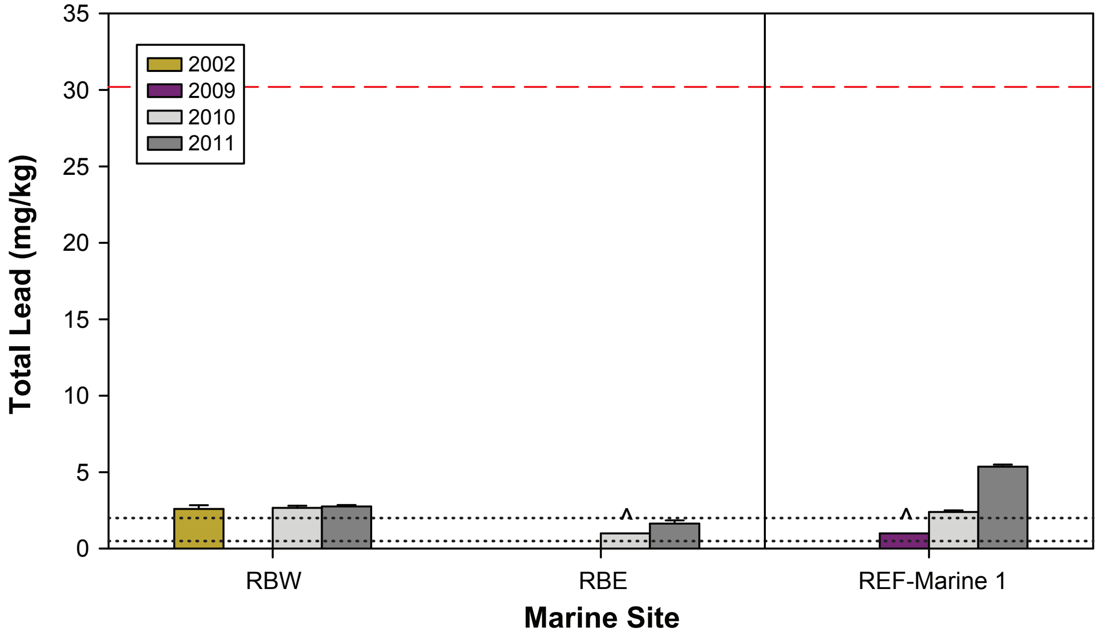

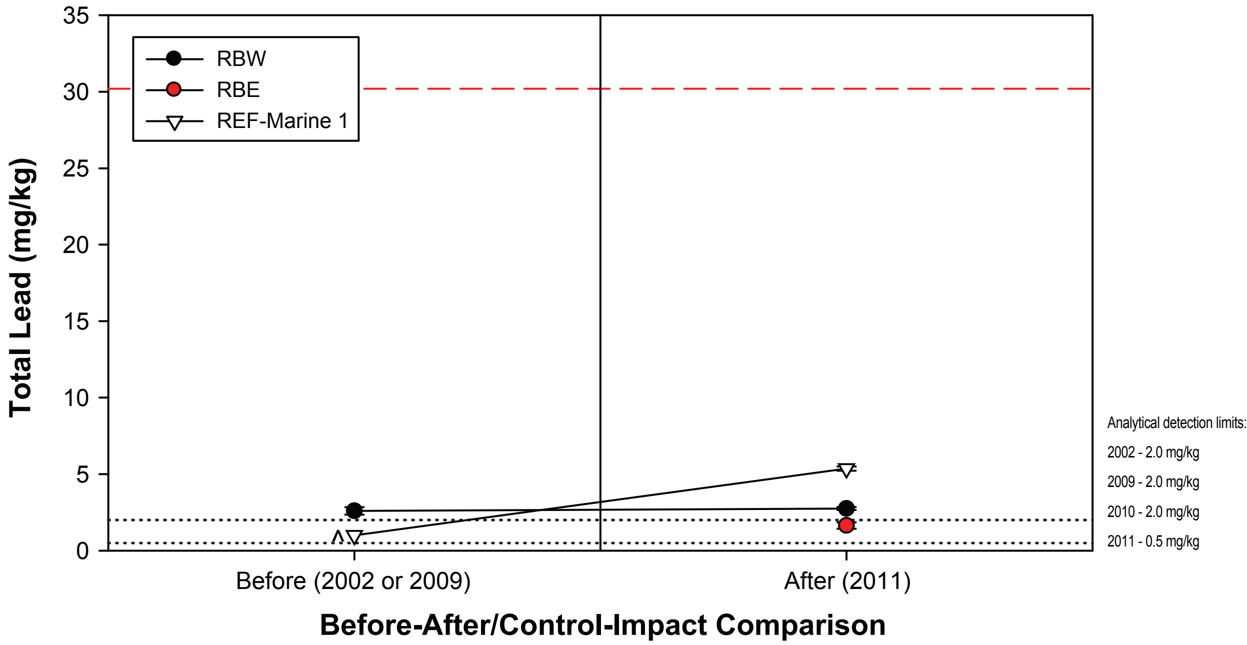

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for lead (30.2 mg/kg); the probable effects level (PEL) for lead (112 mg/kg) is not shown.

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Total Lead Concentration in AEMP Marine Sediments, Doris North Project, 2002-2011

Figure 3.4-25

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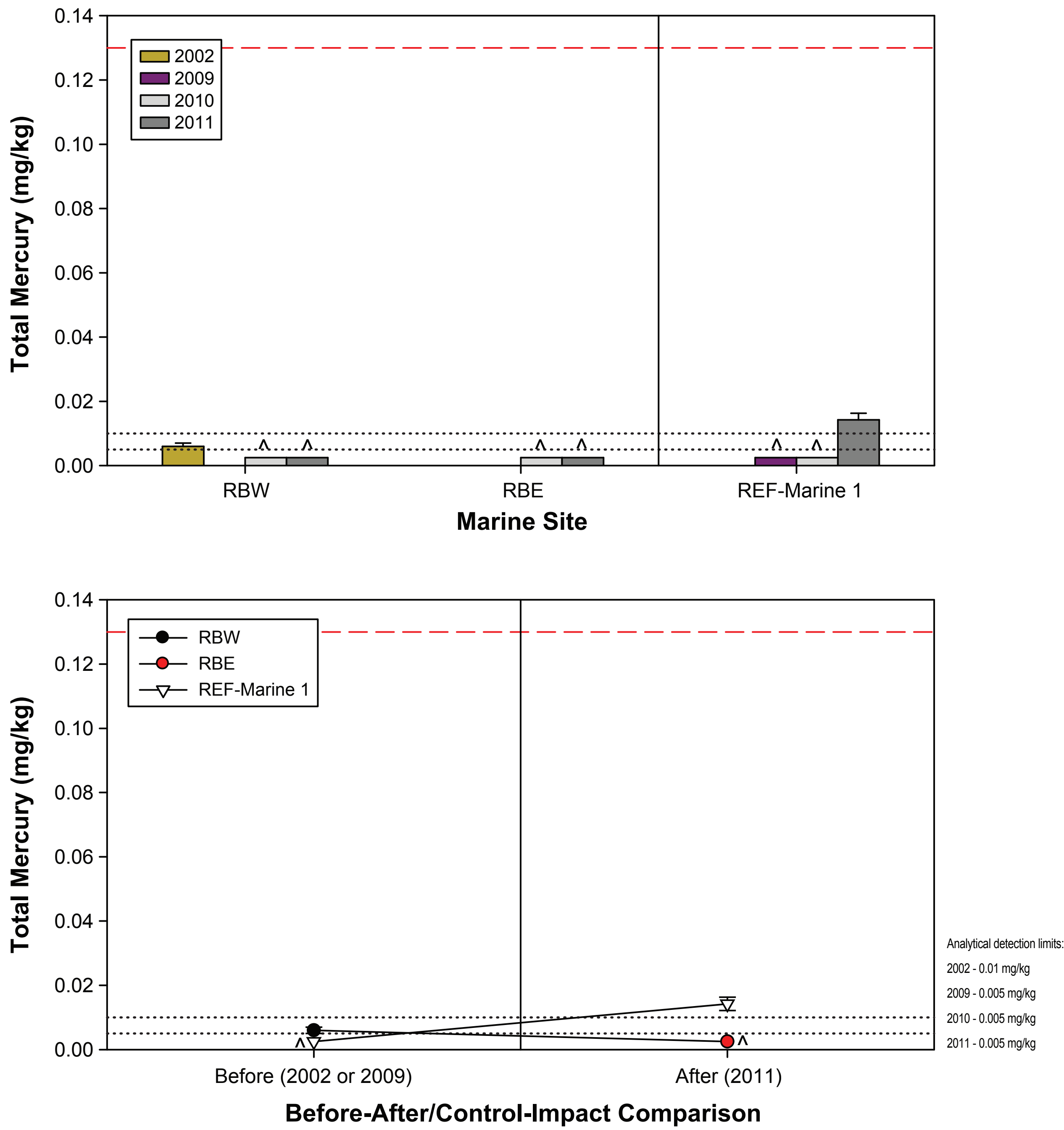

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
^ Indicates that concentrations were below the detection limit in all samples.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for mercury (0.13 mg/kg); the probable effects level (PEL) for mercury (0.7 mg/kg) is not shown.

Figure 3.4-26

Total Mercury Concentration in AEMP Marine Sediments, Doris North Project, 2002-2011

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exposure and reference site samples collected in 2011 were well below the CCME ISQG of 0.13 mg/kg and the PEL of 0.7 mg/kg. There were no apparent effects of 2011 Project activities on total mercury concentrations in marine sediments.

Methylmercury, an organic form of mercury that is of concern because of its toxicity and its tendency to biomagnify in upper trophic levels (CCME 2011b), was measured for the first time in Roberts Bay and Ida Bay sediments in 2011. Mean methylmercury concentrations were more than an order of magnitude lower in sediments from RBW (0.000068 mg/L) and RBE (0.000095 mg/L) than REF-Marine 1 (0.00096 mg/L; Appendix A). The fraction of methylmercury in the total mercury pool cannot be calculated for the marine exposure sites in Roberts Bay because total mercury concentrations were below detection limits. At REF-Marine 1, methylmercury made up approximately 7% of the total mercury pool in the sediments. There is no CCME guideline for methylmercury in marine sediments.

3.4.3.9 Total Zinc

The mean 2011 zinc concentration in sediments from RBW sediments (22.5 mg/kg) was similar to the 2002 mean (20.6 mg/kg; Figure 3.4-27), and the before-after analysis found no evidence of a difference in means ($p = 0.14$). Sediments from RBE had the lowest mean concentration of zinc (14.5 mg/kg), while sediments from REF-Marine 1 had the highest (45.3 mg/kg; Figure 3.4-27). All 2011 sediment zinc concentrations were well below the CCME ISQG of 124 mg/kg and the PEL of 271 mg/kg (Figure 3.4-27). There was no apparent effect of 2011 activities on sediment zinc concentrations at the marine exposure sites.

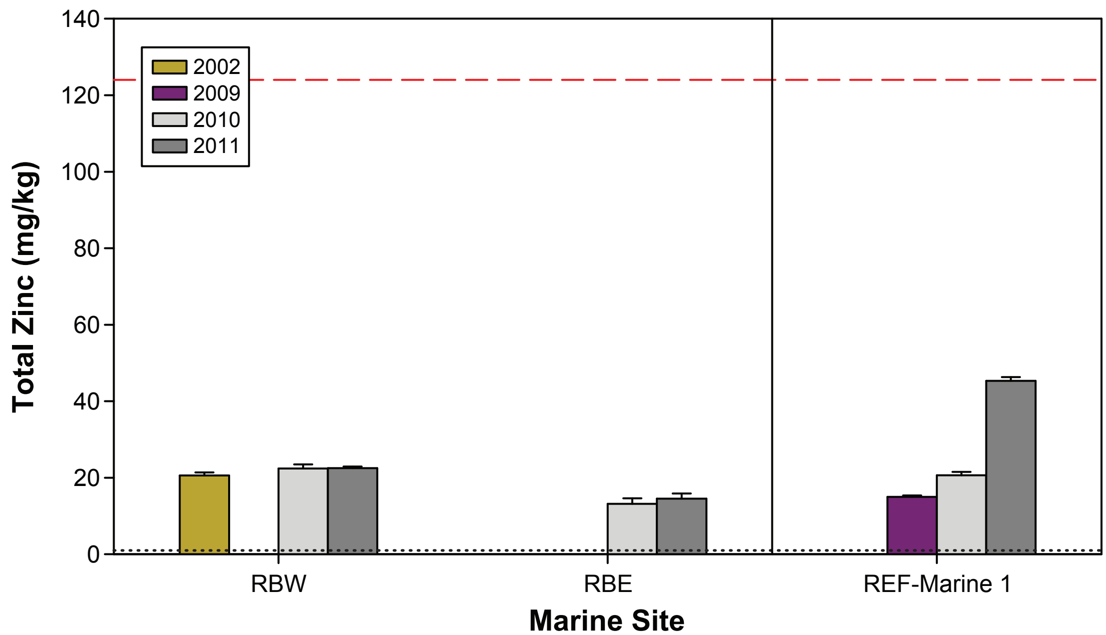
3.5 PRIMARY PRODUCERS

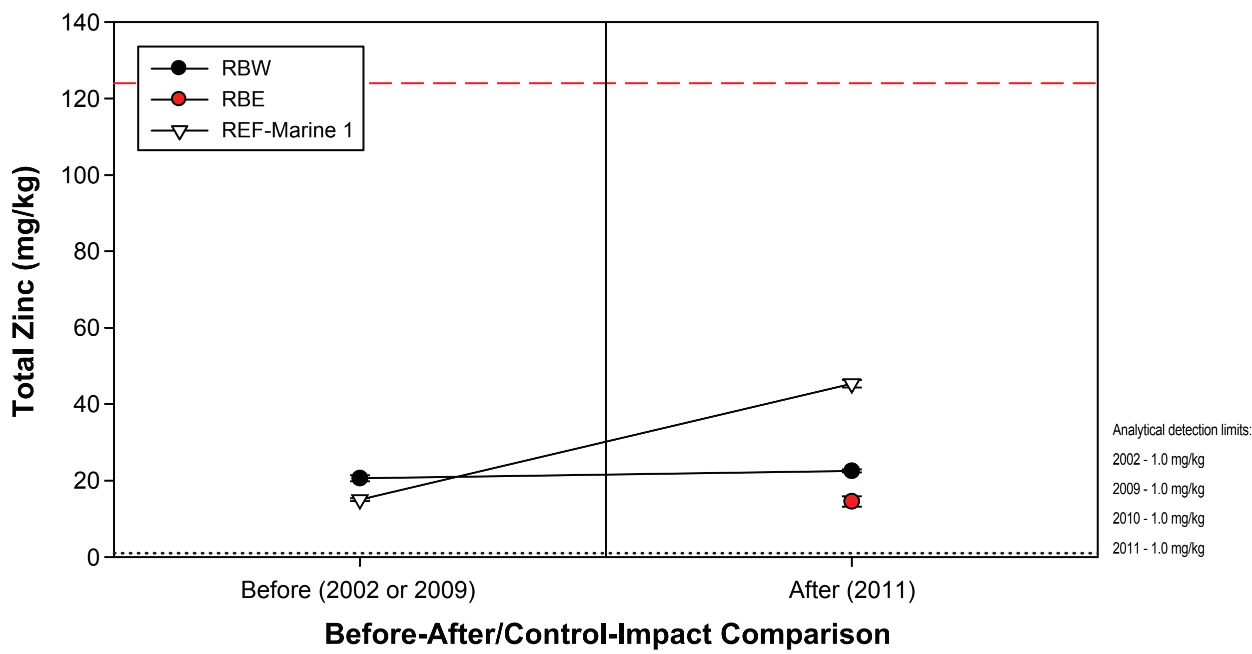
Primary producer biomass (as chlorophyll *a*) samples were collected in streams, lakes, and the marine habitat to assess potential changes in their standing stocks due to eutrophication or toxicity. Historical primary producer (phytoplankton and periphyton) biomass sampling has been conducted in the Doris North Project area since 1996. The main criteria for the selection of relevant baseline periphyton and phytoplankton biomass data for inclusion in the evaluation of effect were the proximity of baseline sampling sites to 2011 AEMP sampling sites, and that sampling methodologies were comparable.

Graphical analyses, before-after comparisons, and BACI analyses (where possible) were all used to determine if there were changes in primary producer biomass in the Doris North Project area. For all graphical and statistical analyses, replicate samples collected on the same date were averaged prior to analysis. The complete results of all statistical methods and analyses are provided in Appendix B.

3.5.1 Stream Periphyton Biomass

Stream periphyton biomass samples were collected from three exposure streams (Doris Outflow, Roberts Outflow, and Little Roberts Outflow) and two reference streams (Reference B Outflow and Reference D Outflow). Baseline data for stream periphyton biomass that were comparable to 2011 data in terms of sampling locations and methodologies were available from 1997, 2000, and 2009 for Doris Outflow, and from 2009 only for Little Roberts and Reference B outflows (Appendix B). No baseline data were available for Roberts Outflow or Reference D Outflow; therefore, before-after analyses could not be performed for periphyton data from these streams, and a BACI analysis could not be performed for Roberts Outflow data.





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for zinc (124 mg/kg); the probable effects level (PEL) for zinc (271 mg/kg) is not shown.

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Total Zinc Concentration in AEMP Marine Sediments, Doris North Project, 2002-2011

Figure 3.4-27

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Periphyton biomass was highly variable over time, particularly at Doris Outflow where several years of baseline data were available (Figure 3.5-1). Chlorophyll *a* concentrations at this stream site decreased by an order of magnitude between 1997 and 2009, before the commencement of any Project activities. This degree of natural variability makes it difficult to isolate trends from natural background variability. Periphyton biomass levels at Doris Outflow in 2011 were similar to 2009 biomass levels, and the before-after analysis confirmed that there was no significant difference between the baseline mean biomass and the 2011 mean biomass at this site ($p = 0.35$).

At Little Roberts Outflow, 2011 biomass levels were higher than 2009 levels (Figure 3.5-1), but a before-after analysis could not be performed (there were too few degrees of freedom to fit the model; Appendix B). The BACI analysis found that the before-after trend at Little Roberts Outflow paralleled the before-after trend that occurred at the reference streams ($p = 0.46$); therefore, the difference in biomass levels at Little Roberts Outflow between 2009 and 2011 was likely a natural occurrence.

Periphyton biomass levels at Roberts Outflow in 2011 were comparable to the biomass levels at the other exposure streams and the reference streams. Therefore, there was no indication that Project activities had any effect on periphyton biomass levels in exposure streams.

3.5.2 Lake Phytoplankton Biomass

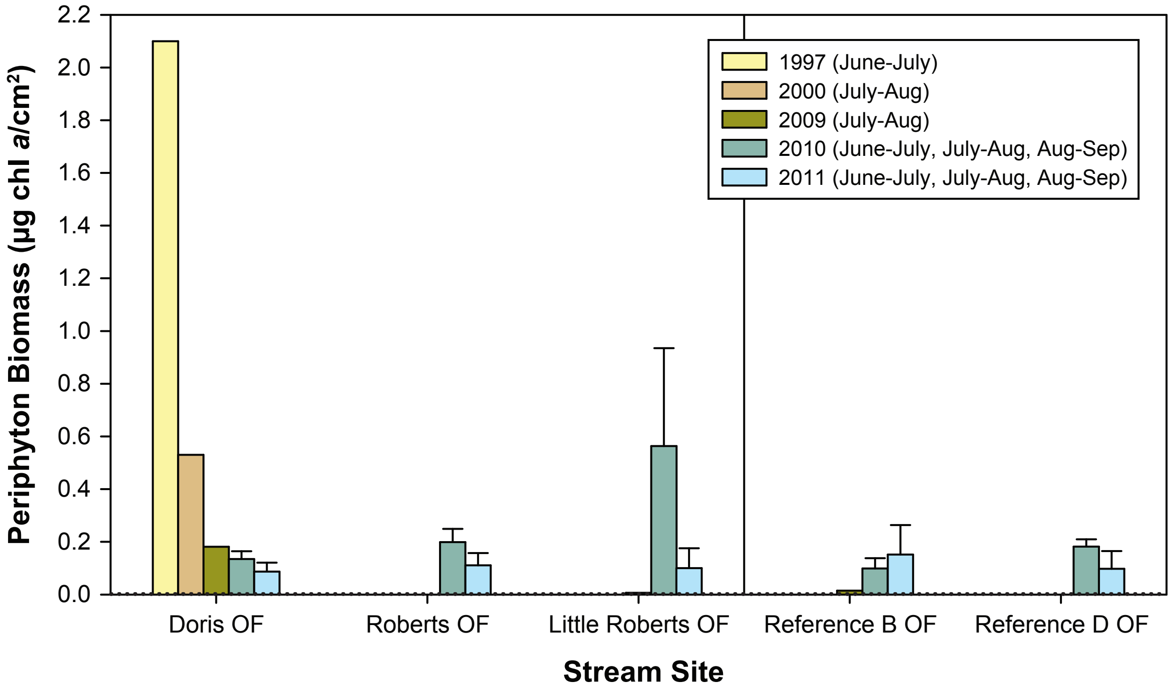
Phytoplankton biomass samples were collected from three exposure lakes (Doris Lake South, Doris Lake North, and Little Roberts Lake) and two reference lakes (Reference Lake B and Reference Lake D) in 2011. Baseline data for lake phytoplankton biomass that were comparable to 2011 data in terms of sampling locations and methodologies were available from 1997, 2000, and 2009 for Doris Lake South, 1997 and 2009 for Little Roberts Lake, and 2009 for Doris Lake North and Reference Lake B (Appendix B). No baseline data were available for Reference Lake D, so a BACI analysis could not be performed for Little Roberts Lake.

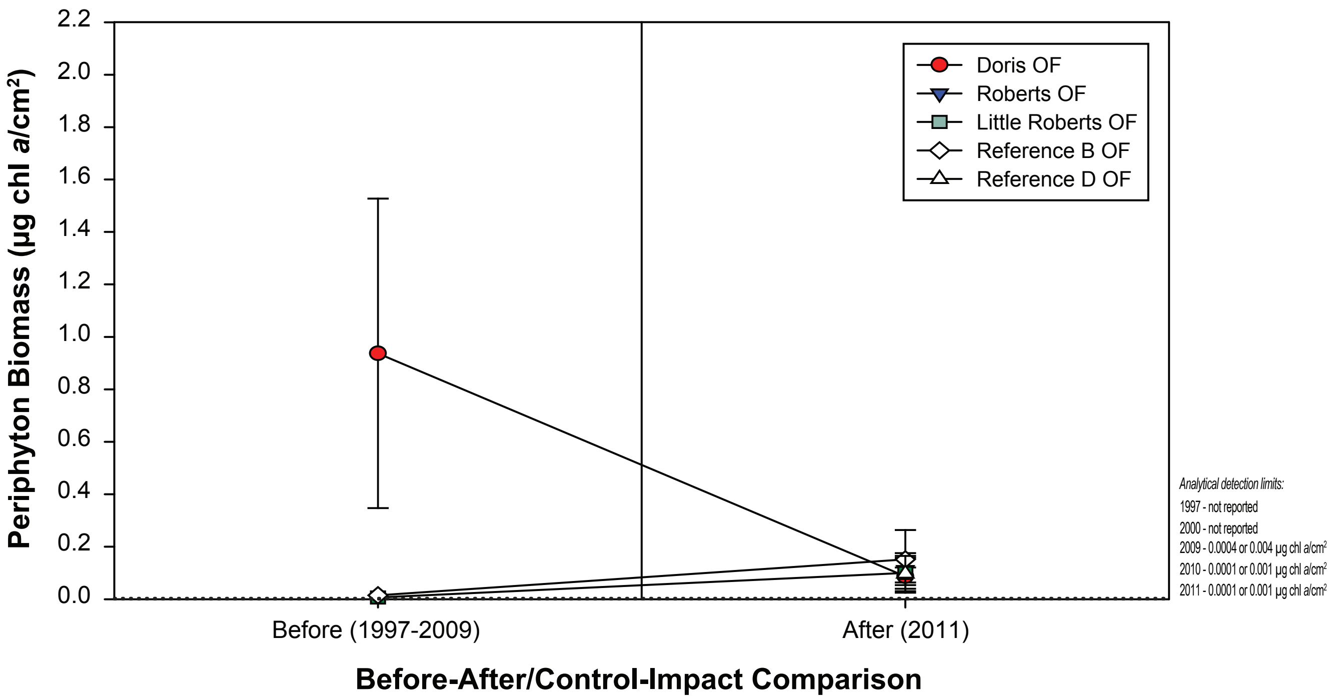
At both Doris Lake South and Little Roberts Lake, mean 2011 phytoplankton biomass levels were within the range of baseline means (Figure 3.4-1). At Doris Lake North, the mean biomass level was higher in 2011 than in 2009 (Figure 3.5-2), which was driven by the high chlorophyll *a* concentrations measured in April 2011 (Appendix A). However, the before-after analysis showed that the mean 2011 biomass level was not significantly different from the mean baseline level at any exposure lake site ($p = 0.55$ for Doris Lake South, $p = 0.69$ for Doris Lake North, and $p = 0.89$ for Little Roberts Lake). Accordingly, there was no apparent effect of 2011 activities on phytoplankton biomass in the AEMP exposure lakes.

3.5.3 Marine Phytoplankton Biomass

Phytoplankton biomass samples from marine areas were collected from two exposure sites in Roberts Bay (RBW and RBE) and one reference site in Ida Bay (REF-Marine 1) in 2011. Historical phytoplankton biomass data have been collected in Roberts Bay since 2006; however, only baseline data from 2009 were considered comparable to 2011 data. Historical data collected between 2006 and 2008 were excluded because of differences in sampling methodology (Appendix B). Baseline data from 2009 were available for all marine exposure and reference sites.

Within each year included in the evaluation of effects (2009 and 2011), marine phytoplankton biomass levels were similar among all exposure and reference sites; however, biomass levels were lower at all sites in 2009 than in 2011 (Figure 3.5-3). Mean phytoplankton biomass levels measured in 2009 were below the detection limit at both RBE and RBW (< 0.04 µg chl *a*/L) and barely above the detection limit at REF-Marine 1 (0.045 µg chl *a*/L). In 2011, mean biomass levels were more than an order of magnitude higher at all marine sites: 0.49 µg chl *a*/L at RBW, 0.44 µg chl *a*/L at RBE, and 0.61 µg chl *a*/L at





Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
The anomalously high periphyton biomass of 194.4 µg chl a/cm² reported for Doris Outflow in July-August 1997 was considered an outlier and was excluded from plots.

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Figure 3.5-1

Periphyton Biomass (as Chlorophyll *a*) in AEMP Stream Sites, Doris North Project, 1997-2011

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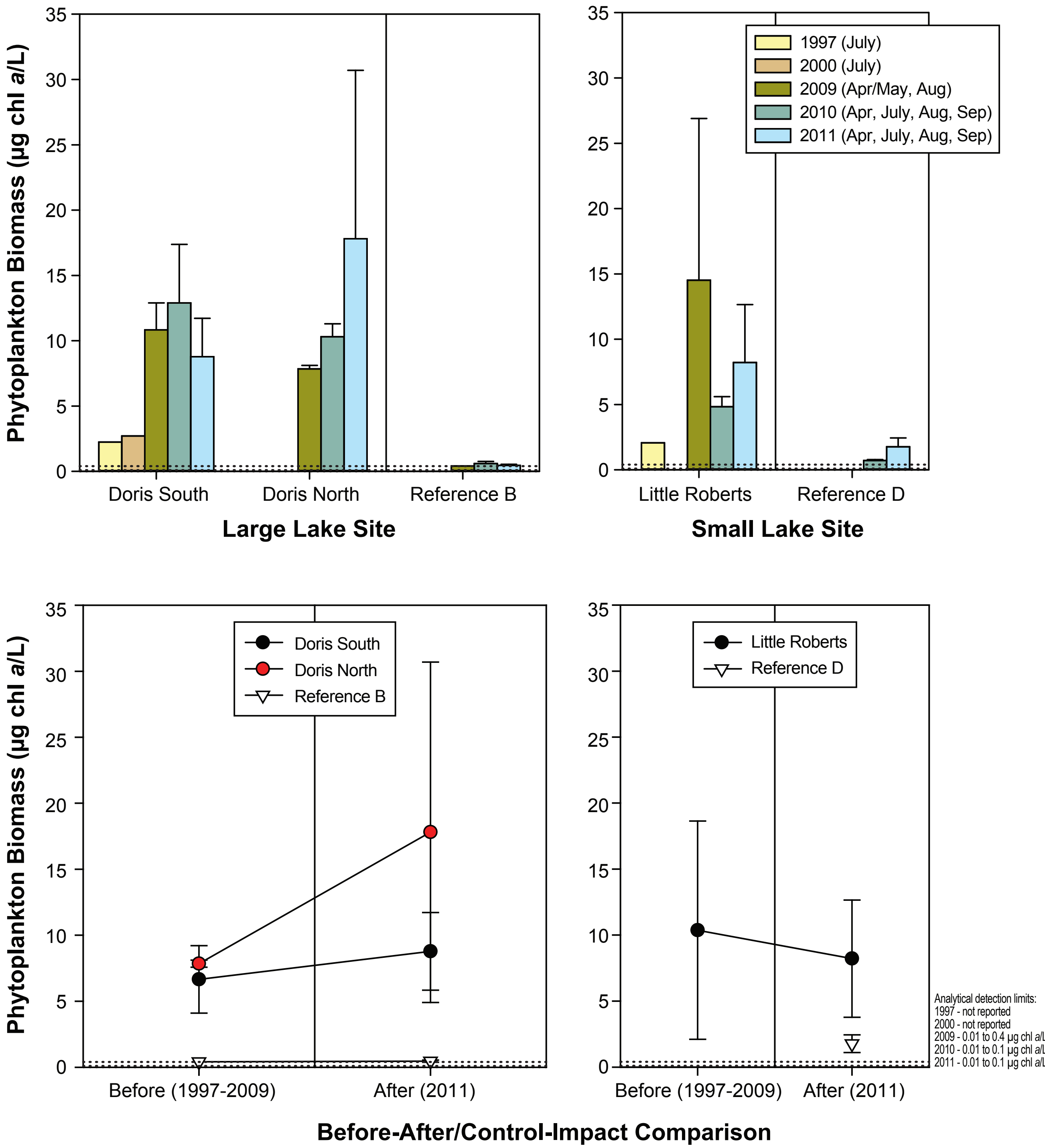

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.

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Phytoplankton Biomass (as Chlorophyll *a*) in AEMP Lake Sites, Doris North Project, 1997-2011

Figure 3.5-2

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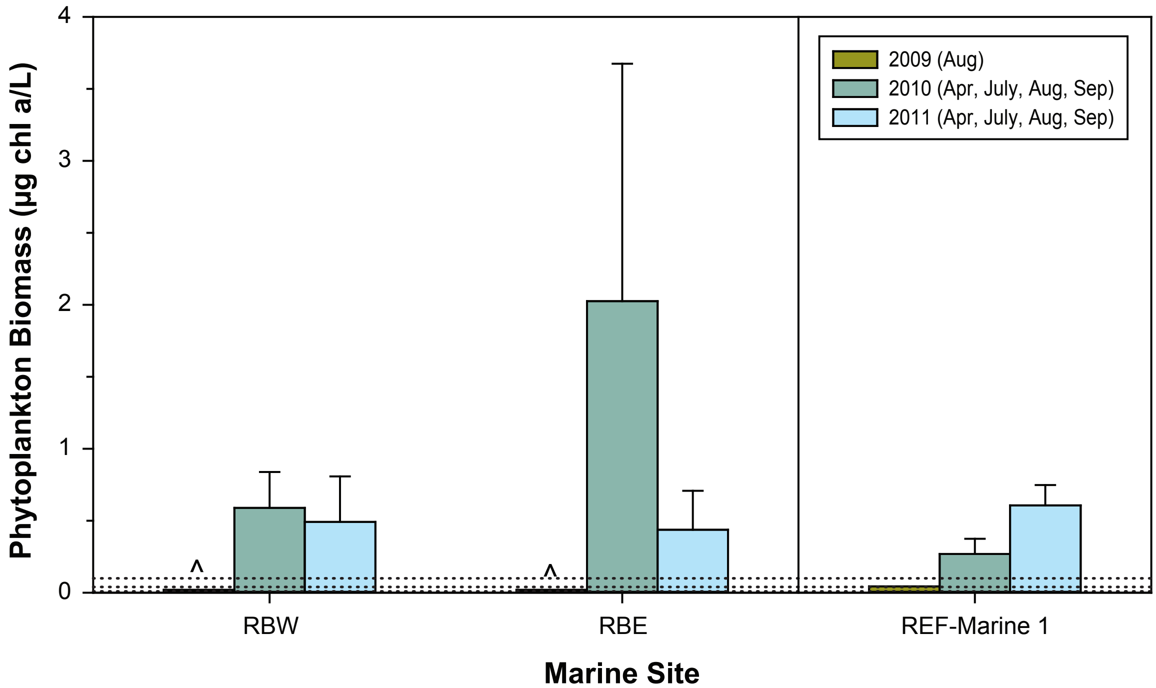

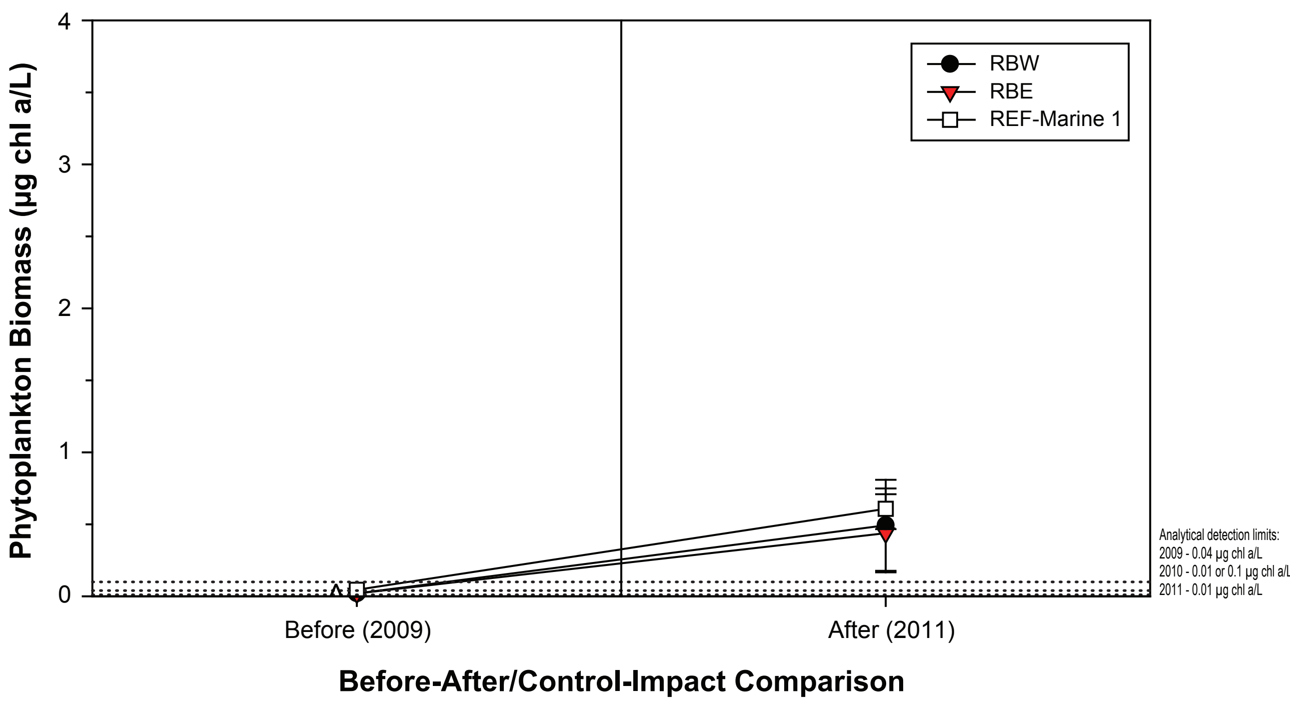

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below detection limits are plotted at half the applicable detection limit.
^ Indicates that concentrations were below the detection limit in all samples.

Figure 3.5-3

Phytoplankton Biomass (as Chlorophyll *a*) in AEMP Marine Sites, Doris North Project, 2009-2011

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REF-Marine 1 (Figure 3.5-3). The apparent increase in biomass levels between 2009 and 2011 may be attributable to natural seasonal differences in biomass levels, as samples collected in 2009 were collected only during one month (August) compared to four months in 2011 (April, July, August, and September). It was not possible to perform before-after analysis on marine phytoplankton data (there were too few degrees of freedom to fit the model; Appendix B). The BACI analysis showed that the 2009 to 2011 trends observed at the exposure sites were not statistically different from the 2009 to 2011 trend observed at the reference site ($p = 0.12$ in RBW and $p = 0.24$ at RBE). Therefore, the increase in chlorophyll *a* concentrations at RBW and RBE cannot be attributed to 2011 Project activities.

3.6 BENTHOS

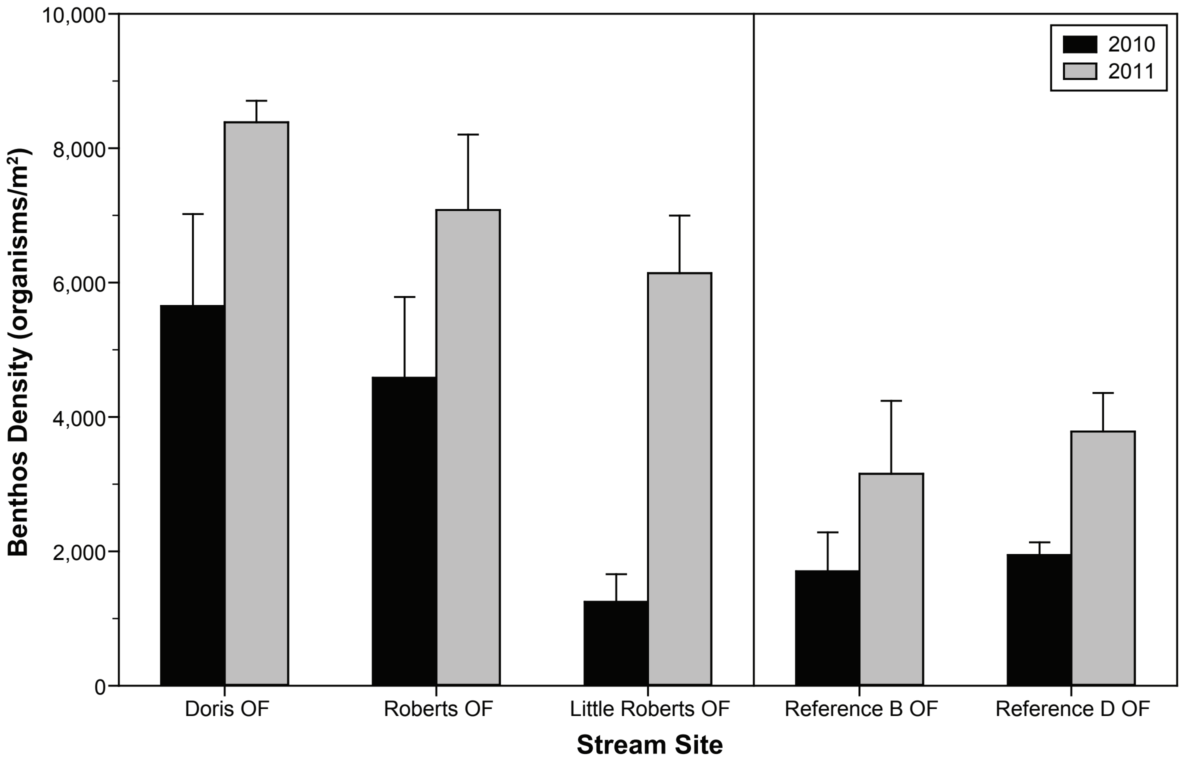
As required in Schedule 5 of the MMER, benthic invertebrate community surveys were conducted in 2011 at AEMP stream, lake, and marine sites, and the data gathered was used to calculate benthos density, evenness (Simpson's Evenness Index), taxa richness, and the similarity index (Bray-Curtis Index). Simpson's Diversity Index, which incorporates taxa richness and evenness, was also calculated. The level of taxonomic resolution used to calculate community descriptors was family-level, as recommended in the EEM guidance document (Environment Canada 2011). All summary statistics for these community descriptors are provided in Appendix A.

The evaluation of effects for benthos required a different approach than that used for the other evaluated parameters because of the lack of comparable baseline data for benthos. The method used to collect benthos samples in 2010 and 2011 involved the pooling of three subsamples for each of five replicate samples; therefore, data collected in 2010 and 2011 were not considered comparable to pre-2010 data (as replicates collected during baseline studies were not composite samples). Instead of employing before-after or BACI comparisons for benthos data, an impact level-by-time analysis was used, whereby the benthos trends at exposure sites between 2010 and 2011 were compared to the 2010 to 2011 trends at reference sites to determine if there was evidence of non-parallelism over time. The results of the evaluation of effects for benthos are discussed below, and complete statistical methodology and results are presented in Appendix B.

3.6.1 Stream Benthos

3.6.1.1 Density

Benthic invertebrate density was higher in 2011 than 2010 at all exposure and reference stream sites (Figure 3.6-1). The increases in density that occurred in Doris Outflow and Roberts Outflow paralleled the increases that occurred in the reference streams ($p = 0.43$ for Doris Outflow and $p = 0.57$ for Roberts Outflow), indicating that the increase in density was a natural phenomenon and was not related to Project activities. However, there was evidence of non-parallelism for Little Roberts Outflow ($p = 0.009$), where density between 2010 and 2011 increased more sharply than at the reference streams. Because only two years of data are available for the analysis of trends, it is difficult to separate Project-related effects from natural annual variability or patchiness in the distribution of benthos within streams. There were no apparent Project-related changes to the water quality, sediment quality, or primary producer biomass in Little Roberts Outflow that could have affected the density of benthic invertebrates; therefore, it is unlikely that the increase in benthos density in Little Roberts Outflow was due to Project activities.



Notes: Error bars represent the standard error of the mean.

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Benthos Density in AEMP Stream Sites, Doris North Project, 2010-2011

Figure 3.6-1

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3.6.1.2 Community Richness, Evenness, and Diversity

Benthos family richness was similar between 2010 and 2011 in all exposure and reference streams (Figure 3.6-2), and there was evidence of parallelism in trends between the exposure streams and the reference streams ($p = 0.21$ for Doris Outflow, $p = 0.88$ for Roberts Outflow, and $p = 0.63$ for Little Roberts Outflow). Trends in Simpson's Diversity Index between 2010 and 2011 were also similar between exposure and reference streams ($p = 0.024$ for Doris Outflow, $p = 0.36$ for Roberts Outflow, and $p = 0.76$ for Little Roberts Outflow). Therefore, there was no apparent effect of Project activities on either benthos family richness or Simpson's Diversity Index.

The mean Simpson's Evenness Index calculated for the benthos community decreased for all exposure and reference streams between 2010 and 2011, except in Doris Outflow, where evenness increased between 2010 and 2011. Accordingly, there was evidence of non-parallelism in trends for Doris Outflow compared to the reference streams ($p < 0.001$), but not for Roberts Outflow ($p = 0.35$) or Little Roberts Outflow (0.52). As only two years of data are available for the analysis of trends, it is difficult to separate Project-related effects from natural annual variability in the evenness of the benthos community of Doris Outflow. There were no apparent Project-related changes to the water quality, sediment quality, or primary producer biomass in Doris Outflow that could have affected the relative abundance of families within the benthic community; therefore, it is unlikely that the increase in evenness in Doris Outflow was due to Project activities.

3.6.1.3 Bray-Curtis Index

The Bray-Curtis Index, a measure of the percentage of difference between an exposure site benthos community and the median reference benthos community, was generally similar between 2010 and 2011 for each stream surveyed (Figure 3.6-3). 2010 to 2011 trends for exposure streams were not significantly different than 2010 to 2011 trends for reference streams ($p = 0.95$ for Doris Outflow, $p = 0.47$ for Roberts Outflow, and $p = 0.45$ for Little Roberts Outflow); therefore, there was no apparent effect of Project activities on the benthos Bray-Curtis Index for exposure streams.

3.6.2 Lake Benthos

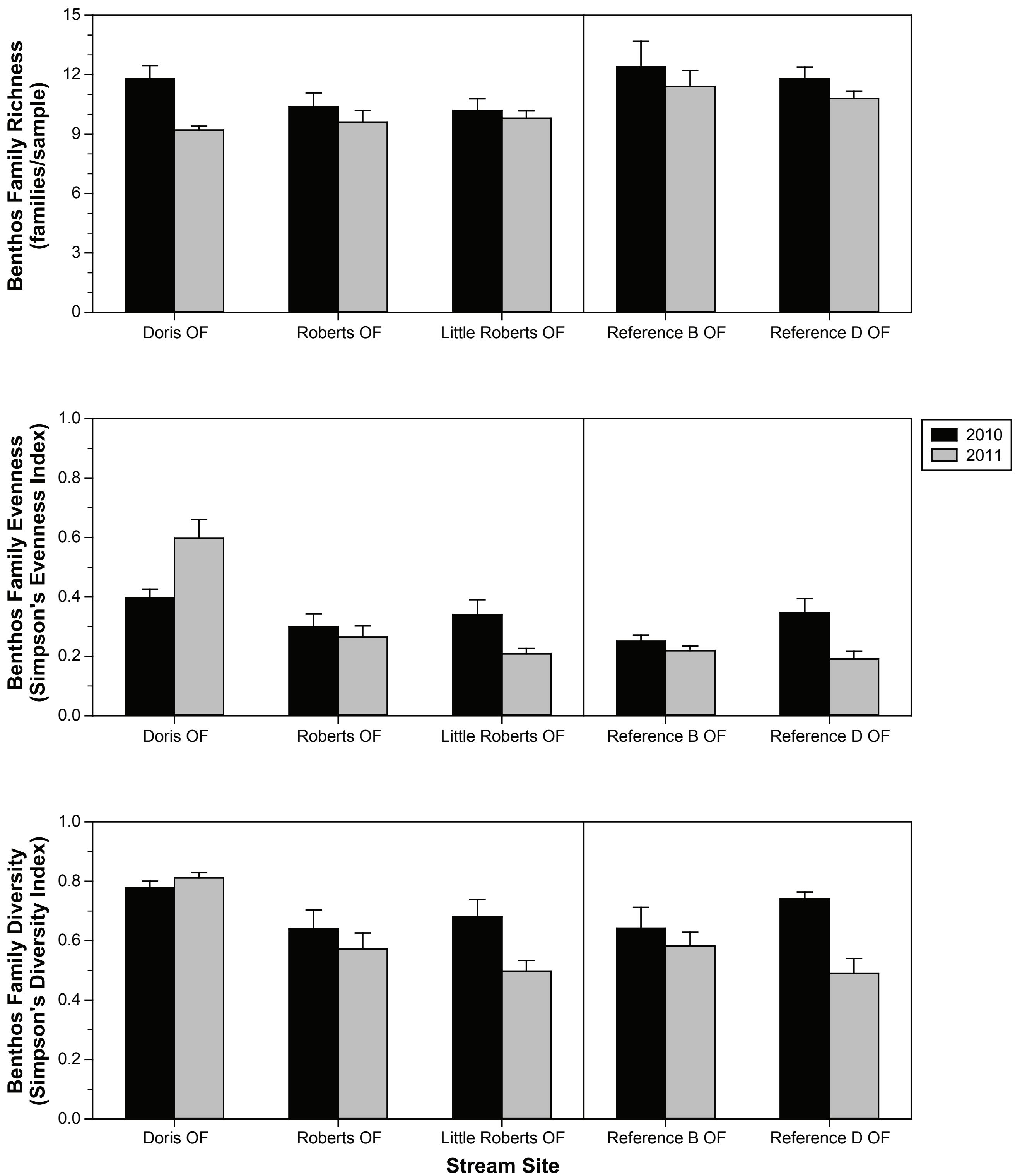
For Doris Lake South, 2010 data were collected from a shallow site, whereas 2011 data were collected from a deep site in the southern section of Doris Lake. Therefore, 2010 data were not considered comparable to 2011 data and no evaluation of effects was possible for Doris Lake South. 2011 benthos data collected from Doris Lake South are included in Figures 3.6-4 to 3.6-6, but no comparisons to 2010 were made for this site.

3.6.2.1 Density

In both 2010 and 2011, benthic invertebrate density was higher at the shallow lake sites (Little Roberts Lake and Reference Lake D) than at the deep lake sites (Doris Lake South, Doris Lake North, and Reference Lake B; Figure 3.6-4). Benthos density was generally similar between 2010 and 2011 at each lake site, and there was evidence of parallelism between 2010 to 2011 density trends at the exposure lakes compared to the reference lakes ($p = 0.046$ for Doris Lake North and $p = 0.73$ for Little Roberts Lake), suggesting that there was no effect of Project activities on benthos density in exposure lakes.

3.6.2.2 Community Richness, Evenness, and Diversity

Benthos family richness tended to be higher at the shallow lakes sites (Little Roberts Lake and Reference Lake D) than at the deep lake sites (Doris Lake South, Doris Lake North, and Reference Lake B; Figure 3.6-5). Family richness was generally similar between 2010 and 2011 at each site, except for



Notes: Error bars represent the standard error of the mean.

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Figure 3.6-2

Benthos Richness, Evenness, and Diversity in AEMP Stream Sites, Doris North Project, 2010-2011

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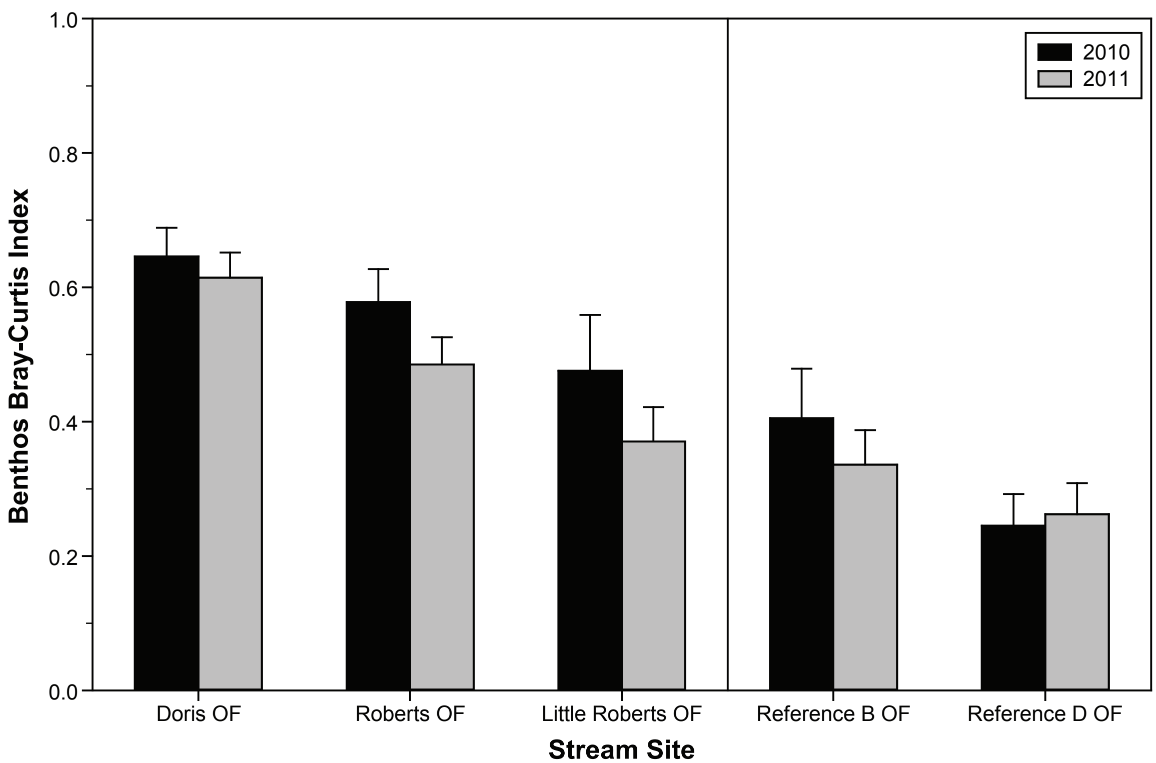
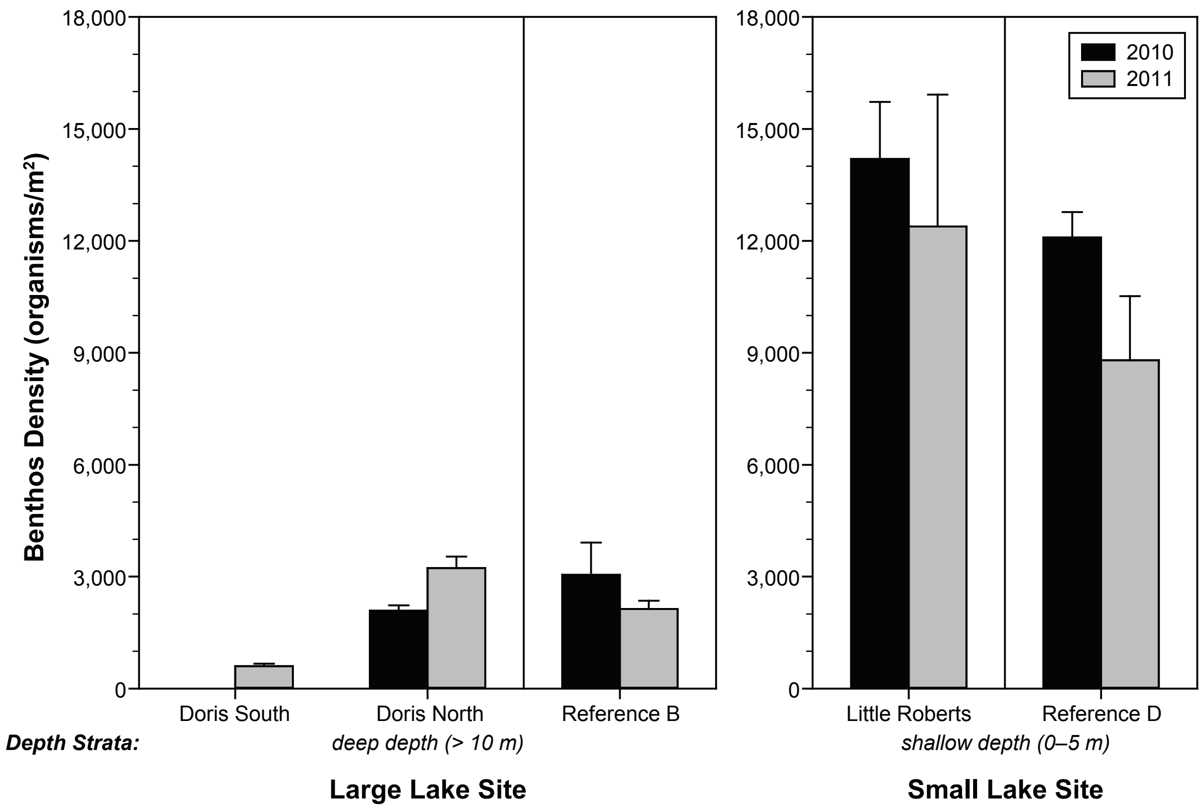


Notes: Error bars represent the standard error of the mean.

Figure 3.6-3

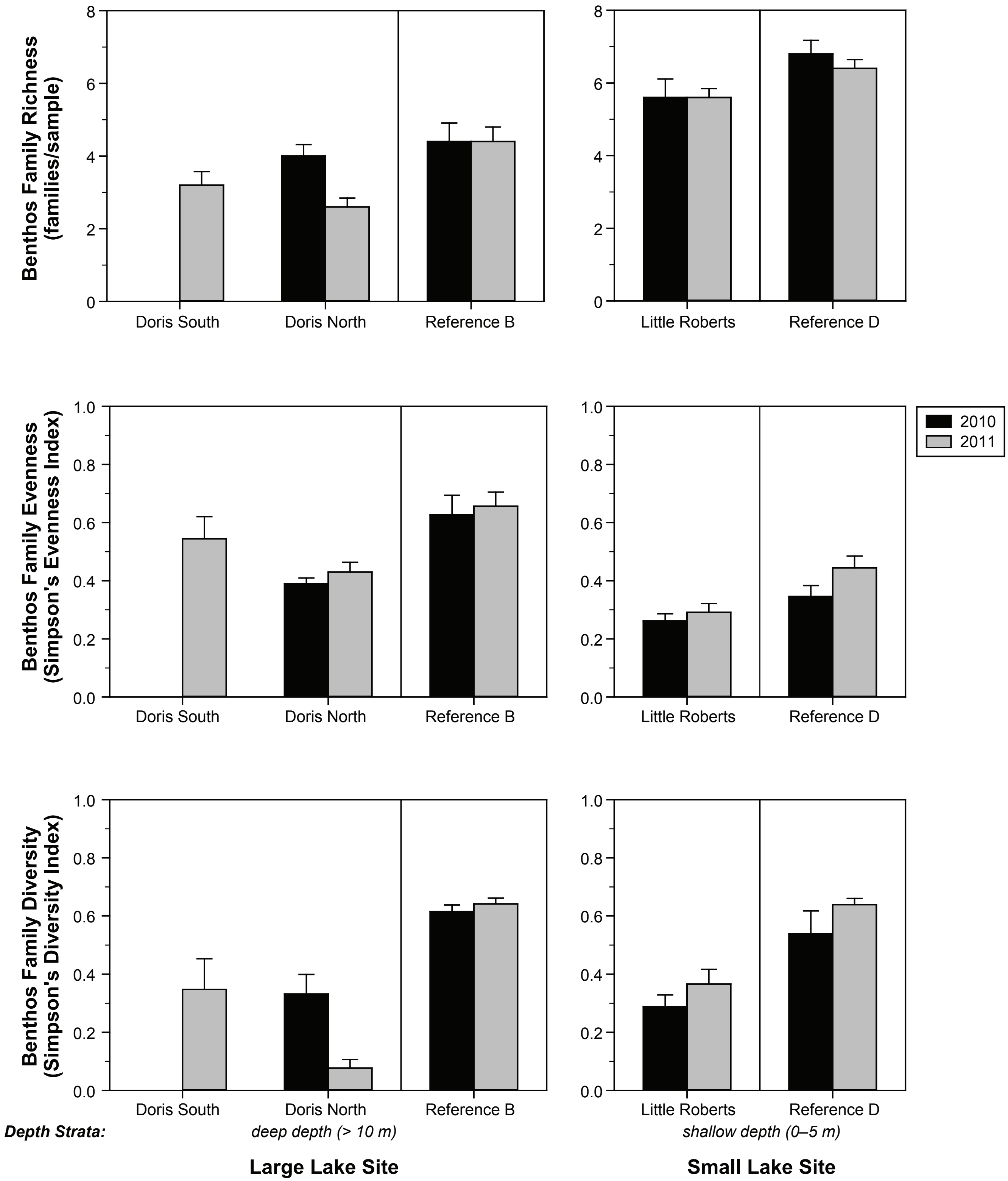
Benthos Bray-Curtis Index for AEMP Stream Sites, Doris North Project, 2010-2011



Notes: Error bars represent the standard error of the mean.

Figure 3.6-4

Benthos Density in AEMP Lake Sites, Doris North Project, 2010-2011



Notes: Error bars represent the standard error of the mean.

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Figure 3.6-5

Benthos Richness, Evenness, and Diversity in AEMP Lake Sites, Doris North Project, 2010-2011

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Doris Lake North where mean richness was lower in 2011 than 2010. However, the impact level-by-time analysis found that the 2010 to 2011 trends at the exposure sites were not significantly different from the 2010 to 2011 trends at the reference sites ($p = 0.085$ for Doris Lake North and $p = 0.59$ for Little Roberts Lake). Therefore there was no evidence of a differential Project-related effect on benthos richness in the exposure lakes.

The mean Simpson's Evenness Index increased slightly at all exposure and reference lakes between 2010 and 2011 (Figure 3.6-5). The impact level-by-time analysis confirmed that the 2010 to 2011 trends for the exposure lakes paralleled the trends observed for the reference lakes ($p = 0.91$ for Doris Lake North and $p = 0.33$ for Little Roberts Lake); therefore, there was no apparent effect of 2011 activities on benthos evenness in the exposure lakes.

The mean Simpson's Diversity Index was slightly higher in 2011 than 2010 at all sites except Doris Lake North, where diversity decreased in 2011 compared to 2010 (Figure 3.6-5). This decrease was mainly driven by a decrease in family richness (Figure 3.6-5). There was evidence of non-parallelism in trends between Doris Lake North and Reference Lake B ($p = 0.003$), but not between Little Roberts Outflow and Reference Lake D ($p = 0.83$). As only two years of data are available for the analysis of trends, it is difficult to separate Project-related effects from natural annual variability in the diversity of the benthos community of Doris Lake North. There were no apparent Project-related changes to the water quality, sediment quality, or primary producer biomass at Doris Lake North that could have affected the diversity of the benthic community at this site; therefore, it is unlikely that the apparent decrease in diversity was due to Project activities.

3.6.2.3 Bray-Curtis Index

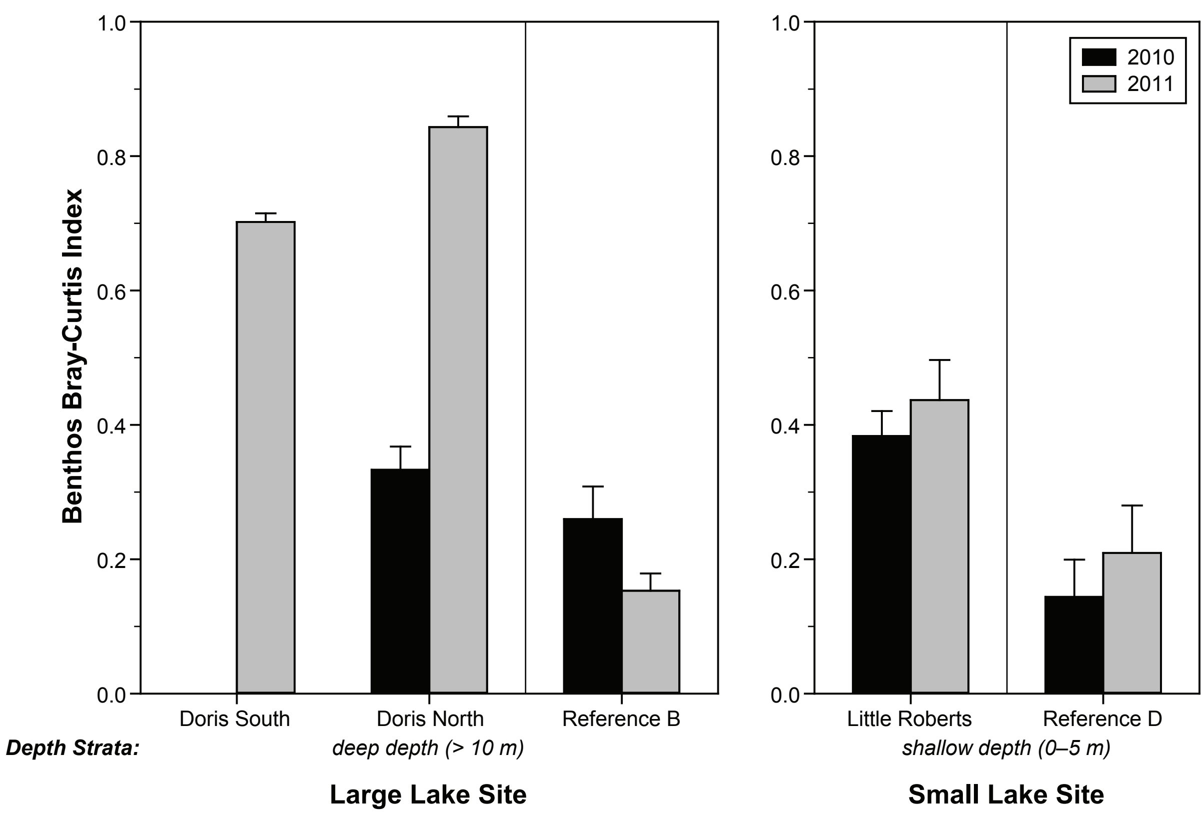
In both Little Roberts Lake and Reference Lake D, the mean Bray-Curtis Index increased slightly between 2010 and 2011 (Figure 3.6-6). These increasing trends were parallel ($p = 0.92$), suggesting that this was the result of natural annual variability. In Doris Lake North, the mean Bray-Curtis Index was more than two-fold higher in 2011 than 2010 (Figure 3.6-6), suggesting that the benthos community sampled in Doris Lake North was more divergent from the median reference community in 2011 than in 2010. The opposite trend was observed at Reference Lake B as the Bray-Curtis Index was lower in 2011 than in 2010 (Figure 3.6-6). Accordingly, there was evidence of non-parallelism in the 2010 to 2011 Bray-Curtis Index trends between Doris lake North and Reference Lake B ($p < 0.001$). Because only two years of data are available for the analysis of trends, it is difficult to separate Project-related effects from natural annual variability or patchiness in the benthos community in lakes. There were no apparent Project-related changes to the water quality, sediment quality, or primary producer biomass in Doris Lake North that could have affected the community composition of benthic invertebrates; therefore, it is unlikely that the increase the Bray-Curtis Index in Doris Lake North was related to Project activities.

3.6.3 Marine Benthos

As recommended in the EEM guidance document (Environment Canada 2011), the marine benthos community was analyzed for the whole community (adults and juveniles) as well as for the adult community in isolation, because juvenile benthos can respond differently to environmental disturbances than adult benthos.

3.6.3.1 Density

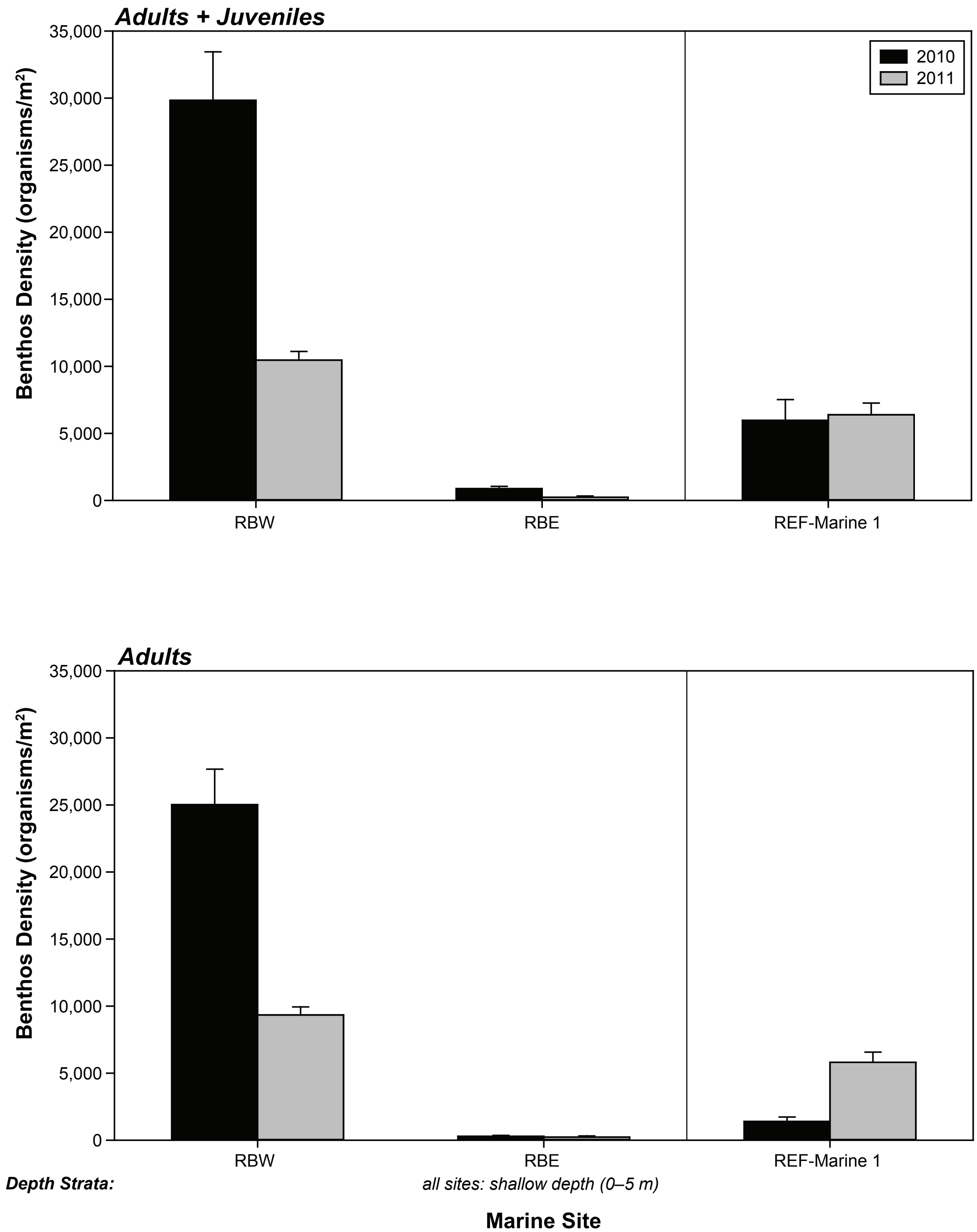
In both 2010 and 2011, whole community as well as adult benthos densities were highest at marine site RBW and lowest at RBE, with intermediate densities at REF-Marine 1 (Figure 3.6-7). In the whole community dataset, there was evidence of non-parallelism in 2010 to 2011 benthos density trends



Notes: Error bars represent the standard error of the mean.

Figure 3.6-6

Benthos Bray-Curtis Index for AEMP Lake Sites, Doris North Project, 2010-2011



Notes: Error bars represent the standard error of the mean.

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Benthos Density in AEMP Marine Sites, Doris North Project, 2010-2011

Figure 3.6-7

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between RBW and REF-Marine 1 ($p < 0.001$), but 2010 to 2011 trends between RBE and REF-Marine 1 were parallel ($p = 0.56$). In the adult dataset, there was evidence of non-parallelism in 2010 to 2011 density trends at both RBW and RBE compared to REF-Marine 1 (both $p < 0.001$). As only two years of data are available for the analysis of trends, it is difficult to separate Project-related effects from natural annual variability in the benthos density at marine exposure sites. There were no apparent Project-related changes to the water quality, sediment quality, or primary producer biomass at RBW or RBE that could have affected benthos density; therefore, it is unlikely that the differences in density from 2010 to 2011 at the marine exposure sites were related to Project activities.

3.6.3.2 Community Richness, Evenness, and Diversity

In both the whole community and the adult only datasets, family richness increased between 2010 and 2011 at all marine exposure and reference sites (Figure 3.6-8a and 3.6-8b). However, the magnitude of the increase was higher at REF-Marine 1 than at either of the exposure sites. Accordingly, there was evidence of non-parallelism in 2010 to 2011 benthos family richness between REF-Marine 1 and the exposure sites (whole community: $p = 0.002$ for RBW and $p = 0.004$ for RBE; adults: $p < 0.001$ for RBW and $p = 0.002$ for RBE).

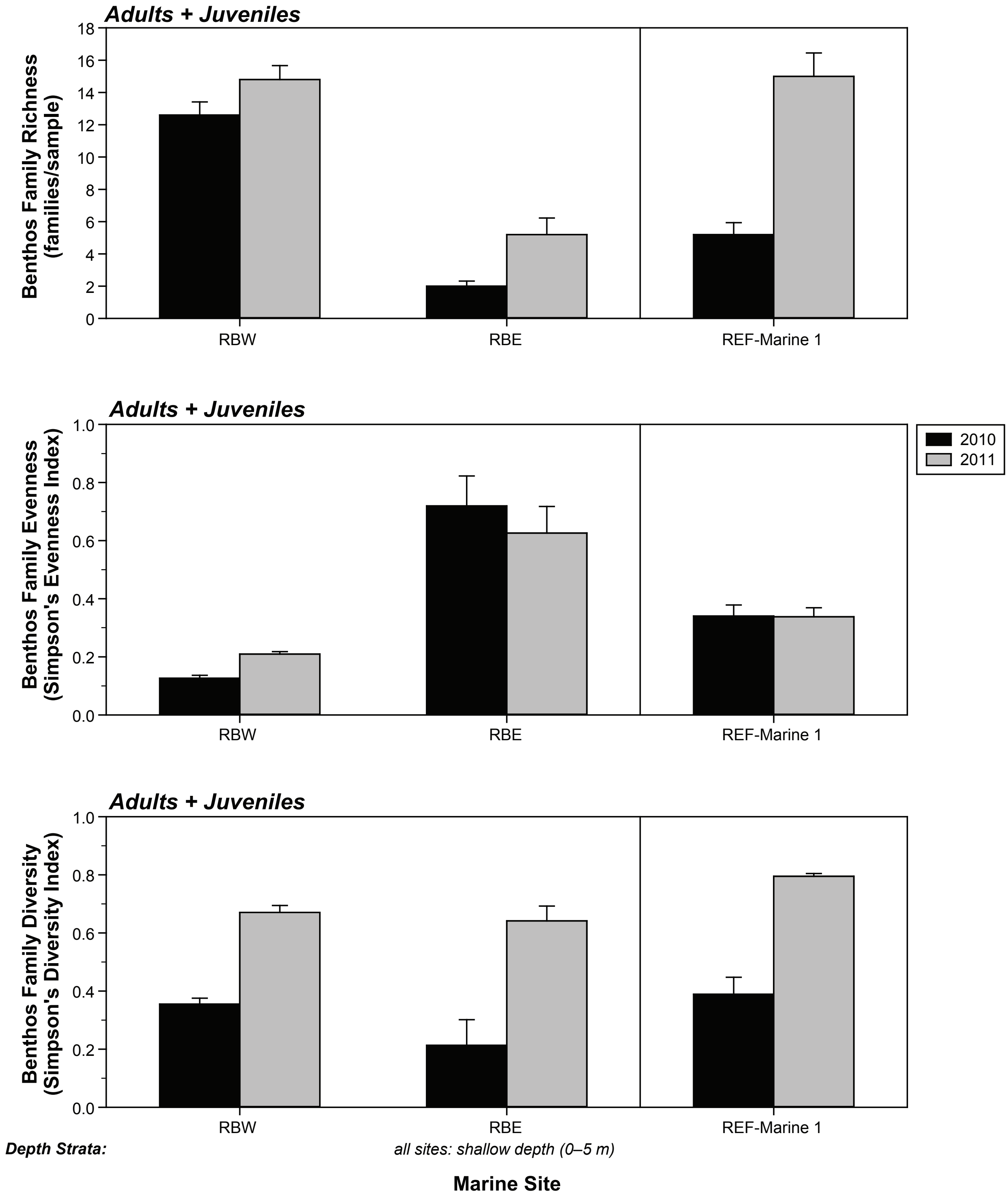
In the whole community dataset, family evenness was nearly identical between 2010 and 2011 at REF-Marine 1 (Figure 3.6-8a). Although mean evenness differed slightly between 2010 and 2011 at both RBW and RBE, the impact level-by-time analysis showed that there was evidence of parallelism in 2010 to 2011 evenness trends between the exposure sites and the reference site ($p = 0.11$ for RBW and $p = 0.54$ for RBE). In the adult benthos dataset, family evenness decreased slightly between 2010 and 2011 at both RBE and REF-Marine 1, while evenness increased slightly between 2010 and 2011 at RBW (Figure 3.6-8b). Accordingly, there was evidence of non-parallelism in the 2010 to 2011 trends between RBW and REF-Marine 1 ($p < 0.001$), but not between RBE and REF-Marine 1 ($p = 0.80$).

As only two years of data are available for the analysis of trends, it is difficult to separate Project-related effects from natural annual variability in the benthos family richness and evenness at marine exposure sites. There were no apparent Project-related changes to the water quality, sediment quality, or primary producer biomass at RBW or RBE that could have affected benthos richness and evenness in 2011; therefore, it is unlikely that the changes in richness and evenness from 2010 to 2011 at the marine exposure sites were related to Project activities.

In both the whole community and the adult only datasets, the Simpson's Diversity Index increased between 2010 and 2011 at all marine exposure and reference sites (Figure 3.6-8a and 3.6-8b). The increases that occurred at the exposure sites between 2010 and 2011 paralleled the increases that occurred at REF-Marine 1 (whole community: $p = 0.20$ for RBW and $p = 0.86$ for RBE; adults: $p = 0.25$ for RBW and 0.20 for RBE). Therefore, these increases were likely unrelated to 2011 Project activities.

3.6.3.3 Bray-Curtis Index

In both the whole community and the adult only datasets, the Bray-Curtis Index decreased between 2010 and 2011 at RBW and REF-Marine 1, and increased between 2010 and 2011 at RBE (Figure 3.6-9). The impact level-by-time analysis showed that 2010 to 2011 trends between RBW and REF-Marine 1 were parallel (whole community: $p = 0.49$; adults: $p = 0.82$), while the 2010 to 2011 trends between RBE and REF-Marine 1 were non-parallel (whole community: $p = 0.002$; adults: $p = 0.001$). Because only two years of data are available for the analysis of trends, it is difficult to separate Project-related effects from natural annual variability in the Bray-Curtis Index. There were no apparent Project-related changes to the water quality, sediment quality, or primary producer biomass at RBE that could have affected the community composition of benthic invertebrates; therefore, it is unlikely that the increase the Bray-Curtis Index at RBE was related to Project activities.



Notes: Error bars represent the standard error of the mean.

Figure 3.6-8a

Benthos Richness, Evenness, and Diversity in AEMP Lake Sites, Doris North Project, 2010-2011

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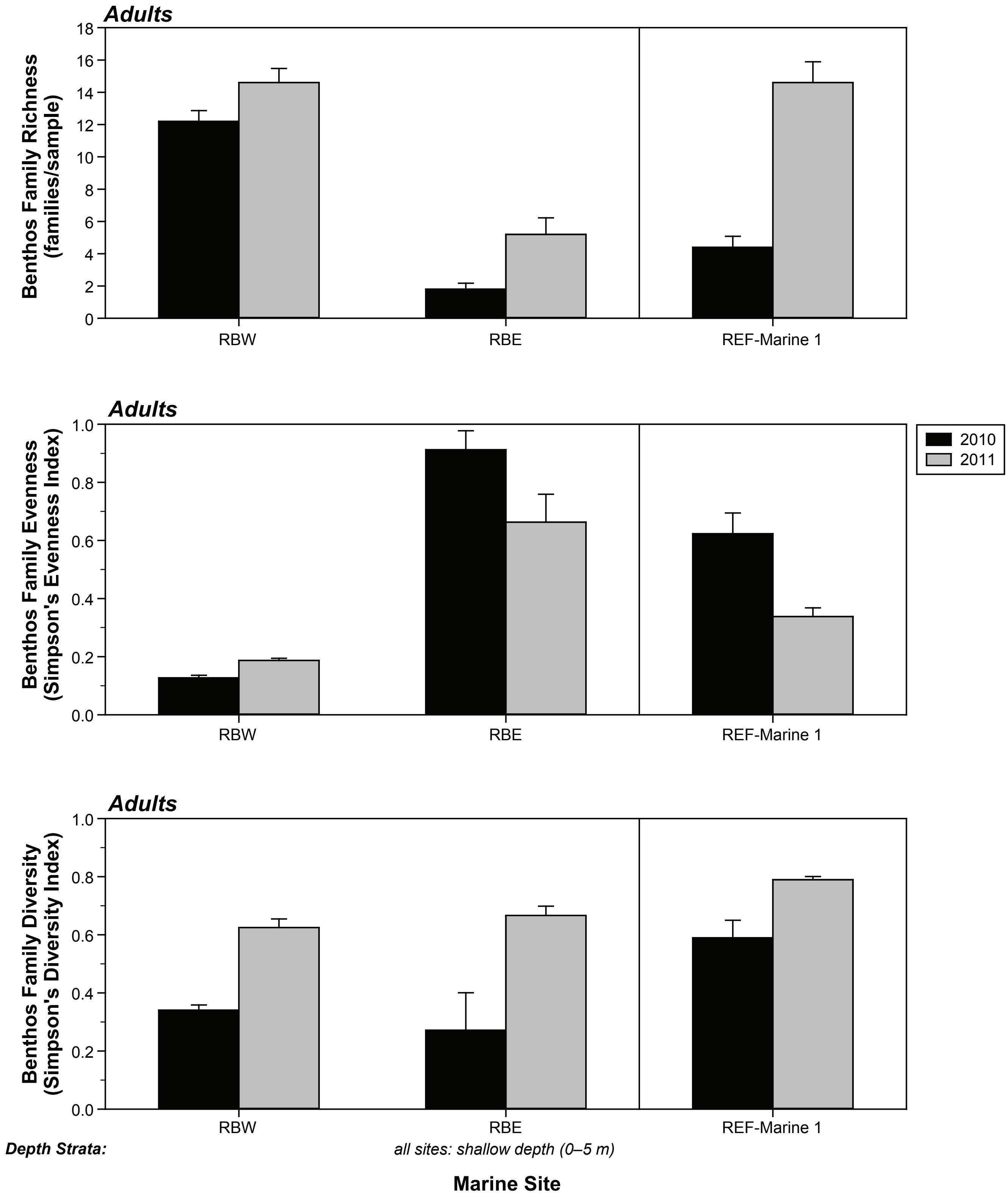

Notes: Error bars represent the standard error of the mean.

Figure 3.6-8b

Benthos Richness, Evenness, and Diversity in AEMP Marine Sites, Doris North Project, 2010-2011

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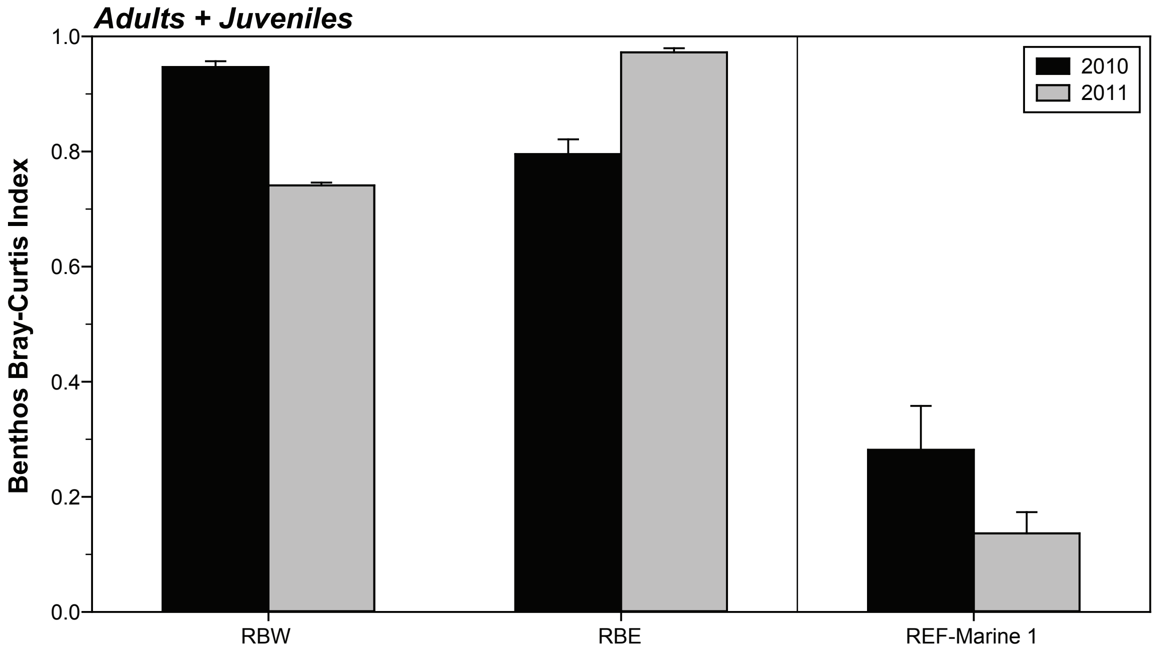

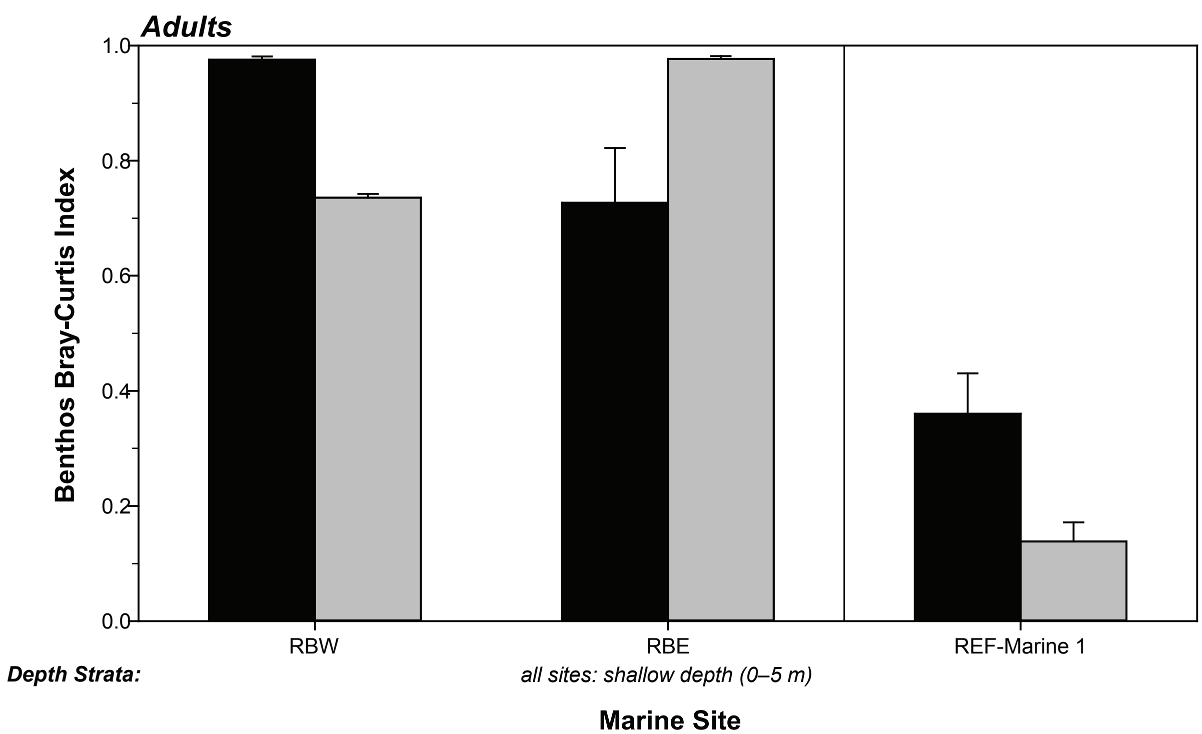

Notes: Error bars represent the standard error of the mean.

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Benthos Bray-Curtis Index for AEMP Marine Sites, Doris North Project, 2010-2011

Figure 3.6-9

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4. Summary of Evaluation of Effects

4. Summary of Evaluation of Effects

The evaluation of effects employed graphical and statistical methods to identify potential effects to the aquatic environment that may have resulted from Project activities in 2011. When historical information was available, before (baseline, pre-2010) and after (evaluation year, 2011) data for specific parameters were first compared at each of the exposure sites to determine whether there was a discernible change in evaluated parameters in 2011. If there was a change, before-after trends in the exposure sites were compared to those at the reference sites (BACI design) to determine if parallel changes occurred (no effect) or if the change was only present in the exposure waterbodies (potential effect). Graphical analysis was used to supplement statistical methods and to aid in the interpretation of temporal trends. Professional judgment was always employed when statistical or graphical methods indicated potential 2011 construction year effects for specific parameters to determine if the effect was likely naturally-occurring or Project-related.

4.1 STREAMS

Table 4.1-1 provides a summary of the 2011 evaluation of effects for the AEMP exposure streams. There was sufficient historical information to evaluate potential Project-related effects on water and sediment quality, periphyton biomass, and the benthic invertebrate community. Overall, there were no apparent Project-related effects on any of the evaluated parameters in the AEMP exposure streams.

Mean 2011 water quality parameter concentrations in AEMP exposure streams were generally below CCME guidelines, except total aluminum and total iron, which were naturally elevated in some exposure streams.

There was evidence of an increase in the concentrations of TSS in Little Roberts Outflow and total molybdenum in Doris Outflow in 2011 compared to baseline concentrations. However, in both these instances, the BACI analysis showed that parallel increases from baseline means also occurred at the reference streams. Thus, there was no evidence that these increases were due to Project activities.

Total cyanide concentrations in Little Roberts Outflow and Roberts Outflow increased in 2011 compared to pre-2010 baseline levels; however, 2011 free cyanide concentrations measured in the exposure streams were always below analytical detection limits and did not exceed the CCME guideline of 0.005 mg/L as free cyanide. The similarity of 2011 mean total cyanide concentrations between exposure and reference streams suggests that the recent increase in cyanide at the exposure streams is an analytical anomaly or a natural phenomenon that also occurred in streams outside of the Project area. It is highly unlikely that there was an anthropogenic cause for the elevated cyanide concentrations measured in 2011, as no cyanide was used on site or brought to site in either 2010 or 2011. Cyanide concentrations will continue to be closely monitored in exposure and reference streams.

Mean 2011 sediment quality parameter concentrations were generally below CCME ISQGs and PELs, except total chromium concentrations, which exceeded the ISQG in all exposure streams and the PEL in Little Roberts Outflow.

At both Doris Outflow and Little Roberts Outflow, there were some differences in the particle size composition of sediment samples collected in 2011 compared to the particle size composition of baseline samples. Variation in sediment particle size composition is unlikely related to 2011 Project activities, and probably reflects natural spatial heterogeneity in stream sediments.

Table 4.1-1. Summary of Evaluation of Effects for the AEMP Streams, Doris North Project, 2011

Parameter	Method of Evaluation	Within Waterbody Before-After Difference (BA analysis)[a]					Before-After Trend Relative to Reference Sites (BACI analysis)[a]			Conclusion of Effect[b, c]		
		Doris OF	Roberts OF	Little Roberts OF	Reference B OF	Reference D OF	Doris OF	Roberts OF	Little Roberts OF	Doris OF	Roberts OF	Little Roberts OF
Water Quality												
pH	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Alkalinity, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Hardness	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Total Suspended Solids	GA, BA, BACI	No difference	No difference	**Increase**	**-**	-	☐	☐	Parallel	No effect	No effect	No effect
Ammonia (as N)	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Nitrate (as N)	GA, BA	-	-	-	No difference	-	-	-	-	No effect	No effect	No effect
Cyanide, Total	GA, BA	No difference	**Increase**	**Increase**	-		-	-	-	No effect	No effect[d]	No effect[d]
Radium-226	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Aluminum, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Arsenic , Total	GA, BA	No difference	No difference	No difference	**Increase**	-	☐	☐	☐	No effect	No effect	No effect
Cadmium, Total	GA, BA	-	-	No difference	-	-	-	-	☐	No effect	No effect	No effect
Copper, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Iron , Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Lead, Total	GA, BA	No difference	No difference	No difference	-	-	☐	☐	☐	No effect	No effect	No effect
Mercury, Total	GA, BA	-	No difference	No difference	**Decrease**	-	-	☐	☐	No effect	No effect	No effect
Molybdenum, Total	GA, BA, BACI	**Increase**	No difference	No difference	-	-	Parallel	☐	☐	No effect	No effect	No effect
Nickel, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	☐	No effect	No effect	No effect
Zinc, Total	GA, BA	No difference	No difference	No difference	-	-	☐	☐	☐	No effect	No effect	No effect
Sediment Quality												
% Gravel (>2 mm)	GA, BA	No difference	-	No difference	No difference		☐	-	☐	No effect	No effect	No effect
% Sand (2.0 mm - 0.063 mm)	GA, BA	**Increase**	-	No difference	No difference		Parallel	-	☐	No effect	No effect	No effect
% Silt (0.063 mm - 4 µm)	GA, BA	No difference	-	**Decrease**	No difference		☐	-	Parallel	No effect	No effect	No effect
% Clay (<4 µm)	GA, BA	No difference	-	**Decrease**	No difference	-	☐	-	**Non-parallel**	No effect	No effect	No effect[d]
Total Organic Carbon	GA, BA	No difference	-	**Decrease**	No difference	-	☐	-	Parallel	No effect	No effect	No effect
Arsenic	GA, BA	No difference	-	No difference	No difference	-	☐	-	☐	No effect	No effect	No effect
Cadmium	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Chromium	GA, BA	No difference	-	No difference	No difference	-	☐	-	☐	No effect	No effect	No effect
Copper	GA, BA	No difference	-	No difference	No difference	-	☐	-	☐	No effect	No effect	No effect
Lead	GA, BA	No difference	-	**Decrease**	No difference	-	☐	-	**Non-parallel**	No effect	No effect	No effect
Mercury	GA, BA	-	-	**Decrease**	-	-	-	-	**Non-parallel**	No effect	No effect	No effect
Zinc	GA, BA	No difference	-	No difference	No difference	-	☐	-	☐	No effect	No effect	No effect
Periphyton												
Biomass	GA, BA, BACI	No difference	-	-	No difference	-	☐	-	Parallel	No effect	No effect	No effect
							2010 to 2011 Trend Relative to Reference Sites (Impact Level-by-Time analysis)[a]					
Benthic Invertebrates												
Total Density	GA, ILBT	-	-	**-**	-	-	Parallel	Parallel	**Non-parallel**	No effect	No effect	No effect[d]
Family Richness	GA, ILBT	-	-	**-**	-	-	Parallel	Parallel	Parallel	No effect	No effect	No effect
Simpson's Evenness Index	GA, ILBT	-	-	**-**	-	-	**Non-parallel**	Parallel	Parallel	No effect[d]	No effect	No effect
Simpson's Diversity Index	GA, ILBT	-	-	**-**	-	-	Parallel	Parallel	Parallel	No effect	No effect	No effect
Bray-Curtis Index	GA, ILBT	-	-	**-**	-	-	Parallel	Parallel	Parallel	No effect	No effect	No effect

Notes: *GA - Graphical analysis; BA - Before-After analysis; BACI - Before-After-Control-Impact analysis; ILBT - Impact Level-by-Time analysis*

[a] *Statistically significant difference at $p<0.01$ to avoid Type I errors.*

[b] *Conclusion of effect is based on graphical analysis, statistical analyses, and professional judgment.*

[c] *For water pH, water alkalinity, water hardness, sediment total organic carbon, sediment particle size, periphyton biomass, and benthos community descriptors, a change in any direction is considered to be an effect.*
For winter dissolved oxygen concentrations, only a decrease is considered to be an effect. For all remaining parameters, only an increase is considered to be an effect.

[d] *Although there was a significant difference, this change cannot be attributed to Project activities.*
For both the BACI and the ILBT analyses, a differential increase or decrease in exposure site parameters over time relative to the reference sites (i.e., a non-parallel effect) may indicate a Project-related effect.

Dash (-) indicates that statistical analysis was not possible because of missing data (i.e., no historical data available), the high proportion of nondetectable concentrations, or the lack of variation in a parameter over time (having no measure of variation causes F-statistic to be infinite).

Square (☐) indicates that BACI results are not reported because the within waterbody before-after comparison shows that there was no significant difference between baseline and 2011 means.

The TOC content of sediments from Little Roberts Outflow decreased slightly in 2011 compared to the baseline mean; however, a parallel trend occurred in the reference streams, suggesting that this was a natural occurrence that was unrelated to Project activities. Total lead and mercury concentrations in sediments from Little Roberts Outflow also decreased in 2011 compared to baseline levels, but decreases in concentrations of these heavy metals are not of environmental concern. Therefore, there were no apparent adverse effects of 2011 Project activities on the evaluated sediment quality parameters.

There was no indication of a Project-related effect on periphyton biomass in the exposure streams.

Stream benthos density trends between 2010 and 2011 in Little Roberts Outflow compared to the reference streams were non-parallel. Similarly, stream benthos Simpson’s Evenness Index trends between 2010 and 2011 in Doris Outflow compared to the reference streams were non-parallel. These differences in trends are unlikely Project-related, and probably reflect natural annual variability or patchiness in the distribution of benthos within streams. 2010 to 2011 trends in family richness, the Simpson’s Diversity Index, and the Bray-Curtis Index at exposure streams paralleled the trends observed for the reference streams, indicating that there were no effects of 2011 Project activities on these benthos community descriptors.

4.2 LAKES

Table 4.2-1 presents the summary of the 2011 evaluation of effects for the AEMP exposure lakes. There was sufficient historical information to evaluate potential Project-related effects on under-ice dissolved oxygen concentrations, Secchi depth, water and sediment quality, phytoplankton biomass, and the benthic invertebrate community. Overall, there were no apparent Project-related effects on any of the evaluated parameters in the AEMP exposure lakes.

There was no evidence of an effect of 2011 Project activities on either under-ice dissolved oxygen concentrations or Secchi depths in the AEMP exposure lakes.

Mean 2011 water quality parameter concentrations in AEMP exposure lakes were generally below CCME guidelines, except total aluminum and total iron in Little Roberts Lake. These two metals also exceeded CCME guidelines in the corresponding reference lake, Reference Lake D.

There was some evidence of a slight increase in the concentration of cadmium in Little Roberts Lake in 2011 compared to baseline concentrations. However, a high proportion (67%) of the concentrations in the dataset were below detection limits, and this apparent increase could be an artifact of substituting one half of the detection limit for values that were below detection. All 2011 total cadmium concentrations in exposure lakes were near or below analytical detection limits, and below the hardness-dependent CCME guideline for cadmium; therefore, there were no apparent adverse effects of 2011 Project activities on total cadmium concentrations in Little Roberts Lake. There was also evidence of a decrease in the mean arsenic concentration in Doris Lake North in 2011 compared to baseline years; however, a decrease is not of environmental concern.

As observed in some exposure streams, the total cyanide concentration in Little Roberts Lake was significantly higher in 2011 than in baseline years. Concentrations of free cyanide measured in the exposure lakes in 2011 were near or below analytical detection limits and were always below the CCME guideline of 0.005 mg/L as free cyanide. The similarity of 2011 mean total cyanide concentrations between exposure and reference lakes suggests that the recent increase in cyanide at the exposure lakes is an analytical anomaly or a natural phenomenon that also occurred in lakes outside of the Project area. It is highly unlikely that there was an anthropogenic cause for the elevated cyanide concentrations measured in 2011, as no cyanide was used on site or brought to site in either 2010 or 2011. Cyanide concentrations will continue to be closely monitored in exposure and reference lakes.

Table 4.2-1. Summary of Evaluation of Effects for the AEMP Lakes, Doris North Project, 2011

Parameter	Method of Evaluation	Within Waterbody Before-After Difference (BA analysis)[a]					Before-After Trend Relative to Reference Site (BACI analysis)[a]			Conclusion of Effect[b, c]		
		Doris South	Doris North	Reference B	Little Roberts	Reference D	Doris South	Doris North	Little Roberts	Doris South	Doris North	Little Roberts
Physical Limnology												
Winter Dissolved Oxygen	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Secchi Depth	GA, BA	No difference	No difference	-	No difference	-	☐	☐	-	No effect	No effect	No effect
Water Quality												
pH	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	-	No effect	No effect	No effect
Alkalinity, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	-	No effect	No effect	No effect
Hardness	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	-	No effect	No effect	No effect
Total Suspended Solids	GA, BA	No difference	No difference	-	No difference	-	☐	☐	-	No effect	No effect	No effect
Ammonia (as N)	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	-	No effect	No effect	No effect
Nitrate (as N)	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	-	No effect	No effect	No effect
Cyanide, Total	GA, BA	No difference	No difference	-	**Increase**	-	-	-	-	No effect	No effect	No effect[d]
Radium-226	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
Aluminum, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	-	No effect	No effect	No effect
Arsenic , Total	GA, BA, BACI	No difference	**Decrease**	No difference	No difference	-	☐	Parallel	-	No effect	No effect	No effect
Cadmium, Total	GA, BA	-	-	-	**Increase**	-	-	-	-	No effect	No effect	No effect[d]
Copper, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	-	No effect	No effect	No effect
Iron , Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	-	No effect	No effect	No effect
Lead, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	-	No effect	No effect	No effect
Mercury, Total	GA, BA	-	No difference	**Decrease**	No difference	-	-	☐	-	No effect	No effect	No effect
Molybdenum, Total	GA, BA	No difference	No difference	-	No difference	-	☐	☐	-	No effect	No effect	No effect
Nickel, Total	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	-	No effect	No effect	No effect
Zinc, Total	GA, BA	No difference	No difference	-	No difference	-	☐	☐	-	No effect	No effect	No effect
Sediment Quality												
% Gravel (>2 mm)	GA	-	-	-	-	-	-	-	-	No effect	No effect	No effect
% Sand (2.0 mm - 0.063 mm)	GA, BA	No difference	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
% Silt (0.063 mm - 4 µm)	GA, BA	No difference	No difference	-	**Increase**	-	-	-	-	No effect	No effect	No effect[d]
% Clay (<4 µm)	GA, BA	No difference	No difference	-	**Decrease**	-	-	-	-	No effect	No effect	No effect[d]
Total Organic Carbon	GA, BA	No difference	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Arsenic	GA, BA	No difference	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Cadmium	GA, BA	No difference	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Chromium	GA, BA	No difference	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Copper	GA, BA	No difference	**Decrease**	-	No difference	-	-	-	-	No effect	No effect	No effect
Lead	GA, BA	No difference	**Decrease**	-	No difference	-	-	-	-	No effect	No effect	No effect
Mercury	GA, BA	No difference	No difference	-	No difference	-	-	-	-	No effect	No effect	No effect
Zinc	GA, BA	No difference	**Decrease**	-	No difference	-	-	-	-	No effect	No effect	No effect
Phytoplankton												
Biomass	GA, BA	No difference	No difference	No difference	No difference	-	☐	☐	-	No effect	No effect	No effect
							2010 to 2011 Trend Relative to Reference Sites (Impact Level-by-Time analysis)[a]					
Benthic Invertebrates												
Total Density	GA, ILBT	-	-	-	-	-	-	Parallel	Parallel	No effect	No effect	No effect
Family Richness	GA, ILBT	-	-	-	-	-	-	Parallel	Parallel	No effect	No effect	No effect
Simpson's Evenness Index	GA, ILBT	-	-	-	-	-	-	Parallel	Parallel	No effect	No effect	No effect
Simpson's Diversity Index	GA, ILBT	-	-	-	-	-	-	**Non-parallel**	Parallel	No effect	No effect[d]	No effect
Bray-Curtis Index	GA, ILBT	-	-	-	-	-	-	**Non-parallel**	Parallel	No effect	No effect[d]	No effect

Notes: *GA - Graphical analysis; BA - Before-After analysis; BACI - Before-After-Control-Impact analysis; ILBT - Impact Level-by-Time analysis*

[a] *Statistically significant difference at $p<0.01$ to avoid Type I errors.*

[b] *Conclusion of effect is based on graphical analysis, statistical analyses, and professional judgment.*

[c] *For water pH, water alkalinity, water hardness, sediment total organic carbon, sediment particle size, phytoplankton biomass, and benthos community descriptors, a change in any direction is considered to be an effect. For Secchi depth and winter dissolved oxygen concentrations, only a decrease is considered to be an effect. For all remaining parameters, only an increase is considered to be an effect.*

[d] *Although there was a significant difference, this change cannot be attributed to Project activities.*

For both the BACI and the ILBT analyses, a differential increase or decrease in exposure site parameters over time relative to the reference sites (i.e., a non-parallel effect) may indicate a Project-related effect.

Dash (-) indicates that statistical analysis was not possible because of missing data (i.e., no historical data available), the high proportion of nondetectable concentrations, or the lack of variation in a parameter over time (having no measure of variation causes F-statistic to be infinite).

Square (☐) indicates that BACI results are not reported because the within waterbody before-after comparison shows that there was no significant difference between baseline and 2011 means.

Mean 2011 sediment quality parameter concentrations were generally below CCME ISQGs, except total chromium, total copper, and total arsenic, which exceeded ISQGs at several lake sites. The mean total arsenic concentration at Doris Lake South also exceeded the PEL guideline.

At Little Roberts Lake, there were some differences in the particle size composition of sediment samples collected in 2011 compared to the particle size composition of baseline samples. Variation in sediment particle size composition is unlikely related to 2011 Project activities, and probably reflects natural spatial heterogeneity in lake sediments.

Total copper, lead, and zinc concentrations in sediments from Doris Lake North decreased in 2011 compared to baseline levels, but decreases in concentrations of these metals are not of environmental concern. Therefore, there were no apparent adverse effects of 2011 Project activities on the evaluated sediment quality parameters.

There was no indication of a Project-related effect on phytoplankton biomass in the exposure lakes.

There was evidence of non-parallelism in the 2010 to 2011 benthos Simpson's Diversity Index trends between Doris Lake North and Reference Lake B. This was also the case for the Bray-Curtis Index. These differences in trends are unlikely Project-related, and probably reflect natural annual variability or patchiness in the composition of the benthos community within lakes. 2010 to 2011 trends in total density, family richness, and the Simpson's Evenness Index at exposure lakes paralleled the trends observed for the reference lakes, indicating that there were no effects of 2011 Project activities on these benthos community descriptors.

4.3 MARINE

Table 4.3-1 presents the summary of the 2011 evaluation of effects for the AEMP marine exposure sites. There was sufficient historical information to evaluate potential Project-related effects on under-ice dissolved oxygen concentrations, water and sediment quality, phytoplankton biomass, and the benthic invertebrate community. Overall, there were no apparent Project-related effects on any of the evaluated parameters in the marine exposure sites.

All dissolved oxygen concentrations and water quality parameters measured at the marine exposure sites during 2011 remained similar to baseline conditions, indicating that 2011 Project activities had no effects on the water chemistry in the surrounding marine habitat. The dissolved oxygen concentrations in Roberts Bay were above the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L), and all water quality parameters were below applicable CCME guidelines for the protection of aquatic life.

At site RBW, there were some differences in the particle size composition of sediment samples collected in 2011 compared to the particle size composition of samples collected in 2002. Variation in sediment particle size composition is unlikely related to 2011 Project activities, and probably reflects natural spatial heterogeneity in marine sediments. Several metals increased in RBW sediments between 2002 and 2011. However, greater increases occurred at the marine reference site (REF-Marine 1) between 2009 and 2011, indicating that this variability was likely natural. All measured sediment quality parameters in marine exposure sites were below CCME ISQGs and PELs.

There was no indication of a Project-related effect on phytoplankton biomass at the marine exposure sites.

Table 4.3-1. Summary of Evaluation of Effects for the AEMP Marine Sites, Doris North Project, 2011

Parameter	Method of Evaluation	Within Waterbody Before-After Difference (BA analysis)[a]			Before-After Trend Relative to Reference Site (BACI analysis)[a]		Conclusion of Effect[b, c]	
		Roberts Bay West (RBW)	Roberts Bay East (RBE)	Ida Bay (REF-Marine 1)	Roberts Bay West (RBW)	Roberts Bay East (RBE)	Roberts Bay West (RBW)	Roberts Bay East (RBE)
Physical Oceanography								
Winter Dissolved Oxygen	GA	-	-	-	-	-	No effect	No effect
Water Quality								
pH	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Alkalinity, Total	GA, BA	-	No difference	-	-	-	No effect	No effect
Hardness	GA, BA	No difference	No difference	-	-	-	No effect	No effect
Total Suspended Solids	GA, BA	-	No difference	-	-	□	No effect	No effect
Ammonia (as N)	GA, BA	-	No difference	No difference	-	□	No effect	No effect
Nitrate (as N)	GA, BA	No difference	-	-	-	-	No effect	No effect
Cyanide, Total	GA, BA	-	No difference	-	-	-	No effect	No effect
Radium-226	GA, BA	-	No difference	-	-	-	No effect	No effect
Aluminum, Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Arsenic , Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Cadmium, Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Copper, Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Iron , Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Lead, Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Mercury, Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Molybdenum, Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Nickel, Total	GA, BA	No difference	No difference	No difference	□	□	No effect	No effect
Zinc, Total	GA, BA	No difference	No difference	**Increase**	-	-	No effect	No effect
Sediment Quality								
% Gravel (>2 mm)	GA, BA	-	-	No difference	-	-	No effect	No effect
% Sand (2.0 mm - 0.063 mm)	GA, BA, BACI	**Increase**	-	**Decrease**	**Non-parallel**	-	No effect[d]	No effect
% Silt (0.063 mm - 4 µm)	GA, BA	No difference	-	**Increase**	□	-	No effect	No effect
% Clay (<4 µm)	GA, BA, BACI	**Decrease**	-	**Increase**	**Non-parallel**	-	No effect[d]	No effect
Total Organic Carbon	GA, BA, BACI	**Increase**	-	**Increase**	**Non-parallel**	-	No effect[d]	No effect
Arsenic	GA, BA, BACI	**Increase**	-	**Increase**	**Non-parallel**	-	No effect[d]	No effect
Cadmium	GA, BA	-	-	**Increase**	-	-	No effect	No effect
Chromium	GA, BA, BACI	**Increase**	-	**Increase**	**Non-parallel**	-	No effect[d]	No effect
Copper	GA, BA, BACI	**Increase**	-	**Increase**	**Non-parallel**	-	No effect[d]	No effect
Lead	GA, BA	No difference	-	**Increase**	□	-	No effect	No effect
Mercury	GA, BA	-	-	**Increase**	-	-	No effect	No effect
Zinc	GA, BA	No difference	-	**Increase**	□	-	No effect	No effect
Phytoplankton								
Biomass	GA, BACI	-	-	-	No difference	No difference	No effect	No effect
					2010 to 2011 Trend Relative to Reference Sites (Impact Level-by-Time analysis)[a]			
Benthic Invertebrates (Adults + Juveniles)								
Total Density	GA, ILBT	-	-	-	**Non-parallel**	Parallel	No effect[d]	No effect
Family Richness	GA, ILBT	-	-	-	**Non-parallel**	**Non-parallel**	No effect[d]	No effect[d]
Simpson's Evenness Index	GA, ILBT	-	-	-	Parallel	Parallel	No effect	No effect
Simpson's Diversity Index	GA, ILBT	-	-	-	Parallel	Parallel	No effect	No effect
Bray-Curtis Index	GA, ILBT	-	-	-	Parallel	**Non-parallel**	No effect	No effect[d]
Benthic Invertebrates (Adults)								
Total Density	GA, ILBT	-	-	-	**Non-parallel**	**Non-parallel**	No effect[d]	No effect[d]
Family Richness	GA, ILBT	-	-	-	**Non-parallel**	**Non-parallel**	No effect[d]	No effect[d]
Simpson's Evenness Index	GA, ILBT	-	-	-	**Non-parallel**	Parallel	No effect[d]	No effect
Simpson's Diversity Index	GA, ILBT	-	-	-	Parallel	Parallel	No effect	No effect
Bray-Curtis Index	GA, ILBT	-	-	-	Parallel	**Non-parallel**	No effect	No effect[d]

Notes: *GA - Graphical analysis; BA - Before-After analysis; BACI - Before-After-Control-Impact analysis; ILBT - Impact Level-by-Time analysis*

[a] *Statistically significant difference at $p<0.01$ to avoid Type I errors.*

[b] *Conclusion of effect is based on graphical analysis, statistical analyses, and professional judgment.*

[c] *For water pH, water alkalinity, water hardness, sediment total organic carbon, sediment particle size, phytoplankton biomass, and benthos community descriptors, a change in any direction is considered to be an effect. For winter dissolved oxygen concentrations, only a decrease is considered to be an effect. For all remaining parameters, only an increase is considered to be an effect.*

[d] *Although there was a significant difference, this change cannot be attributed to Project activities.*

For both the BACI and the ILBT analyses, a differential increase or decrease in exposure site parameters over time relative to the reference sites (i.e., a non-parallel effect) may indicate a Project-related effect.

Dash (-) indicates that statistical analysis was not possible because of missing data (i.e., no historical data available), the high proportion of nondetectable concentrations, or the lack of variation in a parameter over time (having no measure of variation causes F-statistic to be infinite).

Square (□) indicates that BACI results are not reported because the within waterbody before-after comparison shows that there was no significant difference between baseline and 2011 means.

In the whole benthos community (adults and juveniles), there was evidence of non-parallelism in the 2010 to 2011 benthos total density and family richness trends between RBW and REF-Marine 1. There was also evidence of non-parallelism in the 2010 to 2011 family richness and Bray-Curtis Index trends between RBE and REF-Marine 1. In the adult benthos community, there was evidence of non-parallelism in the 2010 to 2011 total density, family richness, and Simpson's Evenness Index trends between RBW and REF-Marine 1. There was also evidence of non-parallelism in the 2010 to 2011 total density, family richness, and Bray-Curtis Index trends between RBE and REF-Marine 1. These differences in trends are unlikely Project-related, and probably reflect natural annual variability or patchiness in the composition of the benthos community within marine sites.

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Appendix A
2011 Data Report

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Appendix A. 2011 Data Report

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Appendix A. 2011 Data Report

A.1 OVERVIEW OF REPORT

This report presents the raw data as well as graphs and tables of the results of the 2011 Aquatic Effects Monitoring Program (AEMP). The 2011 AEMP included: physical profiles of temperature, dissolved oxygen, and salinity (marine sites only); Secchi depth; water quality; sediment quality; primary producer biomass; and benthic invertebrate taxonomy and density. All details of the sampling methodology and data analysis are provided in the main body of the 2011 AEMP report. Figure A.1-1 shows an overview map of all the sampling sites included in the 2011 program and Figures A.1-2 to A.1-8 show detailed maps of AEMP lake and marine sites that include sampling details and bathymetric contours (if available).

Because there is both historical mining activity (an abandoned silver mine) and current non-HBML exploration activity occurring in the Roberts Watershed and lake area, an additional site in Roberts Lake was sampled on September 24, 2011 (Figure A.1-3). The following parameters were measured at the Roberts Lake site: physical profiles, water quality, sediment quality, and phytoplankton biomass. The sampling site in Roberts Lake is situated in the northwestern end of Roberts Lake adjacent to the North Arrow Minerals Inc. exploration camp (Figure A.1-1). The purpose of adding this Roberts Lake site is to help identify any potential confounding influence of activities unrelated to the Doris North Gold Mine Project. The Roberts Lake site is not currently part of the approved AEMP program, but it will be added to the 2012 AEMP program.

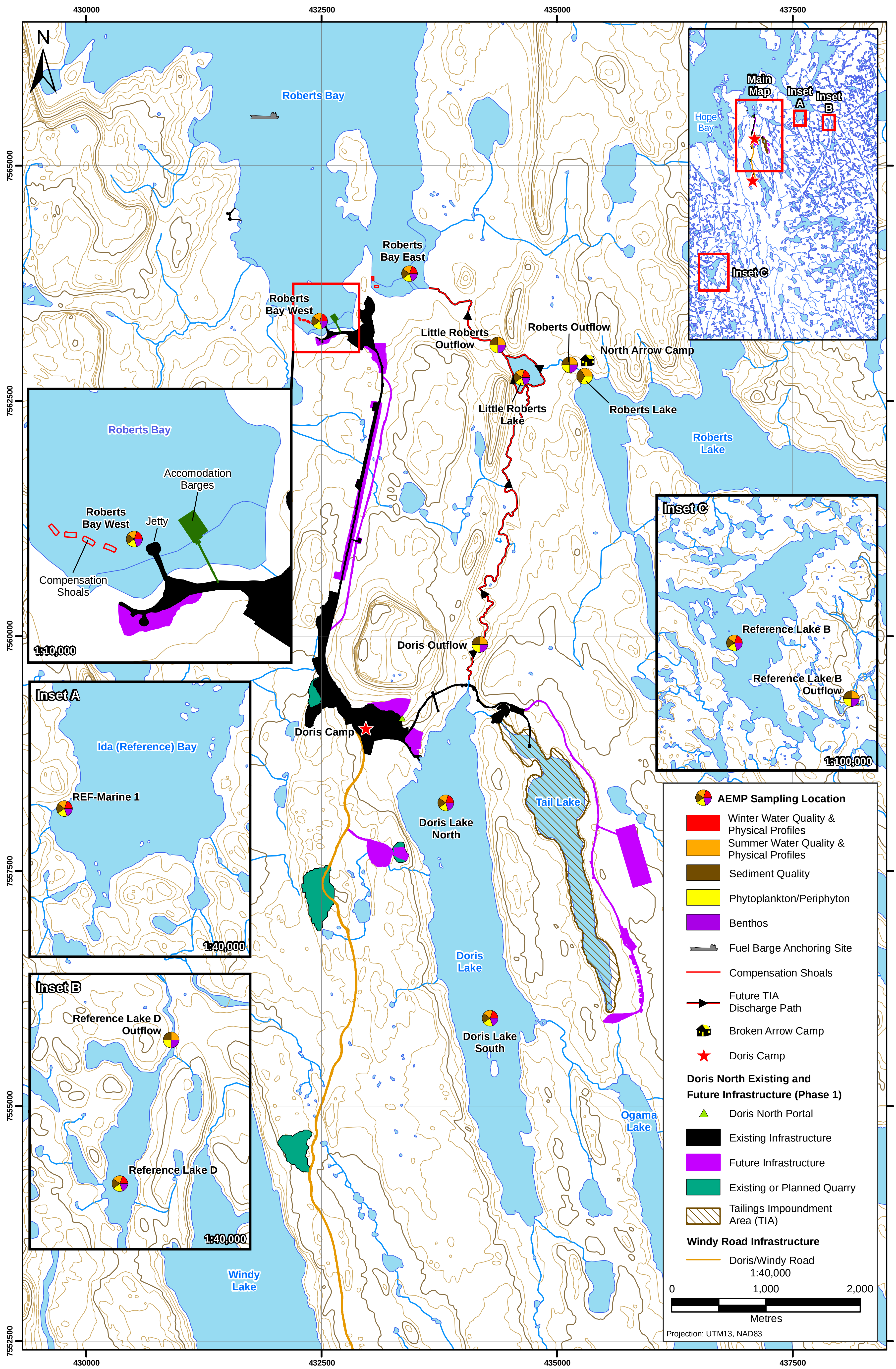

Figure A.1-1

NEWMONT NORTH AMERICA

Sampling Locations, Doris North Project, 2011

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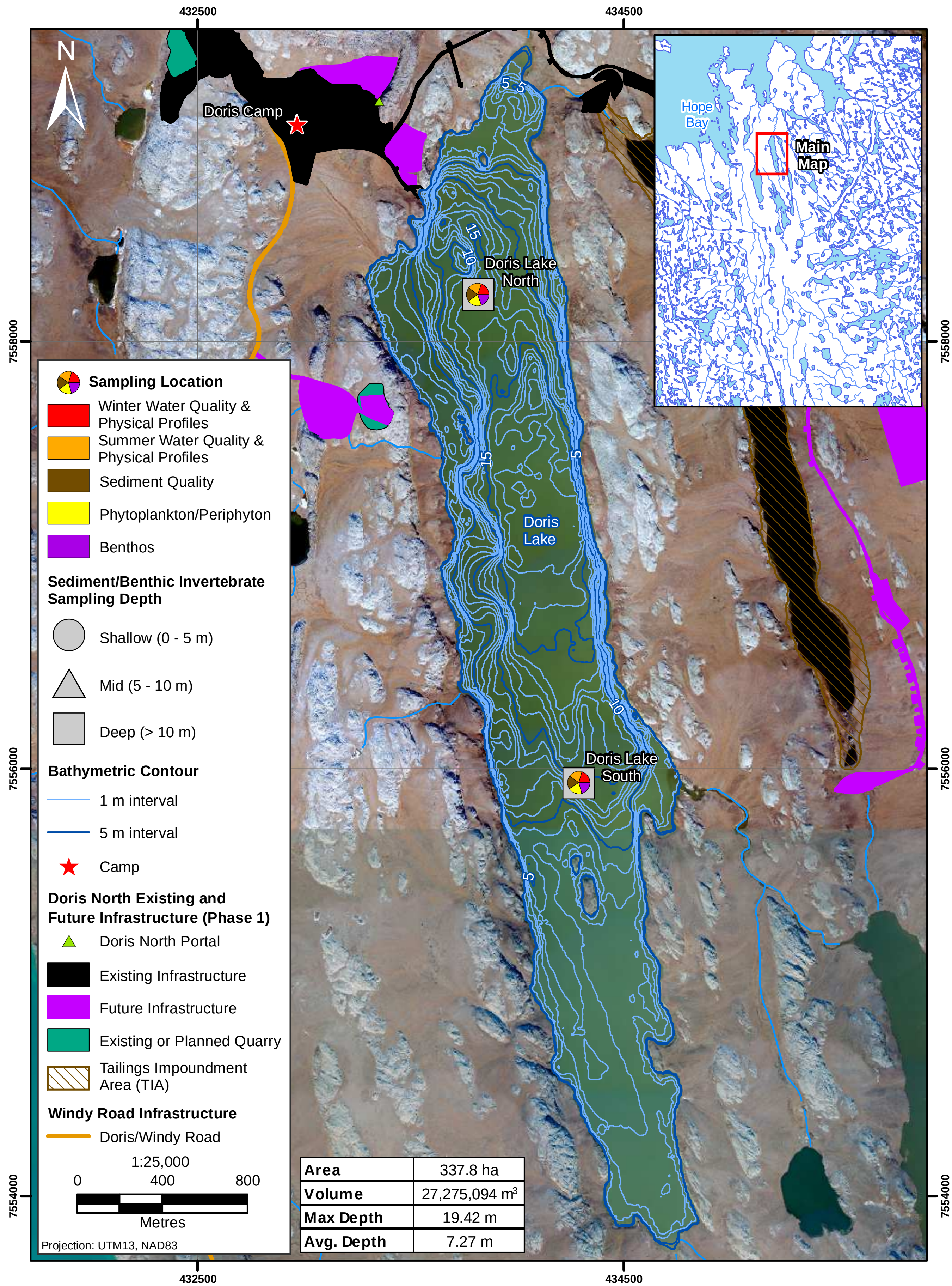

Area	337.8 ha
Volume	27,275,094 m^3
Max Depth	19.42 m
Avg. Depth	7.27 m

Figure A.1-2

Sampling Locations in Doris Lake, Doris North Project, 2011

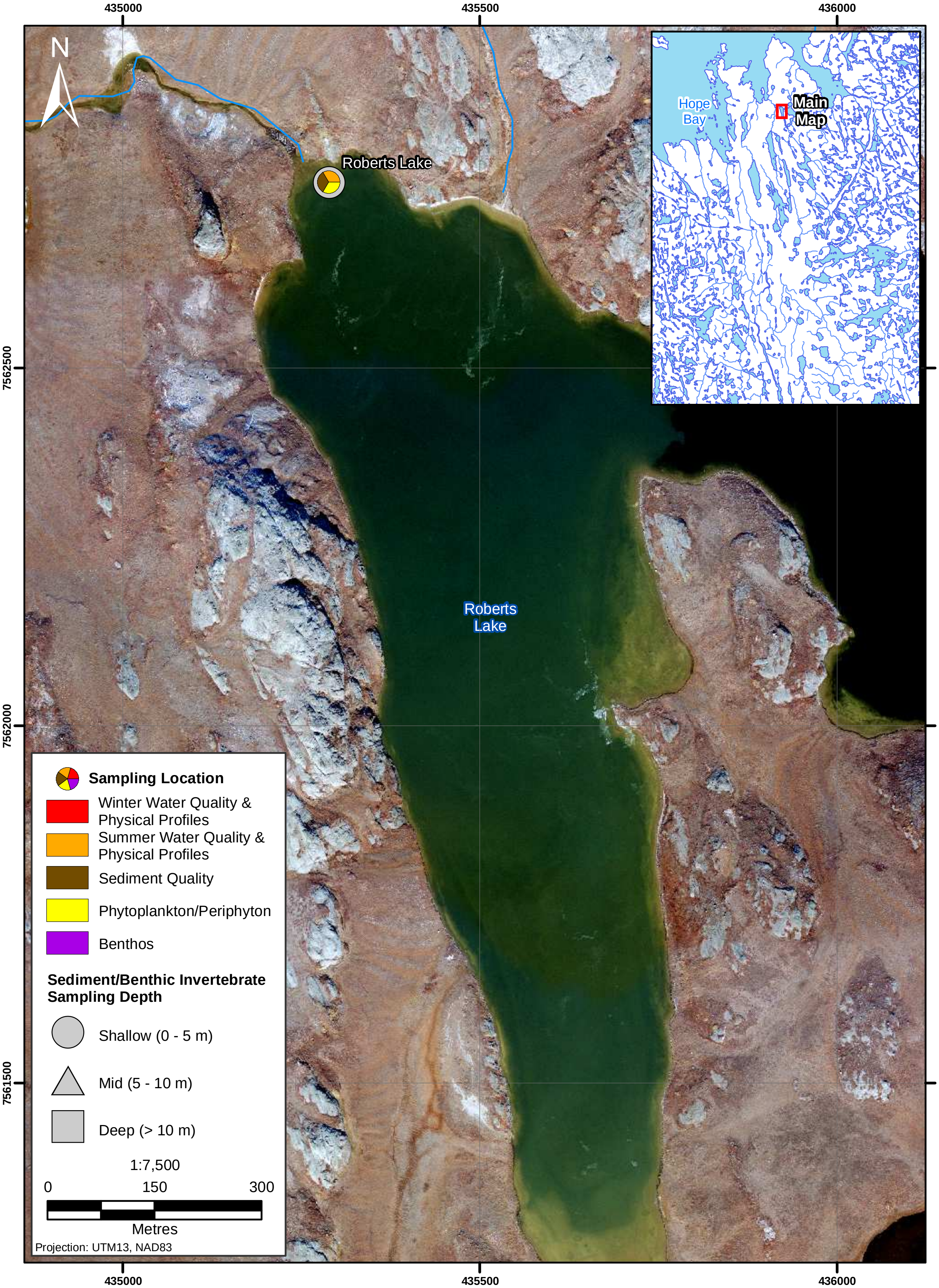

Figure A.1-3

Sampling Location in Roberts Lake, Doris North Project, 2011

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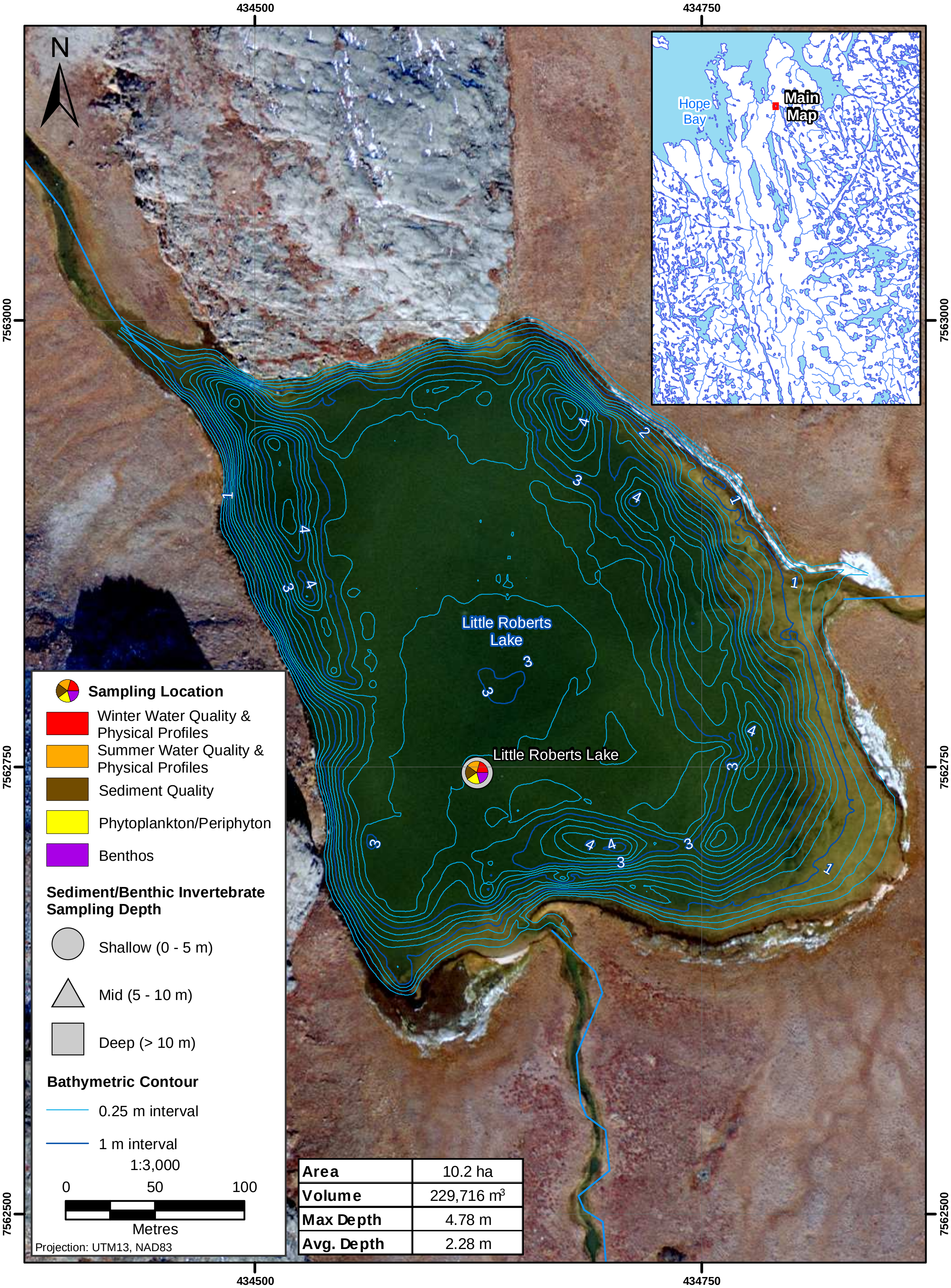

Area	10.2 ha
Volume	229,716 m^3
Max Depth	4.78 m
Avg. Depth	2.28 m

Figure A.1-4

Sampling Location in Little Roberts Lake, Doris North Project, 2011

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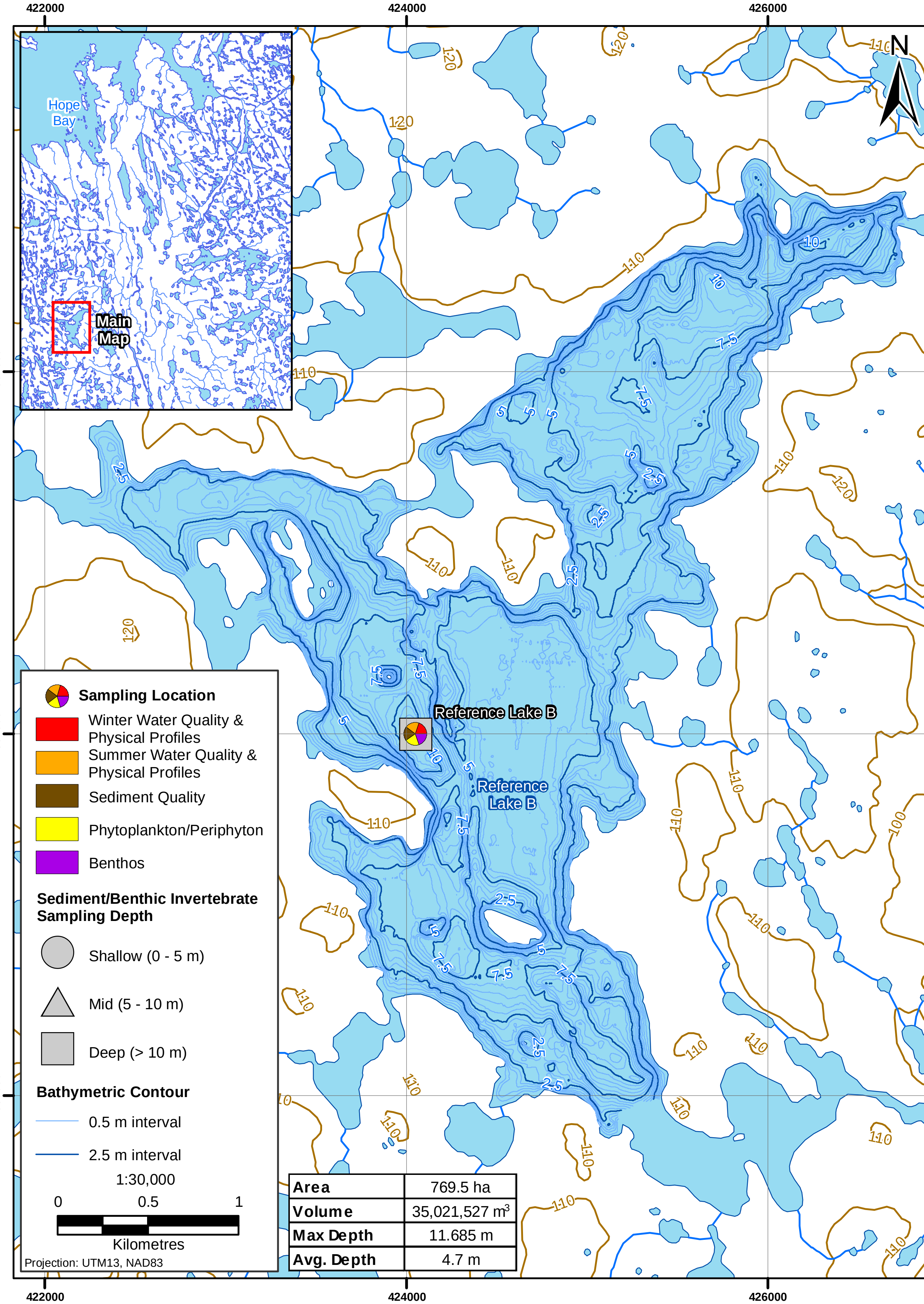
PROJECT #1009-008-05 GIS # HB-01-066d December 05 2011



Area	769.5 ha
Volume	35,021,527 m^3
Max Depth	11.685 m
Avg. Depth	4.7 m

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Figure A.1-5

Sampling Location in Reference Lake B, Doris North Project, 2011

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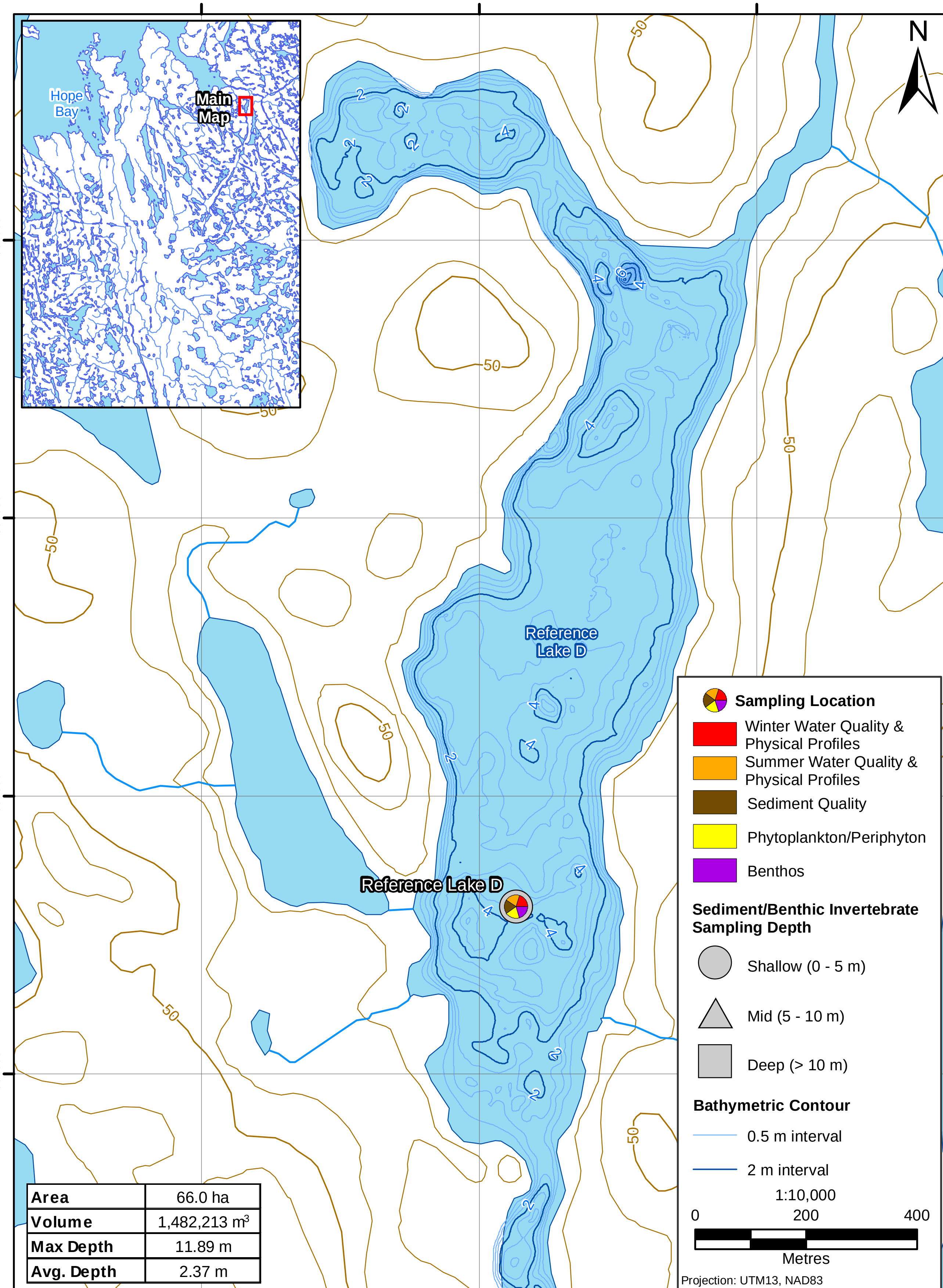

Figure A.1-6

Sampling Location in Reference Lake D, Doris North Project, 2011

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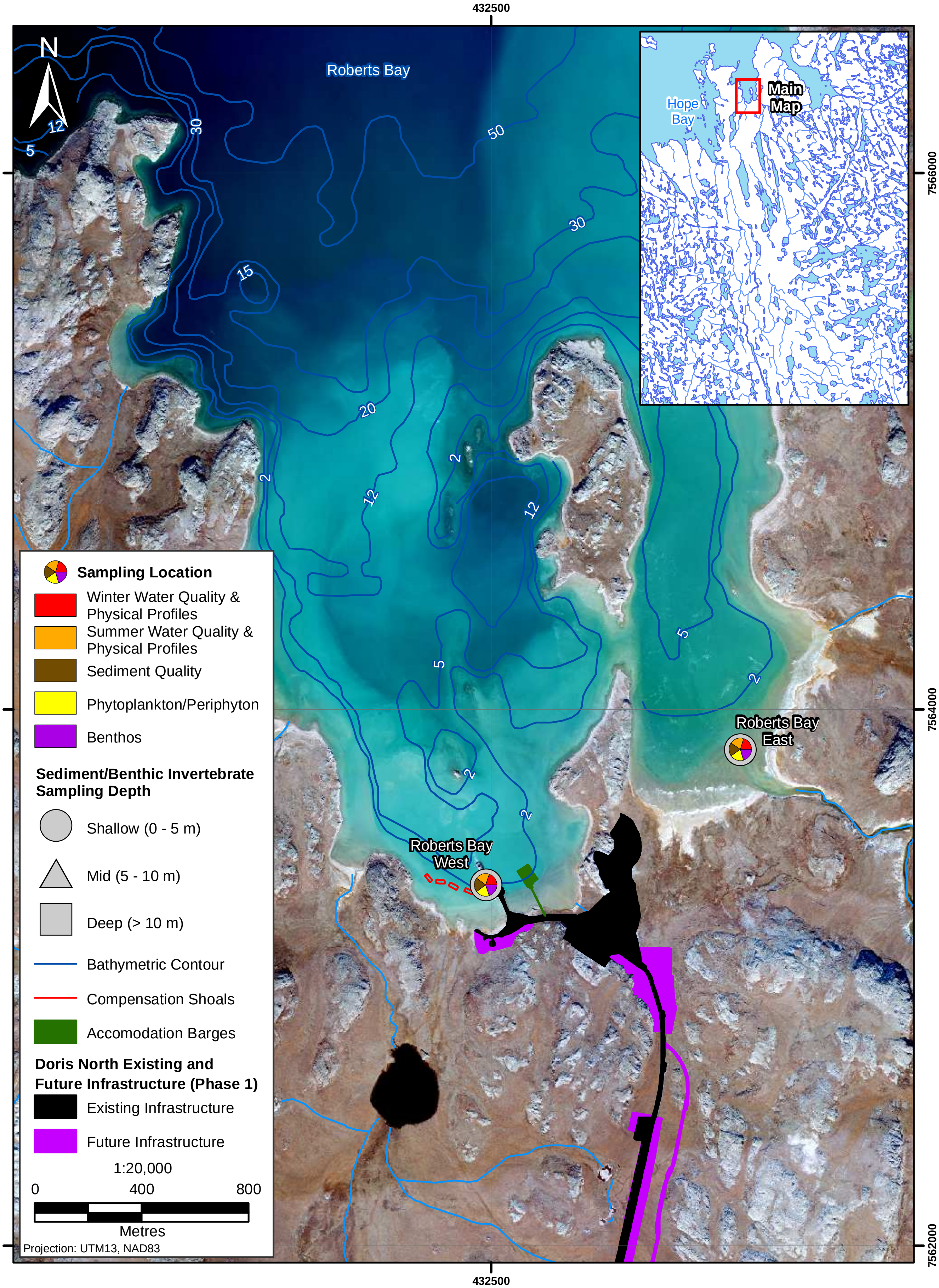

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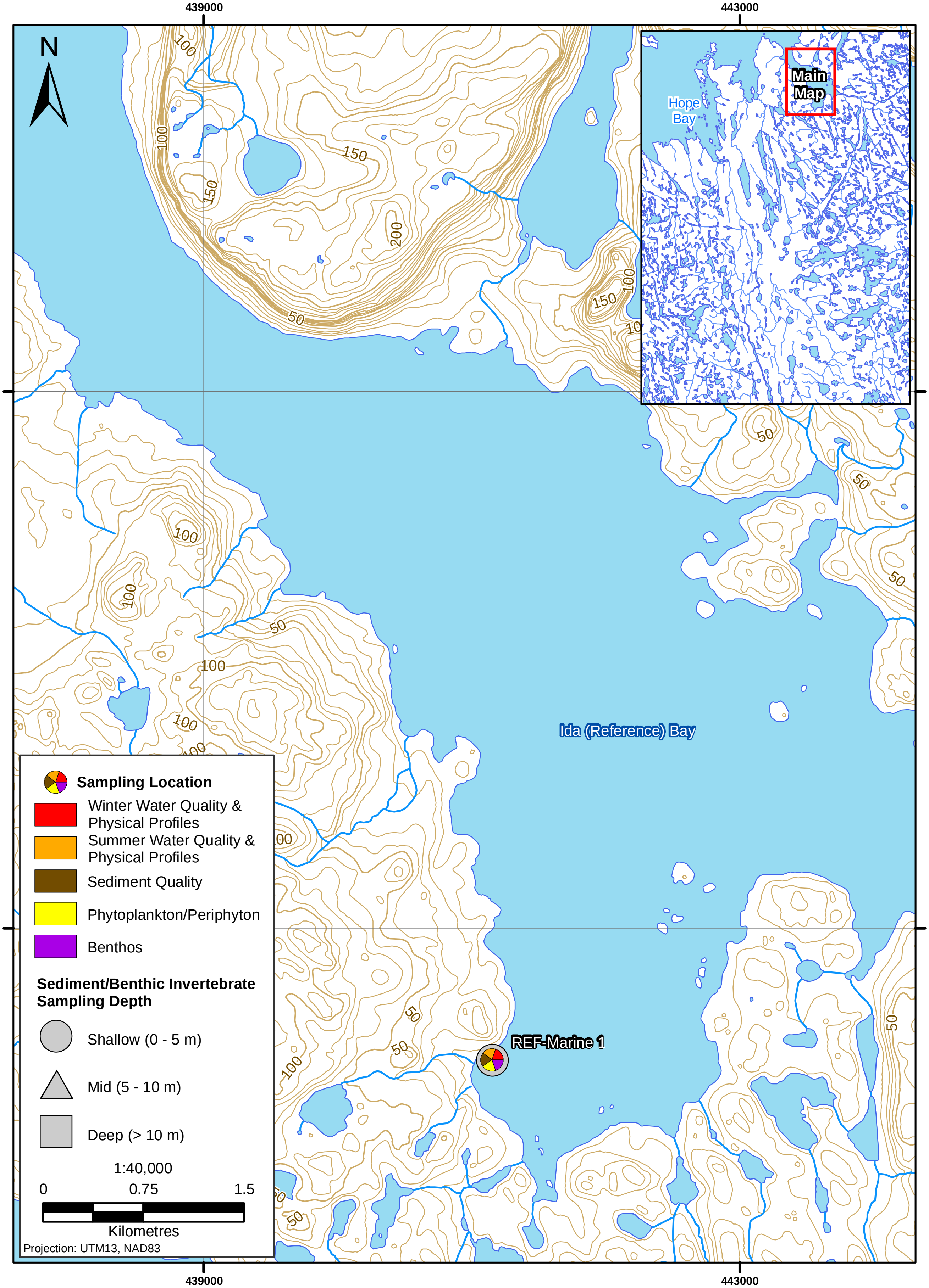
Sampling Locations in Roberts Bay, Doris North Project, 2011

Figure A.1-7

Rescan Engineers & Scientists



NEWMONT The Gold Company

Sampling Location in Ida (Reference) Bay, Doris North Project, 2011

Figure A.1-8

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A.2 2011 PHYSICAL PROFILES AND SECCHI DEPTH

The following sections present the Secchi depth data and the physical profiles collected between April and September 2011 in stream, lake, and marine sites.

A.2.1 Stream Data

Stream water temperatures measured between June and September 2011 are shown in Table A.2-1.

Table A.2-1. Stream Water Temperatures, Doris North Project, 2011

	Date			
tream	**June 26**	**July 23**	**August 28**	**September 19 to 23**
Doris Outflow	0.1°C	13.6°C	11.8°C	6.5°C
Roberts Outflow	0.2°C	14.9°C	11.9°C	6.4°C
Little Roberts Outflow	0.3°C	15.0°C	11.1°C	6.3°C
Reference B Outflow	0.1°C	17.2°C	-	2.9°C
Reference D Outflow	1.1°C	16.4°C	-	5.4°C

Note: Stream water temperature was not measured in Reference B and D outflows in August.

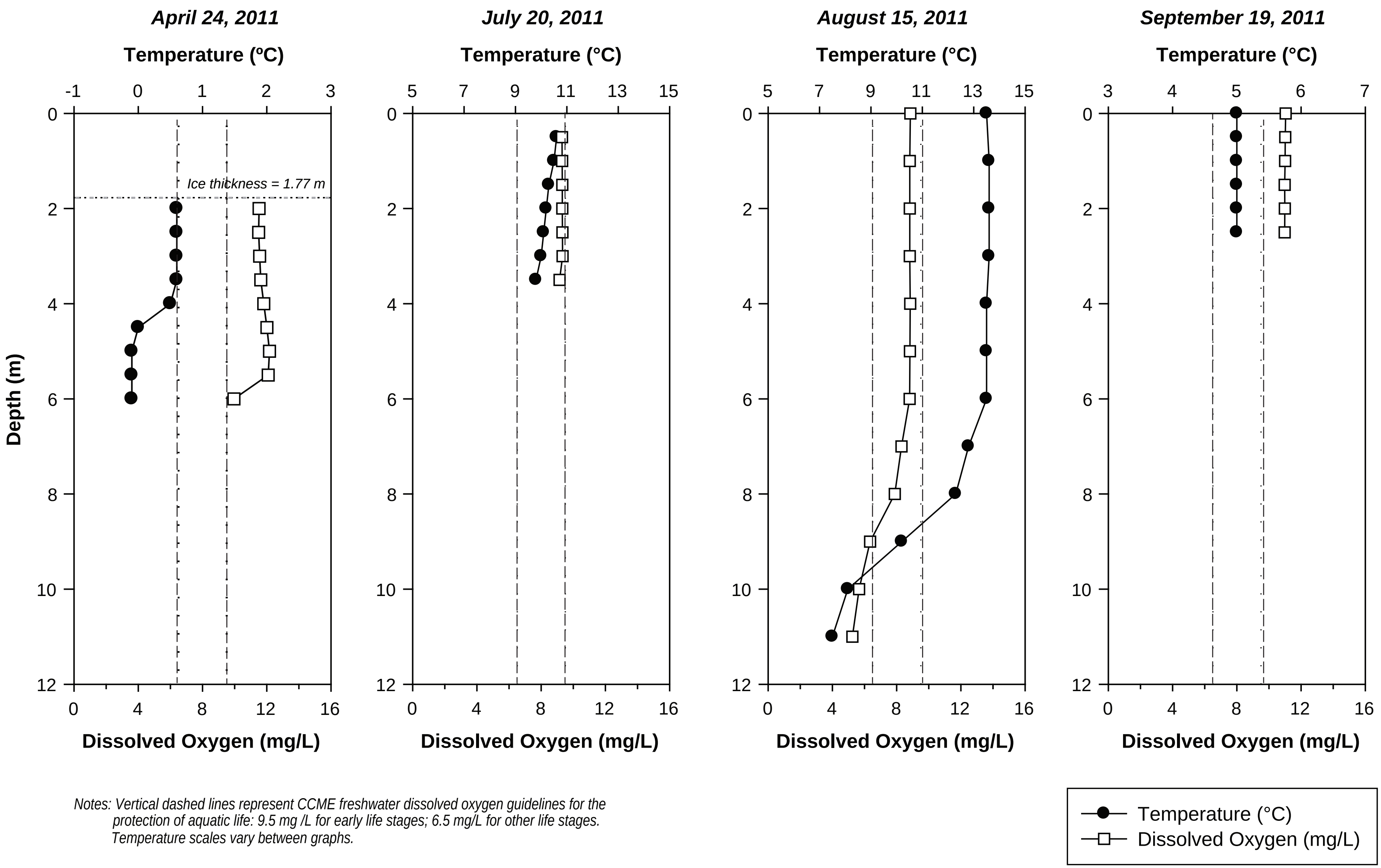
A.2.2 Lake Data

Lake Secchi depths and calculated euphotic zone depths (1% light level) are shown in Table A.2-2. Figures A.2-1 to A.2-6 show the temperature and dissolved oxygen profiles collected at lake sites between April and September 2011, and Annex A.2-1 provides the raw physical profile data.

Table A.2-2. Lake Secchi Depths and Euphotic Zone Depths, Doris North Project, 2011

Lake Site	Sampling Date	Secchi Depth (D_s) (m)	Euphotic Zone Depth 1% Light Level (m)
Large Lake Site			
Doris Lake South	July 19	1.5	4.1*
	August 15	2.0	5.4
	September 19	1.0	2.7
Doris Lake North	July 19	1.6	4.3
	August 15	1.75	4.7
	September 19	NC	-
Roberts Lake	September 24	1.5	4.1*
Reference Lake B	July 18	4.0	10.8
	August 20	8.0	21.6*
	September 18	8.4	22.7*
Small Lake Site			
Little Roberts Lake	July 20	1.4	3.8*
	August 28	1.4	3.8*
	September 24	1.5	4.1*
Reference Lake D	July 20	2.5	6.8*
	August 16	3.2	8.7*
	September 26	2.1	5.7*

*Note: * indicates that the euphotic zone extended to the bottom of the water column.*
NC = not collected



Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages. Temperature scales vary between graphs.

Figure A.2-1

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Doris Lake South, Doris North Project, 2011

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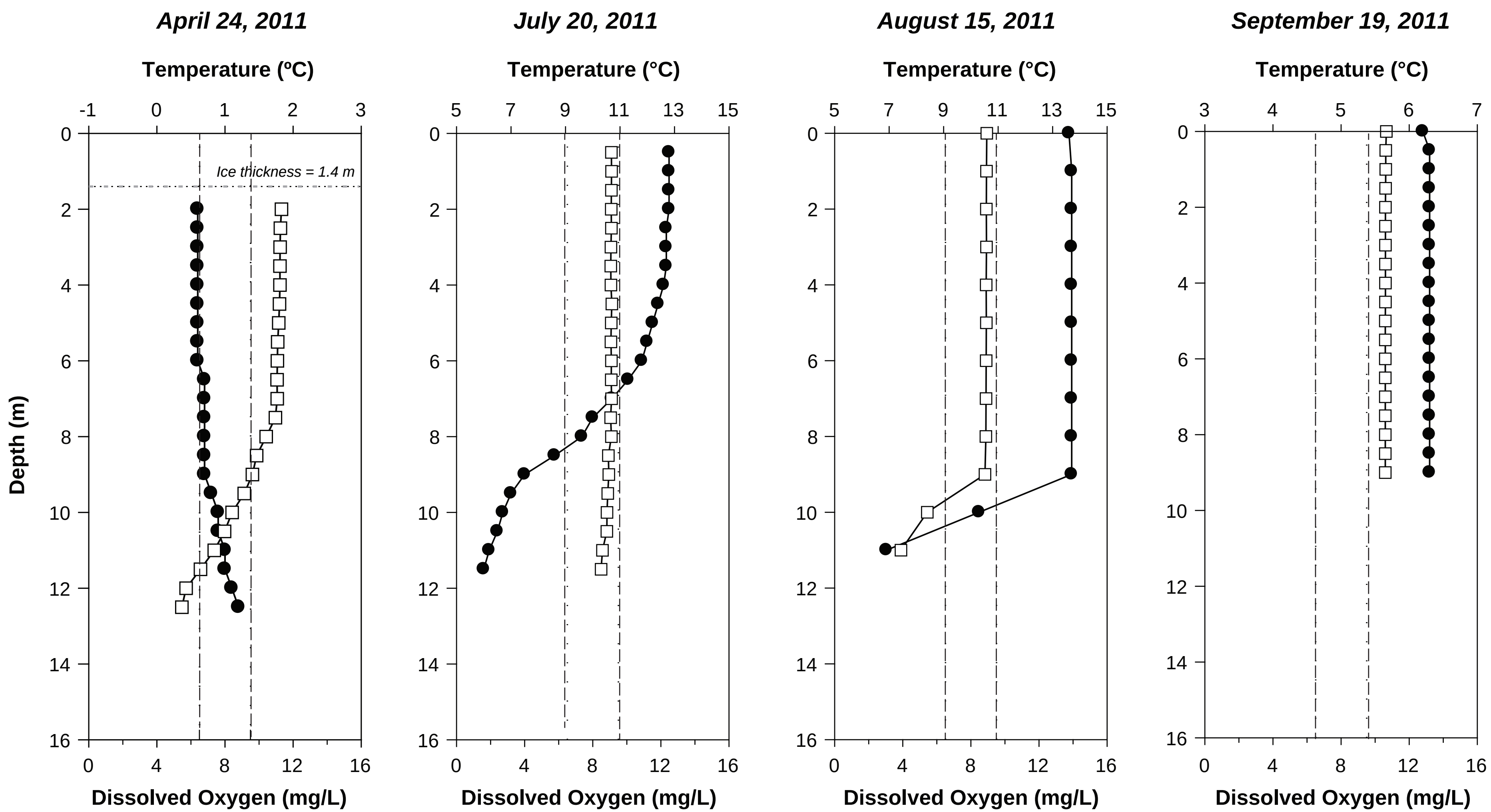


Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages. Temperature scales vary between graphs.

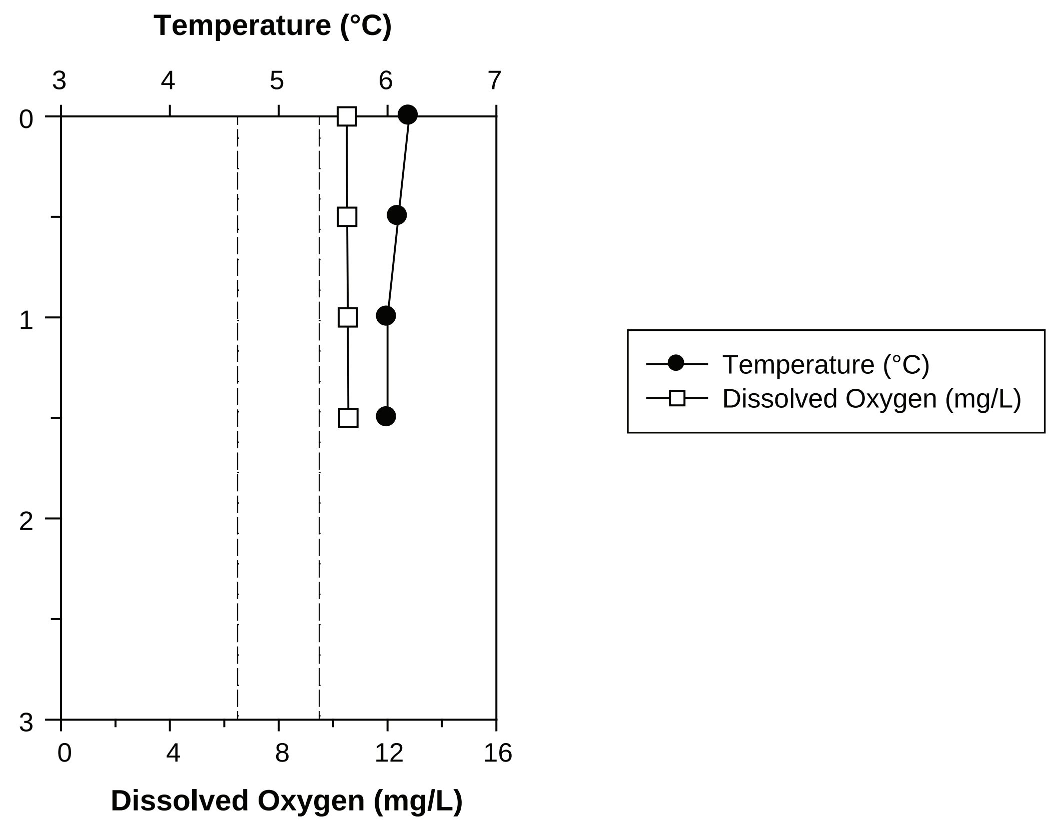
Figure A.2-2

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Doris Lake North, Doris North Project, 2011

Rescan Engineers & Scientists

September 24, 2011



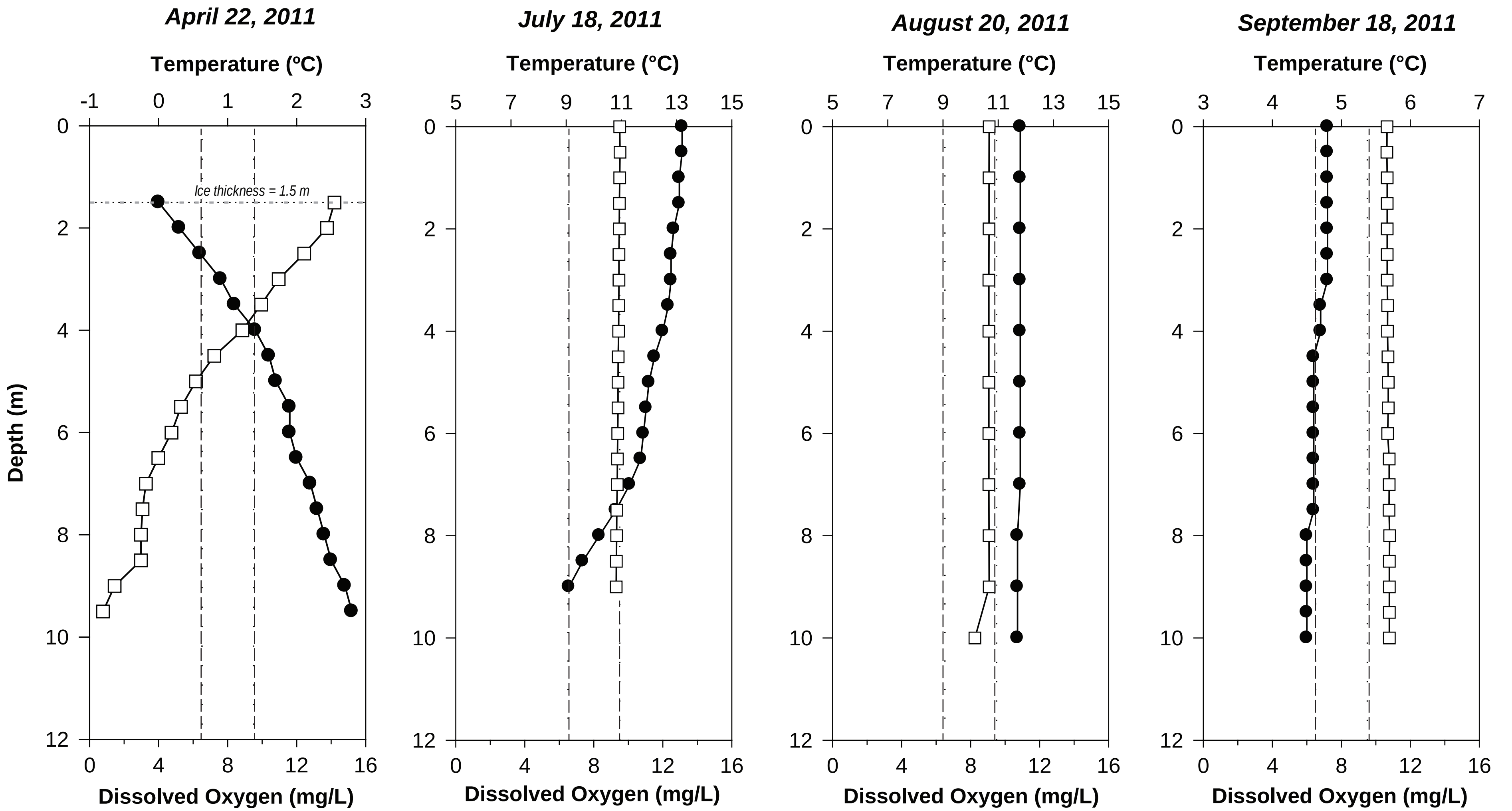
Note: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages.

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Roberts Lake, Doris North Project, 2011

Figure A.2-3

Rescan Engineers & Scientists



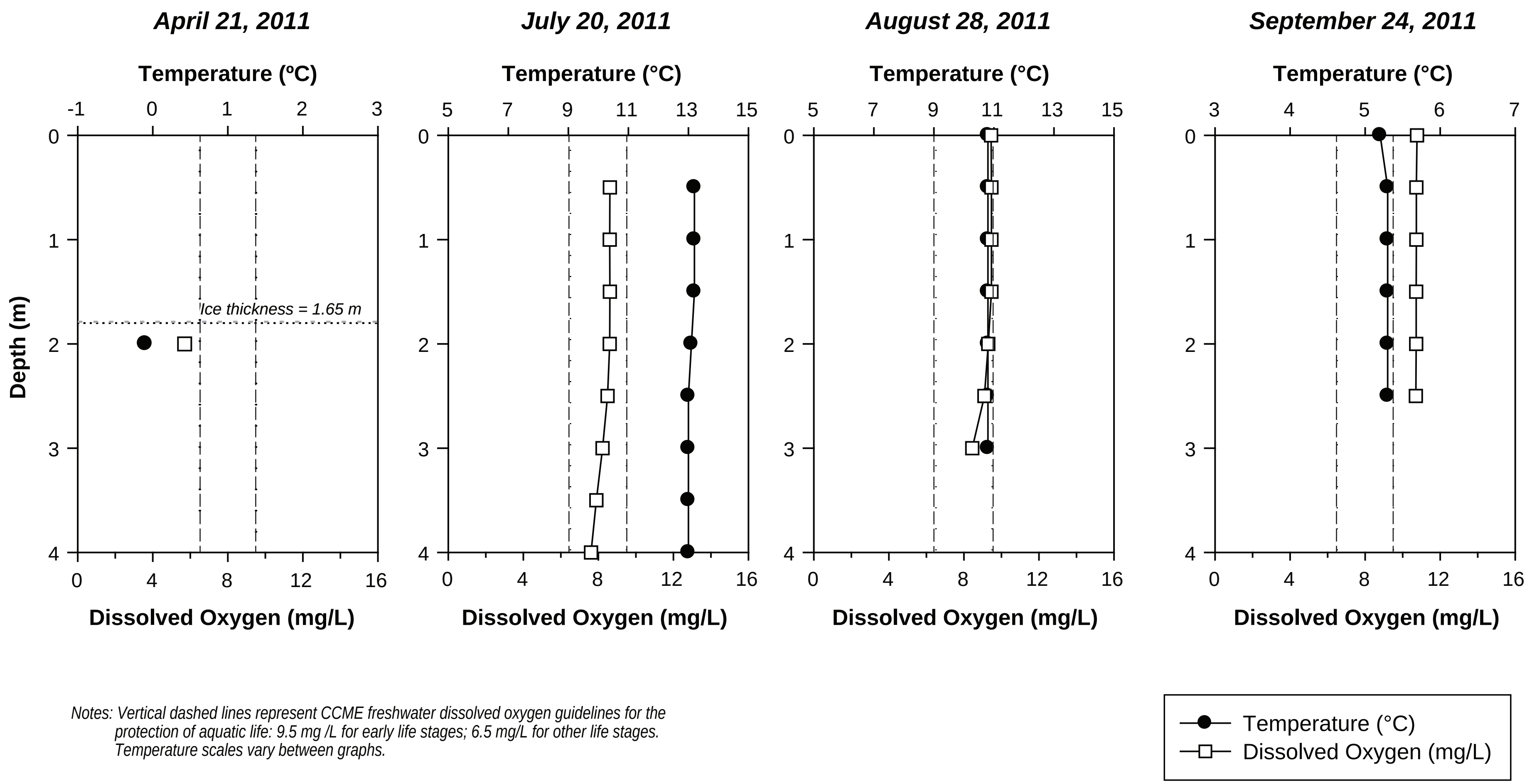
Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages. Temperature scales vary between graphs.

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Reference Lake B, Doris North Project, 2011

Figure A.2-4

Rescan Engineers & Scientists



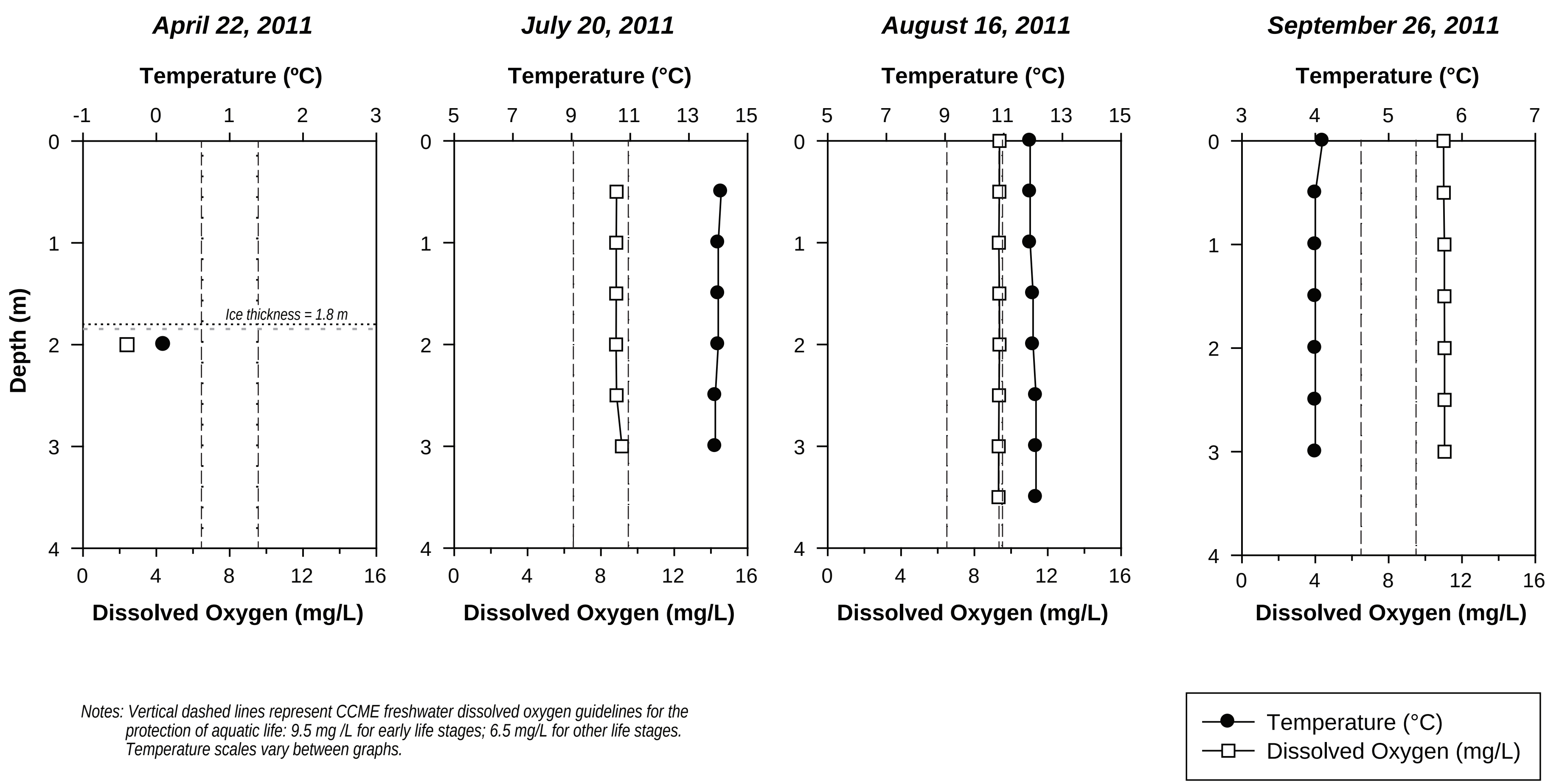
Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages. Temperature scales vary between graphs.

Figure A.2-5

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Little Roberts Lake, Doris North Project, 2011

Rescan Engineers & Scientists



Notes: Vertical dashed lines represent CCME freshwater dissolved oxygen guidelines for the protection of aquatic life: 9.5 mg /L for early life stages; 6.5 mg/L for other life stages. Temperature scales vary between graphs.

Figure A.2-6

NEWMONT NORTH AMERICA

Temperature and Dissolved Oxygen Profiles in Reference Lake D, Doris North Project, 2011

Figure A.2-6

Rescan Engineers & Scientists

Annex A.2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2010

Station: Doris Lake South — **Date:** 24-Apr-11

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
2.0	0.6	11.52	80.1
2.5	0.6	11.50	80.0
3.0	0.6	11.56	80.3
3.5	0.6	11.63	80.6
4.0	0.5	11.82	81.9
4.5	0.0	12.01	82.2
5.0	-0.1	12.17	83.0
5.5	-0.1	12.09	82.5
6.0	-0.1	9.96	67.8

Station: Doris Lake South — **Date:** 20-Jul-11

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.5	10.6	9.30	83.5
1.0	10.5	9.31	83.5
1.5	10.3	9.32	83.3
2.0	10.2	9.32	83.0
2.5	10.1	9.33	82.8
3.0	10.0	9.34	82.7
3.5	9.8	9.15	80.7

Station: Doris Lake South — **Date:** 15-Aug-11

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.0	13.5	8.86	84.9
1.0	13.6	8.82	84.8
2.0	13.6	8.82	84.9
3.0	13.6	8.82	84.8
4.0	13.5	8.85	85.0
5.0	13.5	8.83	84.7
6.0	13.5	8.81	84.6
7.0	12.8	8.31	78.6
8.0	12.3	7.89	73.7
9.0	10.2	6.35	56.2
10.0	8.1	5.67	47.8
11.0	7.5	5.25	43.5

Station: Doris Lake South — **Date:** 19-Sep-11

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.0	5.0	11.04	86.5
0.5	5.0	11.02	86.3
1.0	5.0	11.01	86.3
1.5	5.0	10.98	86.2
2.0	5.0	10.99	86.0
2.5	5.0	10.98	86.0

Station: Doris Lake North — **Date:** 24-Apr-11

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
2.0	0.6	11.32	78.7
2.5	0.6	11.26	78.3
3.0	0.6	11.24	78.2
3.5	0.6	11.23	78.1
4.0	0.6	11.23	78.2
4.5	0.6	11.20	77.8
5.0	0.6	11.16	77.6
5.5	0.6	11.10	77.3
6.0	0.6	11.08	77.1
6.5	0.7	11.06	77.2
7.0	0.7	11.07	77.2
7.5	0.7	10.96	76.4
8.0	0.7	10.42	73.0
8.5	0.7	9.86	68.7
9.0	0.7	9.61	67.0
9.5	0.8	9.13	64.0
10.0	0.9	8.42	59.0
10.5	0.9	7.98	56.0
11.0	1.0	7.37	51.8
11.5	1.0	6.56	46.3
12.0	1.1	5.72	40.4
12.5	1.2	5.47	38.7

Station: Doris Lake North — **Date:** 20-Jul-11

Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.5	12.8	9.10	86.0
1.0	12.8	9.11	86.0
1.5	12.8	9.10	85.9
2.0	12.8	9.09	85.9
2.5	12.7	9.10	85.8
3.0	12.7	9.07	85.5
3.5	12.7	9.06	85.4
4.0	12.6	9.07	85.3
4.5	12.4	9.12	85.3
5.0	12.2	9.09	84.7
5.5	12.0	9.07	84.2
6.0	11.8	9.10	83.9
6.5	11.3	9.09	83.0
7.0	10.7	9.11	81.7
7.5	10.0	9.05	80.2
8.0	9.6	9.10	79.8
8.5	8.6	8.92	76.3
9.0	7.5	8.95	74.7
9.5	7.0	8.88	73.2
10.0	6.7	8.84	72.4
10.5	6.5	8.83	71.6
11.0	6.2	8.57	69.4
11.5	6.0	8.49	68.3

Annex A.2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2010

Station	Doris Lake North			
Date	15-Aug-11			
Parameter	Depth (m)	Temperature (˚C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0.0	13.6	8.94	86.0
	1.0	13.7	8.92	86.0
	2.0	13.7	8.91	85.9
	3.0	13.7	8.92	85.9
	4.0	13.7	8.90	85.9
	5.0	13.7	8.91	85.9
	6.0	13.7	8.90	85.8
	7.0	13.7	8.89	85.7
	8.0	13.7	8.88	85.6
	9.0	13.7	8.83	85.0
	10.0	10.3	5.44	48.0
	11.0	6.9	3.90	31.6

Station	Doris Lake North			
Date	19-Sep-11			
Parameter	Depth (m)	Temperature (˚C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0.0	6.2	10.66	86.1
	0.5	6.3	10.63	86.1
	1.0	6.3	10.63	86.0
	1.5	6.3	10.62	86.0
	2.0	6.3	10.61	85.9
	2.5	6.3	10.61	85.9
	3.0	6.3	10.61	85.9
	3.5	6.3	10.61	85.9
	4.0	6.3	10.61	85.8
	4.5	6.3	10.61	85.8
	5.0	6.3	10.60	85.8
	5.5	6.3	10.60	85.8
	6.0	6.3	10.60	85.8
	6.5	6.3	10.60	85.8
	7.0	6.3	10.60	85.7
	7.5	6.3	10.60	85.7
	8.0	6.3	10.60	85.8
	8.5	6.3	10.60	85.8
	9.0	6.3	10.60	85.8

Station	Little Roberts Lake			
Date	21-Apr-11			
Parameter	Depth (m)	Temperature (˚C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	2.0	-0.1	5.70	38.6

Station	Little Roberts Lake			
Date	20-Jul-11			
Parameter	Depth (m)	Temperature (˚C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0.5	13.2	8.62	82.2
	1.0	13.2	8.61	82.1
	1.5	13.2	8.62	81.9
	2.0	13.1	8.61	82.0
	2.5	13.0	8.49	80.7
	3.0	13.0	8.23	80.6
	3.5	13.0	7.90	75.5
	4.0	13.0	7.61	72.8

Station	Little Roberts Lake			
Date	28-Aug-11			
Parameter	Depth (m)	Temperature (˚C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0.0	10.8	9.45	85.3
	0.5	10.8	9.47	85.4
	1.0	10.8	9.47	85.5
	1.5	10.8	9.47	85.5
	2.0	10.8	9.30	83.8
	2.5	10.8	9.10	80.7
	3.0	10.8	8.45	76.1

Station	Little Roberts Lake			
Date	24-Sep-11			
Parameter	Depth (m)	Temperature (˚C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0.0	5.2	10.77	84.8
	0.5	5.3	10.73	84.7
	1.0	5.3	10.73	84.7
	1.5	5.3	10.72	84.6
	2.0	5.3	10.72	84.6
	2.5	5.3	10.71	84.6

Annex A.2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2010

Station	Roberts Lake			
Date	24-Sep-11			
Parameter	Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0.0	6.2	10.51	84.6
	0.5	6.1	10.52	84.7
	1.0	6.0	10.55	84.7
	1.5	6.0	10.56	84.8

Station	Reference Lake B			
Date	22-Apr-11			
Parameter	Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	1.5	0.0	14.20	97.4
	2.0	0.3	13.76	95.0
	2.5	0.6	12.44	86.3
	3.0	0.9	10.96	77.2
	3.5	1.1	9.94	70.5
	4.0	1.4	8.86	63.0
	4.5	1.6	7.23	52.3
	5.0	1.7	6.16	44.2
	5.5	1.9	5.30	38.4
	6.0	1.9	4.75	34.6
	6.5	2.0	3.99	28.9
	7.0	2.2	3.27	23.9
	7.5	2.3	3.07	22.4
	8.0	2.4	2.98	21.8
	8.5	2.5	2.98	21.9
	9.0	2.7	1.45	10.7
	9.5	2.8	0.78	5.8

Station	Reference Lake B			
Date	18-Jul-11			
Parameter	Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0.0	13.2	9.51	89.2
	0.5	13.2	9.52	89.2
	1.0	13.1	9.51	89.1
	1.5	13.1	9.49	89.0
	2.0	12.9	9.48	88.8
	2.5	12.8	9.46	88.7
	3.0	12.8	9.46	88.7
	3.5	12.7	9.45	88.5
	4.0	12.5	9.44	88.1
	4.5	12.2	9.42	87.9
	5.0	12.0	9.41	87.6
	5.5	11.9	9.41	87.2
	6.0	11.8	9.39	86.5
	6.5	11.7	9.37	86.3
	7.0	11.3	9.36	85.6
	7.5	10.8	9.34	84.9
	8.0	10.2	9.33	83.7
	8.5	9.6	9.31	82.5
	9.0	9.1	9.30	81.8

Station	Reference Lake B			
Date	20-Aug-11			
Parameter	Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0.0	11.8	9.08	83.8
	1.0	11.8	9.07	83.8
	2.0	11.8	9.07	83.7
	3.0	11.8	9.06	83.7
	4.0	11.8	9.06	83.7
	5.0	11.8	9.06	83.7
	6.0	11.8	9.06	83.7
	7.0	11.8	9.06	83.7
	8.0	11.7	9.07	83.6
	9.0	11.7	9.08	83.6
	10.0	11.7	8.25	75.8

Station	Reference Lake B			
Date	18-Sep-11			
Parameter	Depth (m)	Temperature (°C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0.0	4.8	10.65	82.9
	0.5	4.8	10.64	82.9
	1.0	4.8	10.66	83.0
	1.5	4.8	10.66	83.1
	2.0	4.8	10.66	83.0
	2.5	4.8	10.66	83.1
	3.0	4.8	10.66	83.1
	3.5	4.7	10.69	83.0
	4.0	4.7	10.68	83.0
	4.5	4.6	10.71	83.0
	5.0	4.6	10.72	83.0
	5.5	4.6	10.72	83.0
	6.0	4.6	10.69	83.1
	6.5	4.6	10.78	83.5
	7.0	4.6	10.78	83.5
	7.5	4.6	10.77	83.5
	8.0	4.5	10.80	83.5
	8.5	4.5	10.79	83.4
	9.0	4.5	10.79	83.4
	9.5	4.5	10.79	83.4
	10.0	4.5	10.79	83.4

Annex A.2-1. Temperature and Dissolved Oxygen Profiles for AEMP Lakes, Doris North Project, 2010

Station	Reference Lake D			
Date	22-Apr-11			
Parameter	Depth (m)	Temperature (˚C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	2.0	0.1	2.40	16.5

Station	Reference Lake D			
Date	20-Jul-11			
Parameter	Depth (m)	Temperature (˚C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0.5	14.1	8.86	86.0
	1.0	14.0	8.84	85.8
	1.5	14.0	8.84	85.8
	2.0	14.0	8.83	85.6
	2.5	13.9	8.86	85.8
	3.0	13.9	9.15	88.5

Station	Reference Lake D			
Date	16-Aug-11			
Parameter	Depth (m)	Temperature (˚C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0.0	11.9	9.37	86.7
	0.5	11.9	9.36	86.7
	1.0	11.9	9.34	86.7
	1.5	12.0	9.36	86.8
	2.0	12.0	9.37	86.9
	2.5	12.1	9.35	86.8
	3.0	12.1	9.33	86.8
	3.5	12.1	9.32	86.7

Station	Reference Lake D			
Date	26-Sep-11			
Parameter	Depth (m)	Temperature (˚C)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	0.0	4.1	11.00	84.1
	0.5	4.0	11.01	84.0
	1.0	4.0	11.04	84.2
	1.5	4.0	11.04	84.3
	2.0	4.0	11.05	84.3
	2.5	4.0	11.05	84.3
	3.0	4.0	11.05	84.3

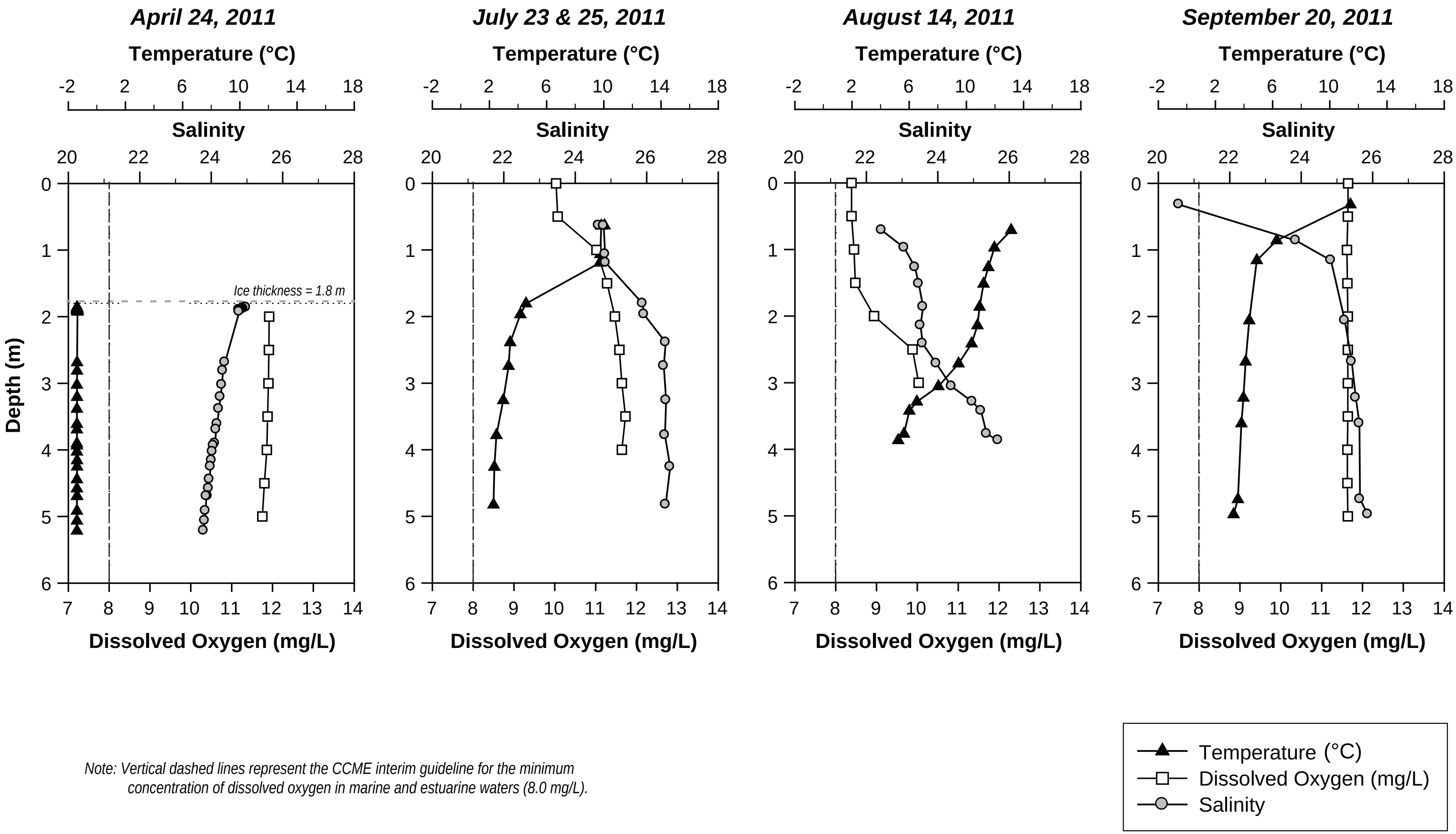
A.2.3 Marine Data

Marine Secchi depths and calculated euphotic zone depths (1% light level) are shown in Table A.2-3. Figures A.2-7 to A.2-9 show the temperature, dissolved oxygen, and salinity profiles collected at marine sites between April and September 2011, and Annexes A.2-2 and A.2-3 provide the raw physical profile data.

Table A.2-3. Marine Secchi Depths and Euphotic Zone Depths, Doris North Project, 2011

Marine Site	Sampling Date	Secchi Depth (D_s) (m)	Euphotic Zone Depth 1% Light Level (m)
RBW	July 23	Bottom (4.3)	-
	August 14	Bottom (3.7)	-
	September 20	Bottom (4.9)	-
RBE	July 22	Bottom (0.5)	-
	August 14	Bottom (1.2)	-
	September 20	Bottom (0.3)	
REF-Marine 1	July 22	7.2	19.5*
	August 19	Bottom (4.7)	-
	September 25	6.1	16.5*

*Note: * indicates that the euphotic zone extended to the bottom of the water column.*



Note: Vertical dashed lines represent the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L).

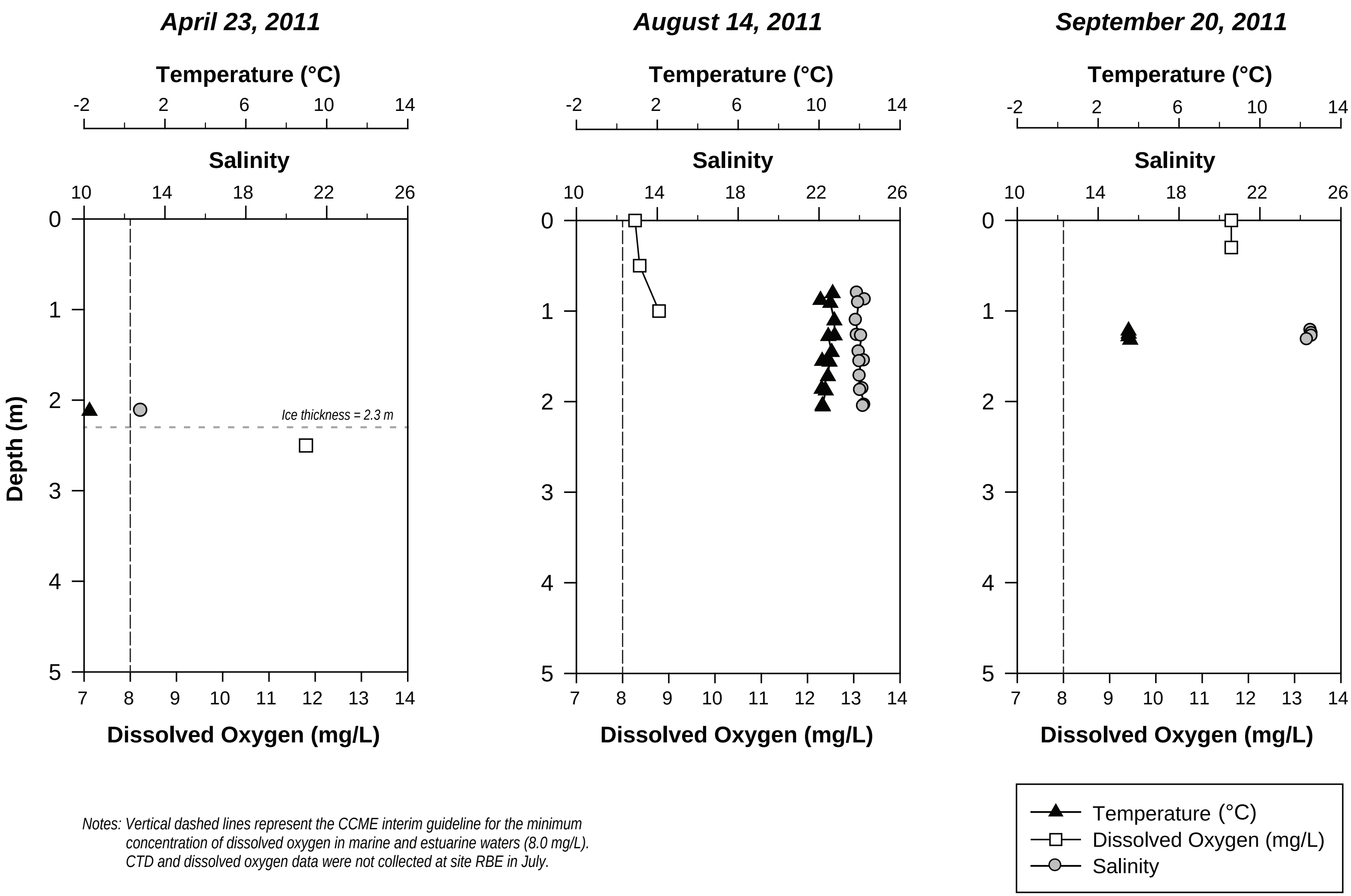
Figure A.2-7

NEWMONT NORTH AMERICA

Temperature, Salinity, and Dissolved Oxygen Profiles at Marine Site RBW, Doris North Project, 2011

Figure A.2-7

Rescan Engineers & Scientists



Notes: Vertical dashed lines represent the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L). CTD and dissolved oxygen data were not collected at site RBE in July.

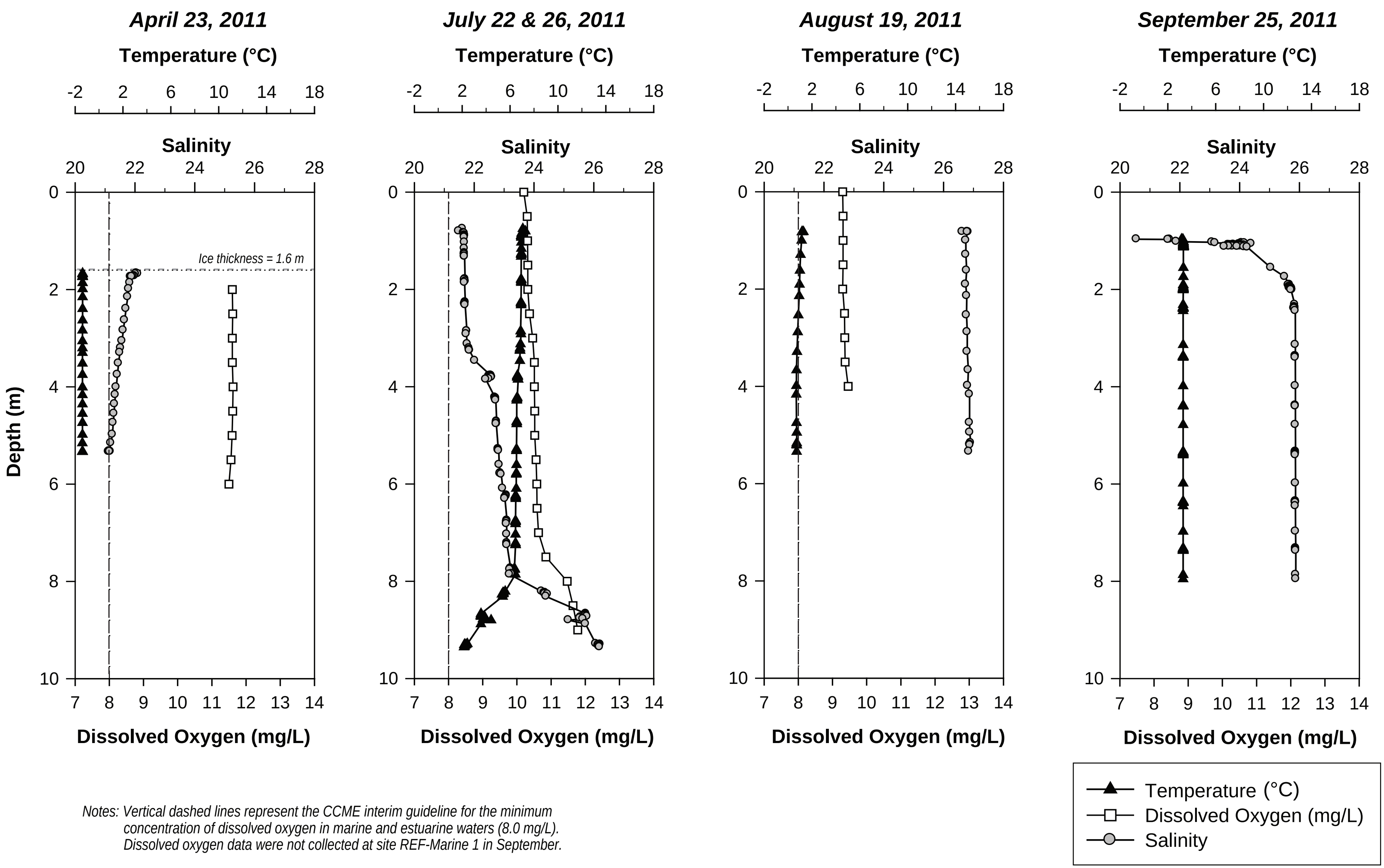
Figure A.2-8

NEWMONT NORTH AMERICA

Temperature, Salinity, and Dissolved Oxygen Profiles at Marine Site RBE, Doris North Project, 2011

Figure A.2-8

Rescan Engineers & Scientists



Notes: Vertical dashed lines represent the CCME interim guideline for the minimum concentration of dissolved oxygen in marine and estuarine waters (8.0 mg/L). Dissolved oxygen data were not collected at site REF-Marine 1 in September.

Figure A.2-9

NEWMONT NORTH AMERICA

Temperature, Salinity, and Dissolved Oxygen Profiles at Marine Site REF-Marine 1, Doris North Project, 2011

Figure A.2-9

Rescan Engineers & Scientists

Annex A.2-2. Temperature and Salinity Profiles for AEMP Marine Sites, Doris North Project, 2010

Station	RBW		
Date	24-Apr-11		
Parameter	Depth (m)	Temperature (°C)	Salinity
	1.86	-1.38	24.94
	1.87	-1.39	24.97
	1.88	-1.38	24.90
	1.89	-1.38	24.88
	1.89	-1.38	24.86
	1.90	-1.38	24.78
	1.90	-1.37	24.84
	1.91	-1.37	24.82
	1.91	-1.36	24.80
	1.93	-1.35	24.79
	2.69	-1.39	24.38
	2.81	-1.39	24.33
	3.03	-1.39	24.30
	3.21	-1.39	24.26
	3.39	-1.39	24.22
	3.61	-1.39	24.17
	3.70	-1.39	24.14
	3.90	-1.39	24.10
	3.94	-1.39	24.07
	4.03	-1.39	24.04
	4.16	-1.39	24.01
	4.25	-1.39	23.98
	4.44	-1.39	23.95
	4.58	-1.39	23.93
	4.69	-1.39	23.90
	4.70	-1.39	23.87
	4.92	-1.39	23.84
	5.07	-1.39	23.82
	5.22	-1.39	23.79

RBW		
25-Jul-11		
Depth (m)	Temperature (°C)	Salinity
0.64	10.05	24.65
0.64	9.81	24.80
1.07	9.75	24.84
1.19	9.72	24.85
1.81	4.55	25.88
1.97	4.16	25.93
2.39	3.45	26.53
2.75	3.33	26.48
3.26	2.97	26.54
3.78	2.48	26.51
4.26	2.34	26.66
4.83	2.28	26.53

RBW		
14-Aug-11		
Depth (m)	Temperature (°C)	Salinity
0.71	13.13	22.43
0.97	11.96	23.06
1.27	11.54	23.36
1.52	11.20	23.47
1.86	10.93	23.59
2.14	10.77	23.52
2.41	10.36	23.58
2.71	9.45	23.96
3.06	8.04	24.39
3.29	6.54	24.97
3.42	6.01	25.21
3.77	5.64	25.37
3.86	5.23	25.69

RBW		
20-Sep-11		
Depth (m)	Temperature (°C)	Salinity
0.32	11.45	20.58
0.86	6.28	23.85
1.16	4.89	24.83
2.06	4.37	25.22
2.68	4.11	25.41
3.22	3.96	25.53
3.61	3.81	25.63
4.75	3.57	25.65
4.97	3.27	25.87

RBE		
23-Apr-11		
Depth (m)	Temperature (°C)	Salinity
2.12	-1.73	12.82

RBE		
14-Aug-11		
Depth (m)	Temperature (°C)	Salinity
0.80	10.67	23.90
0.88	10.07	24.28
0.91	10.56	23.96
1.11	10.76	23.84
1.27	10.77	23.89
1.28	10.45	24.11
1.45	10.62	23.98
1.55	10.15	24.24
1.56	10.52	24.02
1.72	10.44	24.03
1.86	10.13	24.17
1.88	10.33	24.05
2.04	10.17	24.25
2.05	10.19	24.20

RBE		
20-Sep-11		
Depth (m)	Temperature (°C)	Salinity
1.22	3.50	24.53
1.25	3.51	24.58
1.28	3.50	24.57
1.32	3.58	24.35

Annex A.2-2. Temperature and Salinity Profiles for AEMP Marine Sites, Doris North Project, 2010

Station	REF-Marine 1		
Date	23-Apr-11		
Parameter	Depth (m)	Temperature (˚C)	Salinity
	1.67	-1.37	22.05
	1.68	-1.38	22.10
	1.68	-1.37	22.02
	1.72	-1.37	21.98
	1.73	-1.37	21.93
	1.74	-1.37	21.85
	1.74	-1.37	21.90
	1.86	-1.38	21.83
	1.99	-1.37	21.79
	2.15	-1.38	21.76
	2.40	-1.38	21.71
	2.63	-1.38	21.65
	2.84	-1.38	21.61
	3.06	-1.38	21.57
	3.20	-1.39	21.53
	3.30	-1.38	21.50
	3.52	-1.39	21.45
	3.75	-1.39	21.42
	4.01	-1.39	21.38
	4.17	-1.39	21.35
	4.36	-1.39	21.32
	4.55	-1.39	21.30
	4.74	-1.38	21.27
	4.98	-1.39	21.25
	5.16	-1.39	21.20
	5.32	-1.38	21.14
	5.33	-1.39	21.18
	5.33	-1.38	21.12
	5.33	-1.39	21.16

Station	REF-Marine 1		
Date	22-Jul-11		
Parameter	Depth (m)	Temperature (˚C)	Salinity
	0.75	7.06	21.61
	0.80	7.28	21.48
	0.85	6.97	21.68
	0.90	6.95	21.69
	1.03	6.94	21.68
	1.16	6.95	21.68
	1.32	6.93	21.68
	1.86	6.93	21.68
	2.26	6.92	21.70
	2.32	6.92	21.70
	2.86	6.88	21.76
	3.12	6.88	21.77
	3.26	6.83	21.86
	3.47	6.82	22.02
	3.85	6.68	22.39
	4.23	6.57	22.72
	4.77	6.56	22.74
	5.32	6.54	22.82
	5.80	6.52	22.91
	6.09	6.51	22.96
	6.23	6.47	23.08
	6.30	6.47	23.03
	6.76	6.45	23.10
	7.25	6.45	23.10
	7.76	6.39	23.19
	7.86	6.45	23.18
	8.21	5.59	24.26
	8.31	5.38	24.41
	8.67	3.58	25.73
	8.72	3.63	25.70
	8.88	3.56	25.72
	9.29	2.43	26.07
	9.32	2.23	26.15
	9.35	2.15	26.19

Station	REF-Marine 1		
Date	19-Aug-11		
Parameter	Depth (m)	Temperature (˚C)	Salinity
	0.82	1.18	26.79
	0.82	1.29	26.62
	0.83	1.16	26.82
	0.83	1.18	26.80
	1.00	1.13	26.74
	1.29	1.04	26.75
	1.62	0.99	26.77
	1.91	0.96	26.74
	2.14	0.93	26.78
	2.54	0.86	26.77
	2.88	0.81	26.79
	3.29	0.74	26.79
	3.67	0.71	26.83
	3.99	0.69	26.81
	4.17	0.69	26.87
	4.75	0.70	26.87
	4.95	0.73	26.88
	5.16	0.73	26.90
	5.20	0.71	26.88
	5.21	0.73	26.89
	5.34	0.72	26.84

Station	REF-Marine 1		
Date	25-Sep-11		
Parameter	Depth (m)	Temperature (˚C)	Salinity
	0.97	3.14	20.55
	0.97	3.25	21.66
	0.98	3.28	21.61
	1.02	3.30	21.88
	1.03	3.29	23.08
	1.05	3.30	23.18
	1.07	3.30	23.98
	1.09	3.30	23.67
	1.10	3.29	23.86
	1.11	3.32	24.02
	1.13	3.30	24.26
	1.55	3.29	25.04
	1.74	3.30	25.51
	1.90	3.29	25.67
	1.94	3.29	25.66
	1.99	3.28	25.72
	2.01	3.28	25.75
	2.31	3.28	25.85
	2.40	3.28	25.84
	2.44	3.28	25.86
	3.14	3.28	25.86
	3.37	3.28	25.86
	4.40	3.28	25.86
	4.78	3.28	25.87
	5.34	3.28	25.87
	5.38	3.28	25.87
	5.41	3.28	25.86
	5.99	3.28	25.87
	6.39	3.28	25.87
	6.45	3.28	25.86
	6.98	3.28	25.87
	7.37	3.28	25.88
	7.87	3.28	25.88
	7.95	3.27	25.88

Annex A.2-3. Dissolved Oxygen Profiles for AEMP Marine Sites, Doris North Project, 2010

Station	RBW		
Date	24-Apr-11		
Parameter	Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
	2.0	11.92	77.8
	2.5	11.91	77.8
	3.0	11.90	77.7
	3.5	11.88	78.0
	4.0	11.86	77.5
	4.5	11.80	77.5
	5.0	11.75	77.6

RBW		
25-Jul-11		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.0	10.03	89.3
0.5	10.07	89.4
1.0	11.02	86.8
1.5	11.28	86.5
2.0	11.47	87.0
2.5	11.58	87.0
3.0	11.64	85.8
3.5	11.73	85.7
4.0	11.64	84.5

RBW		
14-Aug-11		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.0	8.39	89.4
0.5	8.39	89.2
1.0	8.45	89.7
1.5	8.48	89.6
2.0	8.94	90.3
2.5	9.88	94.0
3.0	10.03	94.1

RBW		
20-Sep-11		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.0	11.65	86.9
0.5	11.64	86.6
1.0	11.62	86.2
1.5	11.63	85.9
2.0	11.64	86.0
2.5	11.64	86.0
3.0	11.64	86.0
3.5	11.64	85.9
4.0	11.63	85.9
4.5	11.63	85.9
5.0	11.64	85.8

RBE		
23-Apr-11		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
2.0	11.80	77.3

RBE		
14-Aug-11		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.0	8.27	88.1
0.5	8.37	88.3
1.0	8.79	92.0

RBE		
20-Sep-11		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.0	11.63	86.0
0.3	11.63	86.0

REF-Marine		
23-Apr-11		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
2.0	11.60	75.8
2.5	11.61	75.8
3.0	11.60	75.5
3.5	11.60	75.5
4.0	11.62	75.9
4.5	11.61	75.8
5.0	11.59	76.0
5.5	11.56	75.6
6.0	11.50	75.2

REF-Marine		
26-Jul-11		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.0	10.20	84.1
0.5	10.30	84.8
1.0	10.31	84.9
1.5	10.32	85.0
2.0	10.32	85.0
2.5	10.37	85.1
3.0	10.46	85.5
3.5	10.51	85.7
4.0	10.51	85.7
4.5	10.52	85.8
5.0	10.52	85.8
5.5	10.56	85.9
6.0	10.58	86.0
6.5	10.59	86.2
7.0	10.63	86.1
7.5	10.85	86.1
8.0	11.47	86.7
8.5	11.64	85.1
9.0	11.78	84.2

REF-Marine		
19-Aug-11		
Depth (m)	Dissolved Oxygen (mg/L)	Oxygen Saturation (%)
0.0	9.30	80.4
0.5	9.31	78.5
1.0	9.31	78.0
1.5	9.31	77.5
2.0	9.30	77.4
2.5	9.35	77.6
3.0	9.36	77.7
3.5	9.37	77.8
4.0	9.46	78.6

A.3 2011 WATER QUALITY

The following sections present the water quality data collected between April and September 2011 from stream, lake, and marine sites, as well as the blank QA/QC water quality data. Only the parameters that were subjected to an evaluation of effects (see main body of AEMP report) are shown graphically. All water quality parameters were screened against CCME water quality guidelines for the protection of aquatic life (CCME 2011b). CCME guidelines are included in all graphs, tables, and annexes.

A.3.1 Stream Data

Stream water quality data were collected monthly from June to September 2011. Figures A.3-1 to A.3-9 show monthly trends of select water quality parameters. Table A.3-1 presents the percentage of stream water quality samples in which parameter concentrations were higher than CCME guidelines, and Table A.3-2 provides the factor by which average 2011 concentrations were higher than CCME guidelines. Annex A.3-1 presents the raw stream water quality data.

A.3.2 Lake Data

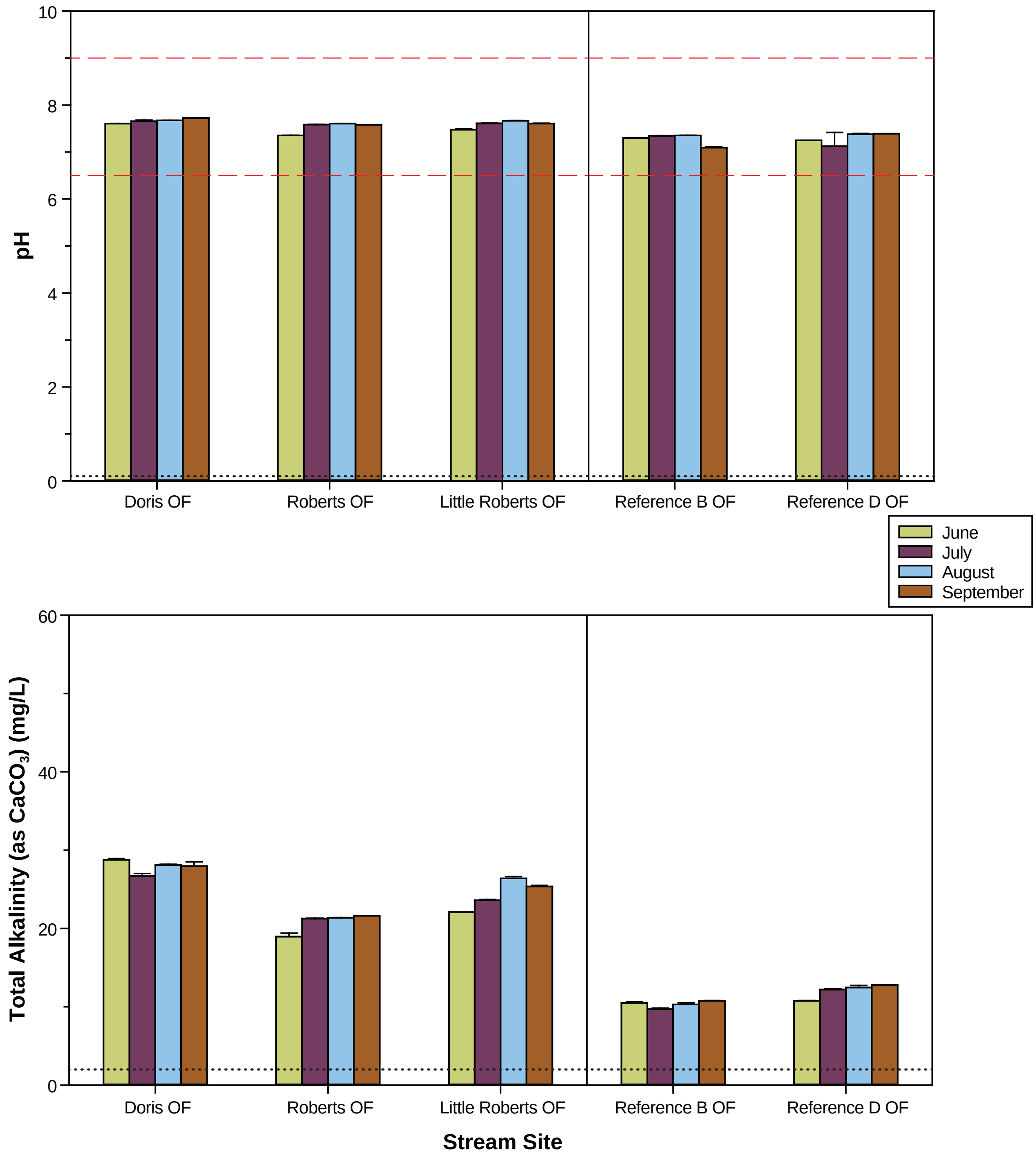
Lake water quality data were collected in April (under-ice sampling) and monthly from July to September 2011. Figures A.3-10 to A.3-18 show seasonal trends of select water quality parameters. Table A.3-3 presents the percentage of lake water quality samples in which parameter concentrations were higher than CCME guidelines, and Table A.3-4 provides the factor by which average 2011 concentrations were higher than CCME guidelines. Annex A.3-2 presents the raw lake water quality data.

A.3.3 Marine Data

Marine water quality data were collected in April (under-ice sampling) and monthly from July to September 2011. Figures A.3-19 to A.3-27 show seasonal trends of select water quality parameters. Annex A.3-3 presents the raw marine water quality data. Marine water quality data were screened against CCME guidelines for the protection of marine and estuarine aquatic life (CCME 2011b), and all measured parameters were below recommended CCME guidelines.

A.3.4 Quality Assurance/Quality Control (QA/QC) Data

Annex A.3-4 presents the results of the QA/QC blank data collected to identify possible sources of contamination to water quality samples. Several of the equipment blanks collected as part of the AEMP water quality sampling program contained contaminating levels of total ammonia, nitrate, total cyanide, total organic carbon, and various metals. This suggests that the GO-FLO bottles were not thoroughly rinsed with double de-ionized water at ALS laboratories or in the field prior to the collection of equipment blanks, and may have contained residual acid (ALS uses nitric or hydrochloric acid to clean GO-FLOs). However, there was no indication that these contaminants were introduced into water quality samples. Prior to the collection of lake and marine water quality samples, GO-FLO bottles are thoroughly flushed and rinsed with site-specific water. Results of the water quality surveys did not show any obvious signs of contamination introduced by the GO-FLO. The elevated total cyanide concentrations found in some lake samples (collected using a GO-FLO) were similar to concentrations found in stream samples (which are not collected using a GO-FLO), suggesting that the elevated concentrations in lake samples did not result from contamination introduced by the GO-FLO.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits.
Red dashed lines represent the CCME freshwater guideline pH range (6.5–9.0).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

NEWMONT NORTH AMERICA

pH and Total Alkalinity in Stream Sites, Doris North Project, 2011

Figure A.3-1

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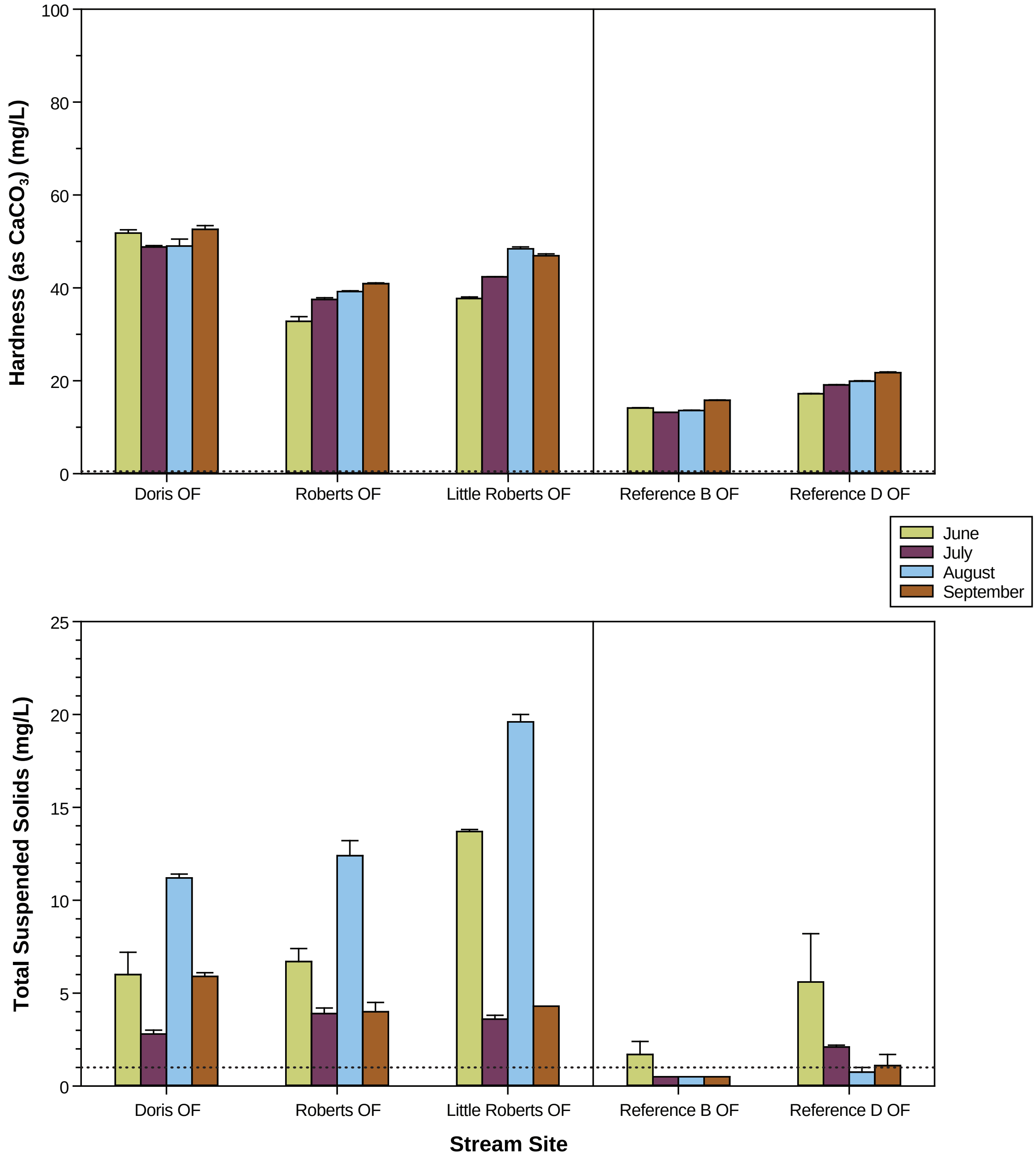


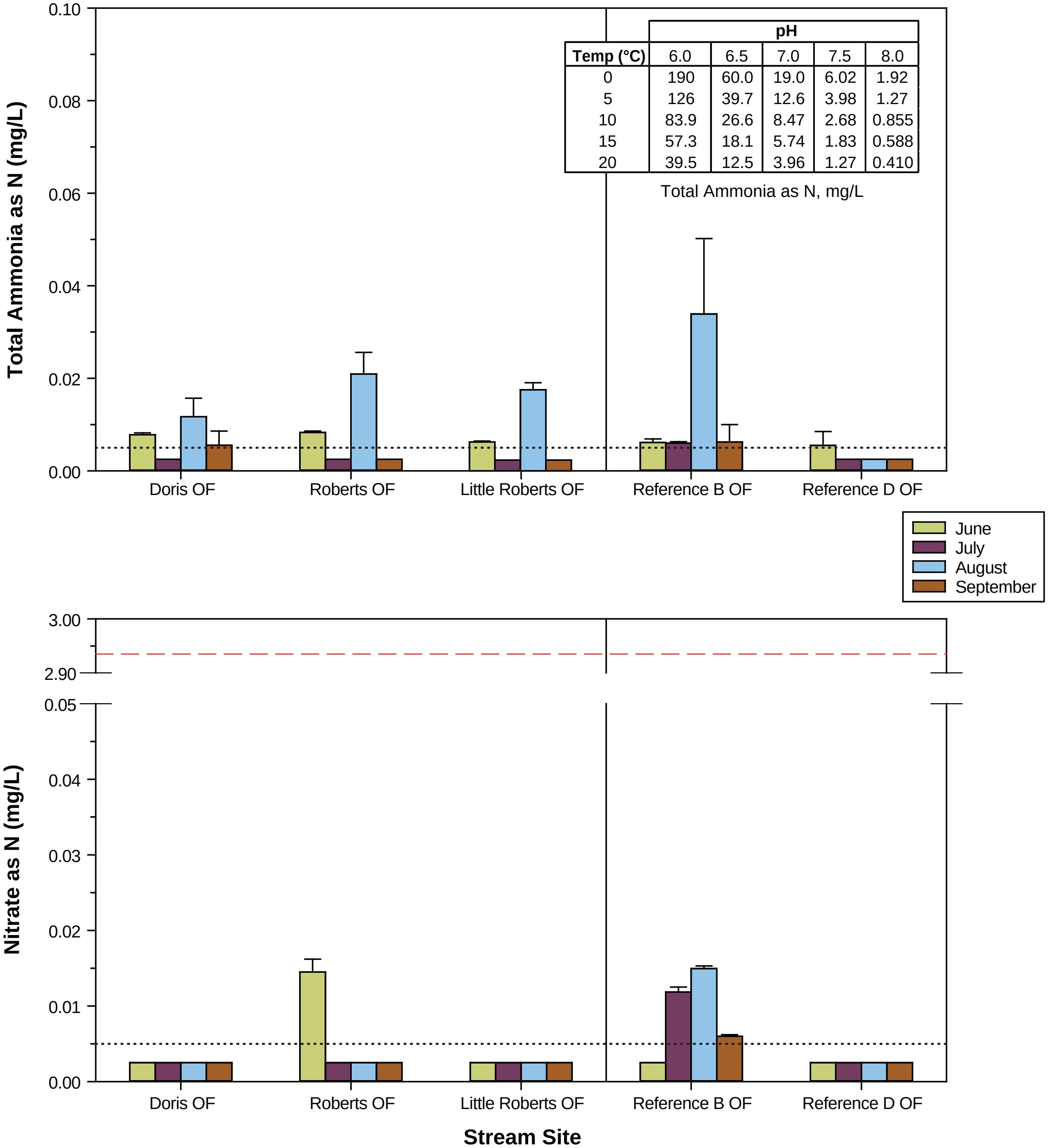
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guideline for total suspended solids is dependent upon background levels.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.
Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Hardness and Total Suspended Solids in Stream Sites, Doris North Project, 2011

Figure A.3-2

Rescan Engineers & Scientists



Temp (°C)	pH 6.0	6.5	7.0	7.5	8.0
0	190	60.0	19.0	6.02	1.92
5	126	39.7	12.6	3.98	1.27
10	83.9	26.6	8.47	2.68	0.855
15	57.3	18.1	5.74	1.83	0.588
20	39.5	12.5	3.96	1.27	0.410

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Inset table shows the pH- and temperature-dependent CCME freshwater guideline for total ammonia.
Red dashed line represents the interim CCME freshwater guideline for nitrate as N (2.935 mg/L).
Total ammonia and nitrate are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Ammonia and Nitrate Concentrations inStream Sites, Doris North Project, 2011

Figure A.3-3

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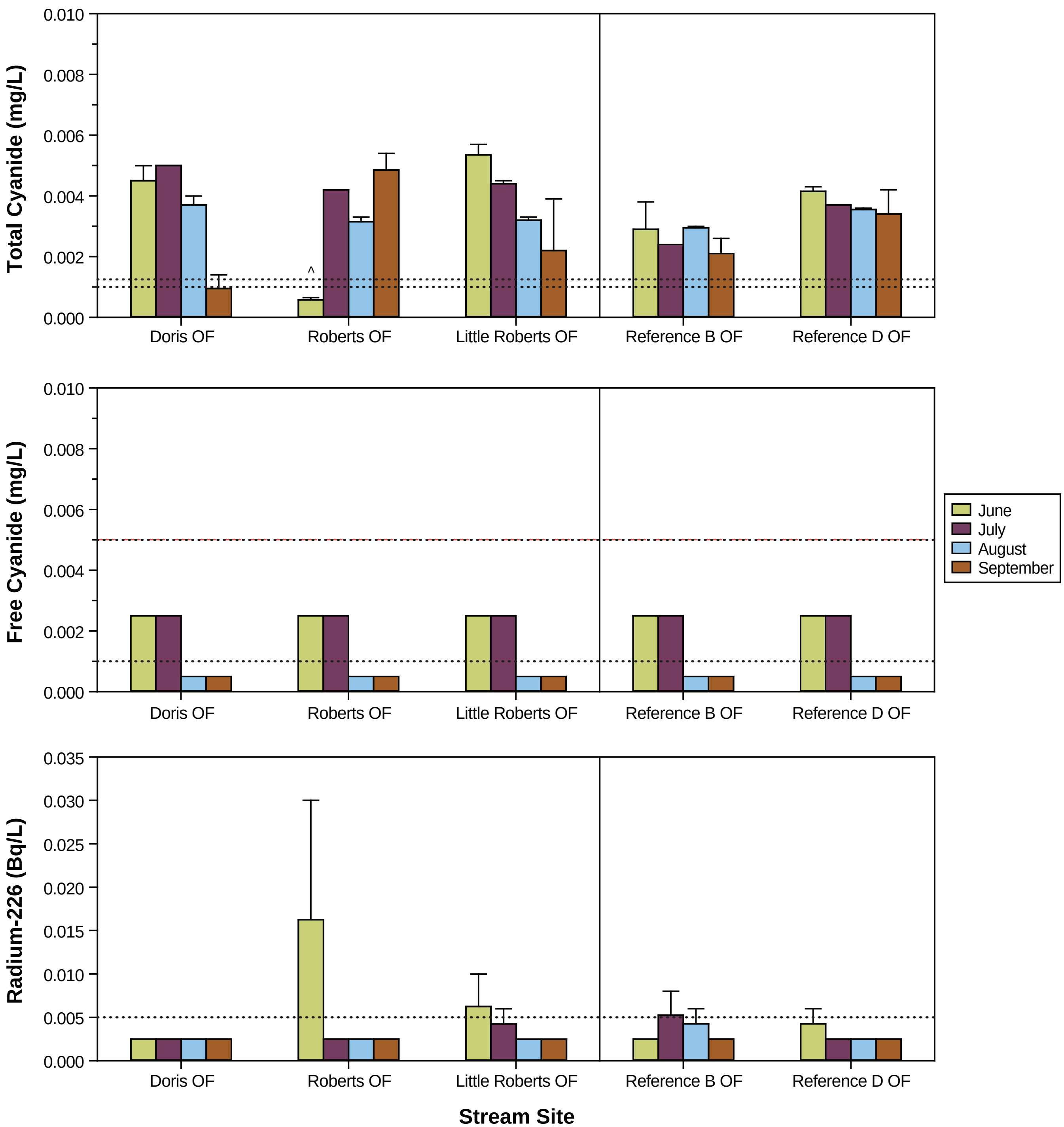
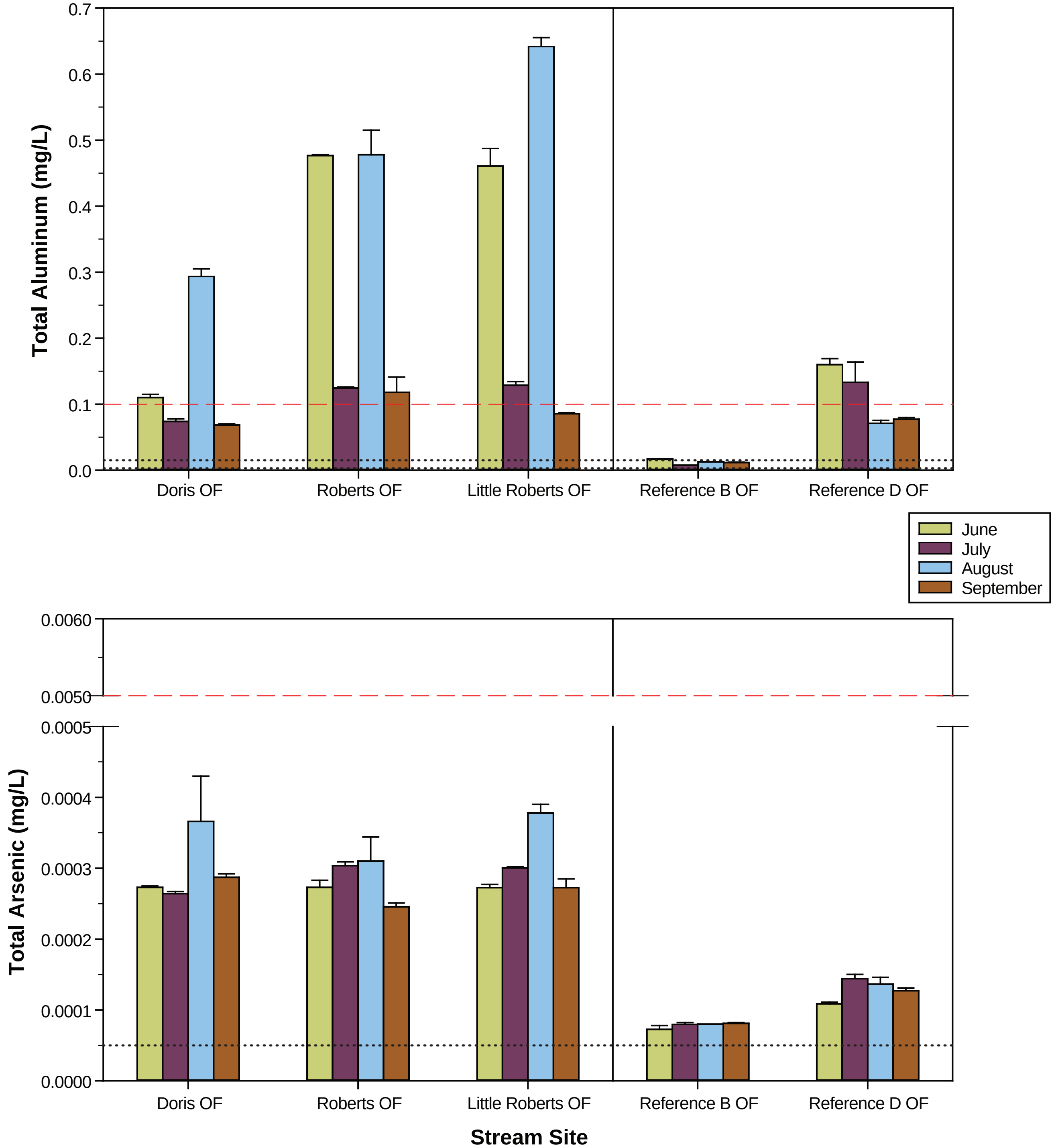


Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
^ Indicates that total cyanide concentrations in all samples were below the detection limit.
Free cyanide concentrations in stream samples were always below the detection limit.
Red dashed line represents the CCME freshwater guideline for free cyanide (0.005 mg/L).
Total cyanide and radium-226 are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

Figure A.3-4

Total Cyanide, Free Cyanide, and Radium-226 Concentrations in Stream Sites, Doris North Project, 2011



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the pH-dependent CCME freshwater guideline for aluminum (0.005 mg/L at pH < 6.5; 0.1 mg/L at pH ≥ 6.5) and the CCME freshwater guideline for arsenic (0.005 mg/L).
pH was greater than 6.5 in all stream samples.
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Aluminum and Total Arsenic Concentrations in Stream Sites, Doris North Project, 2011

Figure A.3-5

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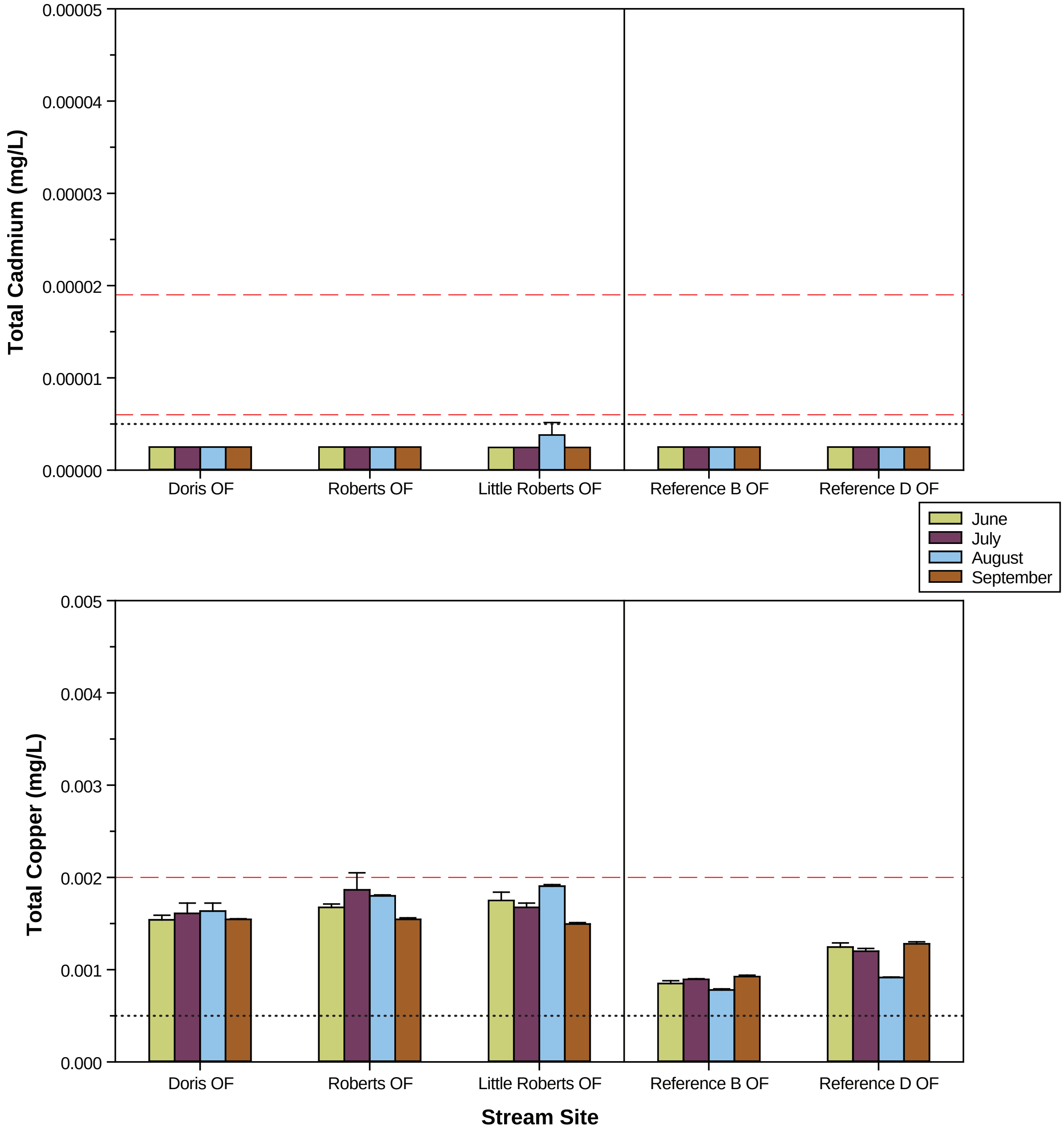

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guidelines for cadmium and copper are hardness dependent.
Red dashed lines represent the minimum and maximum site-specific CCME freshwater guidelines for cadmium (0.000006 and 0.000019 mg/L) and for copper (0.002 mg/L) based on the hardness (as $CaCO_3$) range in streams of 13.2 to 53.4 mg/L.
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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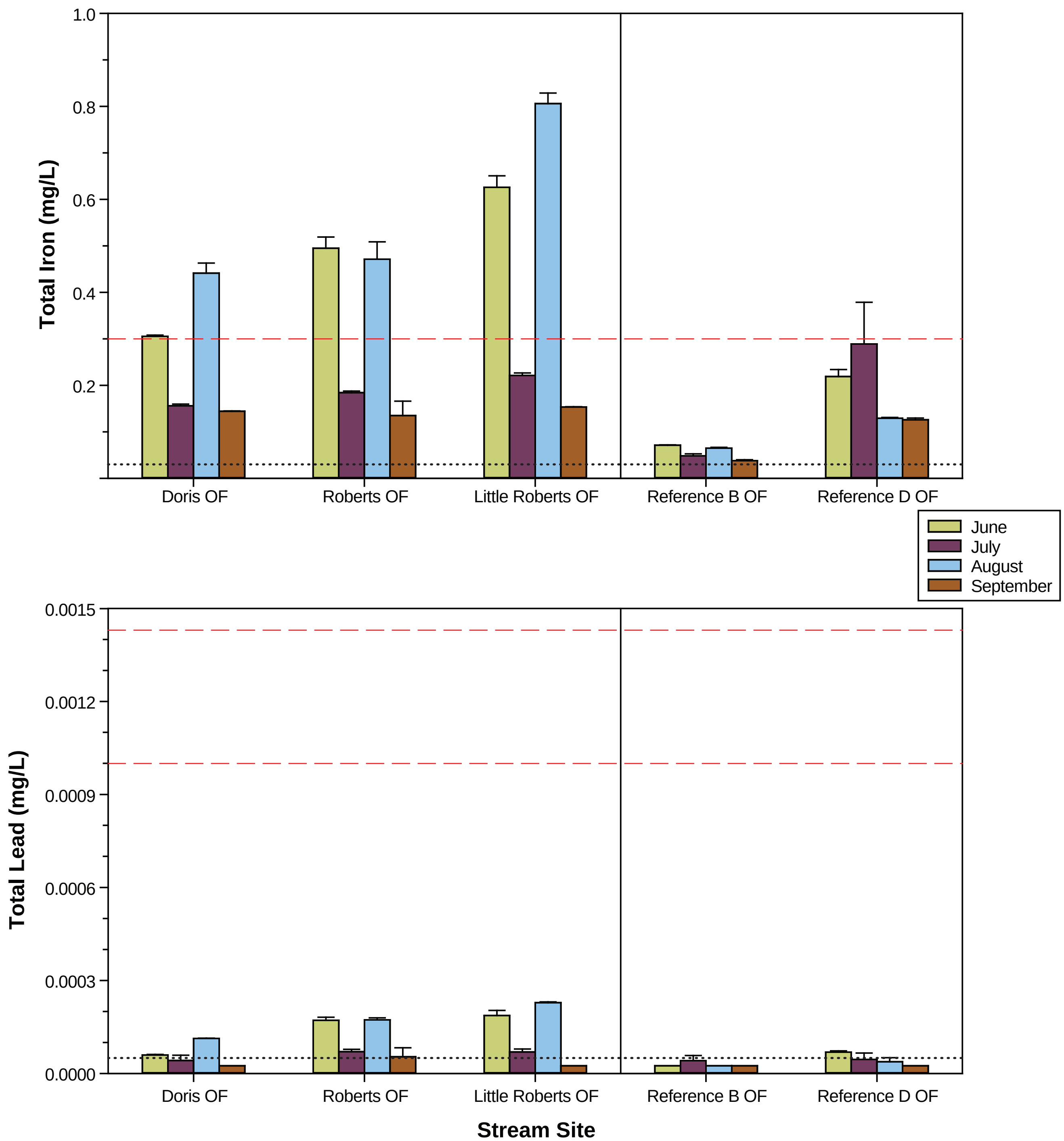
Total Cadmium and Total Copper Concentrations in Stream Sites, Doris North Project, 2011

Figure A.3-6

Rescan Engineers & Scientists



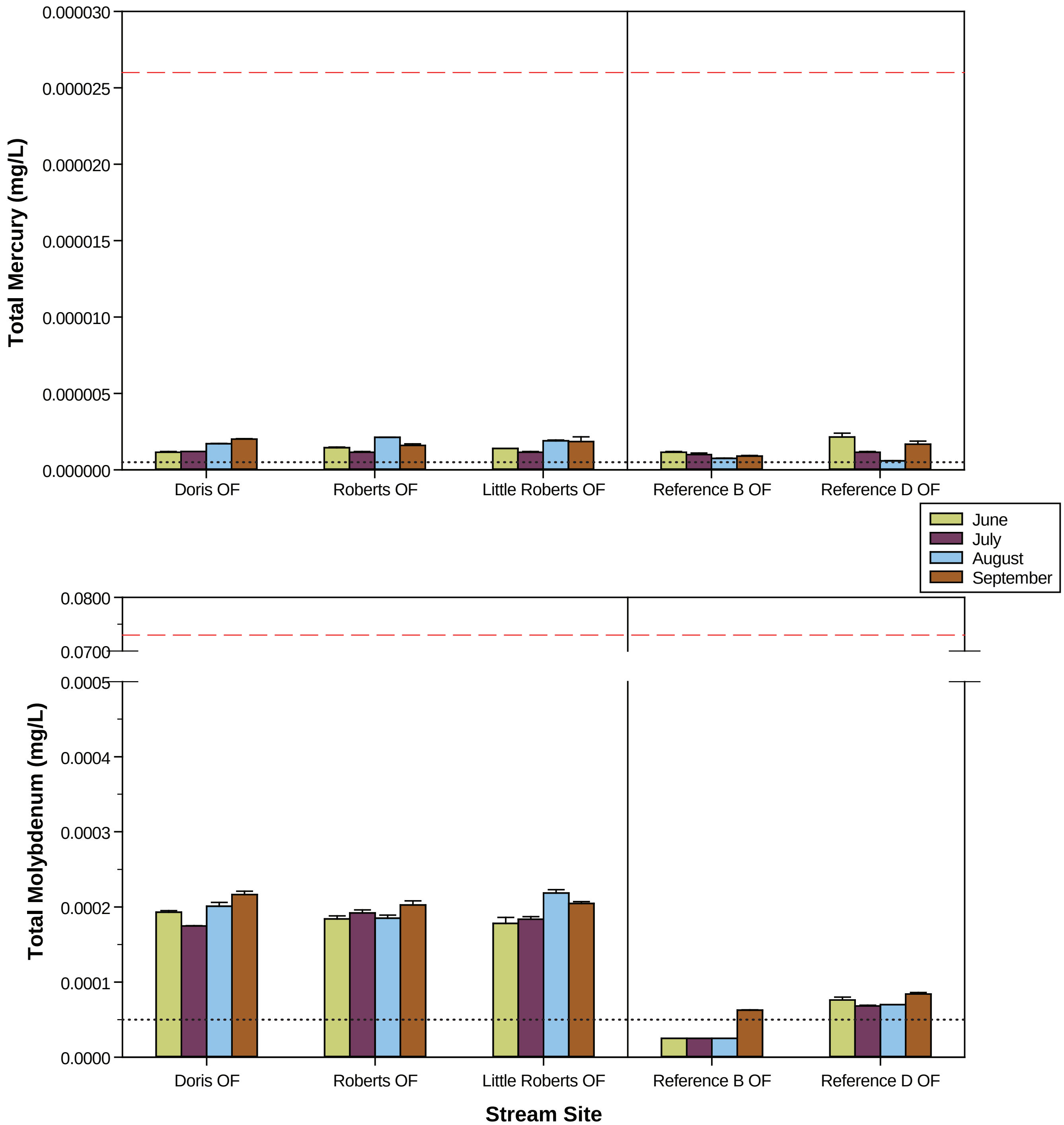
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guideline for lead is hardness dependent.
Red dashed lines represent the CCME freshwater guideline for iron (0.3 mg/L) and the minimum and maximum site-specific CCME freshwater guideline for lead (0.001 and 0.00143 mg/L) based on the hardness (as $CaCO_3$) range in streams of 13.2 to 53.4 mg/L.
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Iron and Total Lead Concentrations in Stream Sites, Doris North Project, 2011

Figure A.3-7

Rescan Engineers & Scientists



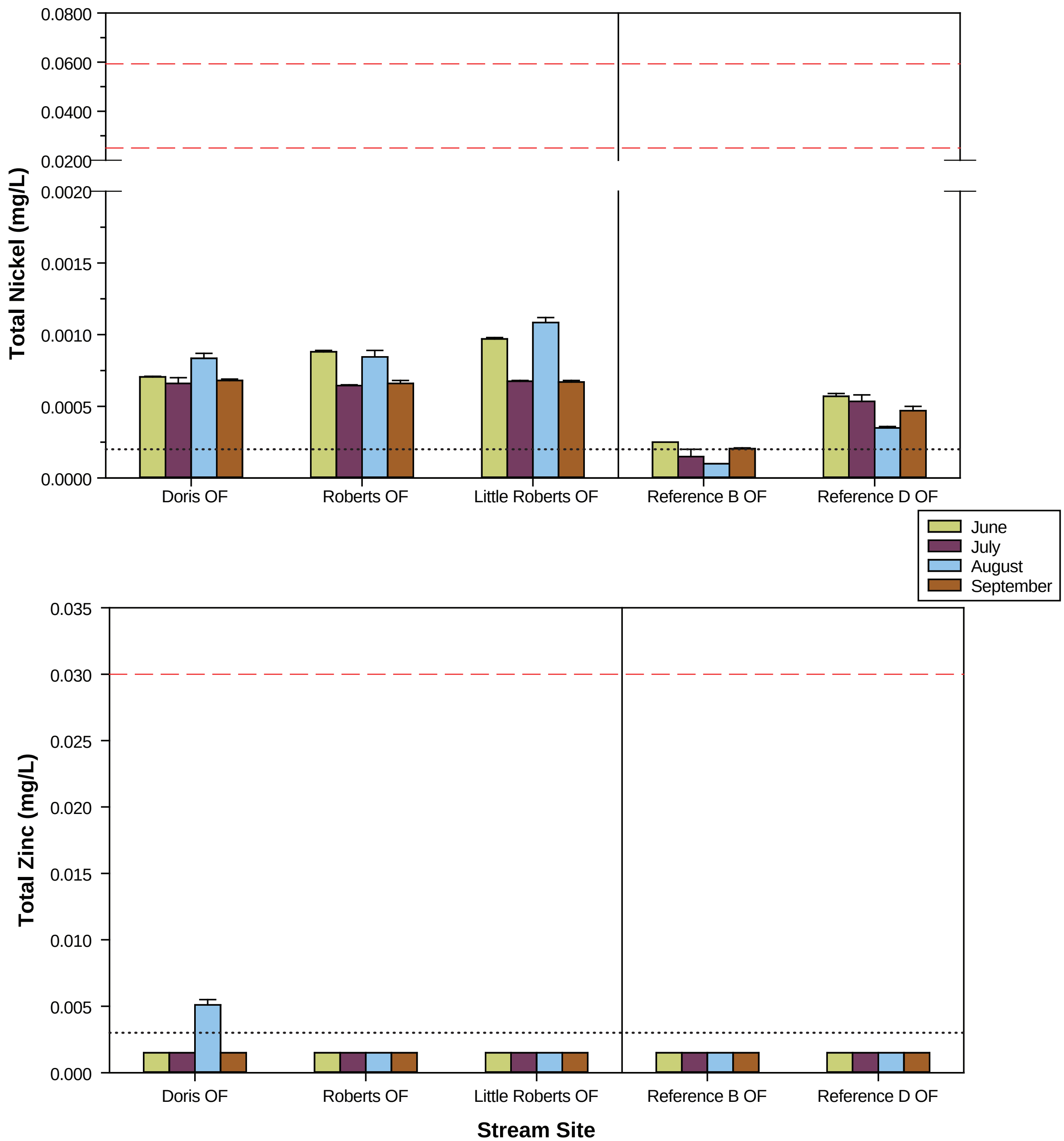
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the CCME freshwater guidelines for inorganic mercury (0.000026 mg/L) and molybdenum (0.073 mg/L).
Total mercury and total molybdenum are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

NEWMONT NORTH AMERICA

Total Mercury and Total Molybdenum Concentrations in Stream Sites, Doris North Project, 2011

Figure A.3-8

Rescan Engineers & Scientists



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME guideline for nickel is hardness dependent.
Red dashed lines represent the CCME freshwater guideline for zinc (0.03 mg/L) and the minimum and maximum site-specific CCME guideline for nickel (0.025 and 0.059mg/L) based on the hardness (as $CaCO_3$) range in streams of 13.2 to 53.4 mg/L.
Total nickel and total zinc are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Nickel and Total Zinc Concentrations in Stream Sites, Doris North Project, 2011

Figure A.3-9

Rescan Engineers & Scientists

Table A.3-1. Water Quality in Stream Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2011

Stream Site	Total Number of Samples Collected	CCME Guideline Value[a]:	pH	Chloride (Cl^-)	Fluoride (F^-)	Total Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Phosphorus	Free Cyanide	Aluminum (Al)-Total	Arsenic (As)-Total	Boron (B)-Total	Cadmium (Cd)-Total
			6.5-9.0	short-term: 640 mg/L long-term: 120 mg/L	Inorganic F: 0.12 mg/L[b]	pH- and temperature-dependent	2.935 mg/L[b]	0.06 mg/L	Trigger ranges from guidance framework[c]	0.005 mg/L	0.005 mg/L if pH<6.5; 0.1 mg/L if pH≥6.5	0.005 mg/L	short-term: 29 mg/L long-term: 1.5 mg/L	equation[b,d]
Doris Outflow	8		0	0	0	0	0	0	Mesotrophic to Eutrophic	0	50	0	0	0
Roberts Outflow	8		0	0	0	0	0	0	Mesotrophic to Meso-eutrophic	0	87.5	0	0	0
Little Roberts Outflow	8		0	0	0	0	0	0	Mesotrophic to Eutrophic	0	75	0	0	0
Reference B Outflow	8		0	0	0	0	0	0	Oligotrophic	0	0	0	0	0
Reference D Outflow	8		0	0	0	0	0	0	Oligotrophic to Mesotrophic	0	50	0	0	0

Stream Site	Total Number of Samples Collected	CCME Guideline Value[a]:	Chromium (Cr)-Total	Copper (Cu)-Total	Iron (Fe)-Total	Lead (Pb)-Total	Mercury (Hg)-Total	Molybdenum (Mo)-Total	Nickel (Ni)-Total	Selenium (Se)-Total	Silver (Ag)-Total	Thallium (Tl)-Total	Uranium (U)-Total	Zinc (Zn)-Total
			Cr(VI): 0.001 mg/L Cr(III): 0.0089 mg/L[b]	≥0.002 mg/L[e]	0.3 mg/L	≥0.001 mg/L[f]	Inorganic Hg: 0.000026 mg/L	0.073 mg/L[b]	≥0.025 mg/L[g]	0.001 mg/L	0.0001 mg/L	0.0008 mg/L	short-term: 0.033 mg/L long-term: 0.015 mg/L	0.03 mg/L
Doris Outflow	8		0	0	50	0	0	0	0	0	0	0	0	0
Roberts Outflow	8		0	12.5	50	0	0	0	0	0	0	0	0	0
Little Roberts Outflow	8		25[h]	0	50	0	0	0	0	0	0	0	0	0
Reference B Outflow	8		0	0	0	0	0	0	0	0	0	0	0	0
Reference D Outflow	8		0	0	12.5	0	0	0	0	0	0	0	0	0

Values represent the percentages of 2011 samples that are both above detection limits and higher than CCME guidelines.

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) Interim guideline.

c) Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotriphic; 0.004-0.01 = Oligotrophic; 0.01-0.02 = Mesotrophic; 0.02-0.035 = Meso-eutrophic; 0.035-0.1 = Eutrophic; >0.1 = Hyper-eutrophic.

d) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{\{0.86[\log(hardness)]-3.2\}}/1000$.

e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{\{0.8545[\ln(hardness)]-1.465\}} * 0.0002$. *Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(hardness)]-4.705\}}/1000$. *Lead guideline is a minumum of 0.001 mg/L regardless of hardness.*

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}}/1000$. *Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.*

h) In these instances, total chromium concentrations were higher than the CCME guideline for hexavalent chromium (Cr(VI)) of 0.001 mg/L.

Table A.3-2. Water Quality in Stream Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2011

Stream Site	Total Number of Samples Collected	CCME Guideline Value[a]:	pH	Chloride (Cl^-)	Fluoride (F^-)	Total Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Phosphorus	Free Cyanide	Aluminum (Al)-Total	Arsenic (As)-Total	Boron (B)-Total	Cadmium (Cd)-Total
			6.5-9.0	short-term: 640 mg/L long-term: 120 mg/L	Inorganic F: 0.12 mg/L[b]	pH- and temperature-dependent	2.935 mg/L[b]	0.06 mg/L	Trigger ranges from guidance framework[c]	0.005 mg/L	0.005 mg/L if pH<6.5; 0.1 mg/L if pH≥6.5	0.005 mg/L	short-term: 29 mg/L long-term: 1.5 mg/L	equation[b,d]
Doris Outflow	8		-	-	-	-	-	-	Mesotrophic to Eutrophic	-	1.36	-	-	-
Roberts Outflow	8		-	-	-	-	-	-	Mesotrophic to Meso-eutrophic	-	2.99	-	-	-
Little Roberts Outflow	8		-	-	-	-	-	-	Mesotrophic to Eutrophic	-	3.29	-	-	-
Reference B Outflow	8		-	-	-	-	-	-	Oligotrophic	-	-	-	-	-
Reference D Outflow	8		-	-	-	-	-	-	Oligotrophic to Mesotrophic	-	1.10	-	-	-

Stream Site	Total Number of Samples Collected	CCME Guideline Value[a]:	Chromium (Cr)-Total	Copper (Cu)-Total	Iron (Fe)-Total	Lead (Pb)-Total	Mercury (Hg)-Total	Molybdenum (Mo)-Total	Nickel (Ni)-Total	Selenium (Se)-Total	Silver (Ag)-Total	Thallium (Tl)-Total	Uranium (U)-Total	Zinc (Zn)-Total
			Cr(VI): 0.001 mg/L Cr(III): 0.0089 mg/L[b]	≥0.002 mg/L[e]	0.3 mg/L	≥0.001 mg/L[f]	Inorganic Hg: 0.000026 mg/L	0.073 mg/L[b]	≥0.025 mg/L[g]	0.001 mg/L	0.0001 mg/L	0.0008 mg/L	short-term: 0.033 mg/L long-term: 0.015 mg/L	0.03 mg/L
Doris Outflow	8		-	-	-	-	-	-	-	-	-	-	-	-
Roberts Outflow	8		-	-	1.07	-	-	-	-	-	-	-	-	-
Little Roberts Outflow	8		-	-	1.51	-	-	-	-	-	-	-	-	-
Reference B Outflow	8		-	-	-	-	-	-	-	-	-	-	-	-
Reference D Outflow	8		-	-	-	-	-	-	-	-	-	-	-	-

Values represent the factor by which average 2011 concentrations are higher than CCME guidelines; dashes represent average 2011 concentrations that are below CCME guidelines.

The average 2011 concentration of a particular parameter may be below the CCME guideline concentration even if a percentage of samples is higher than this guideline concentration.

Half the detection limit was substitued for values that were below the detection limit for the calculation of parameter averages.

For hardness-dependent guidelines, the average hardness over all sampling periods was used to determine the site-specific CCME guideline.

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) Interim guideline.

c) Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotriphic; 0.004-0.01 = Oligotrophic; 0.01-0.02 = Mesotrophic; 0.02-0.035 = Meso-eutrophic; 0.035-0.1 = Eutrophic; >0.1 = Hyper-eutrophic.

d) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{\{0.86[\log(hardness)]-3.2\}}/1000$.

e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{\{0.8545[\ln(hardness)]-1.465\}} * 0.0002$*. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(hardness)]-4.705\}}/1000$*. Lead guideline is a minumum of 0.001 mg/L regardless of hardness.*

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}}/1000$*. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.*

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2011

Site ID:	Units	CCME Guideline for the Protection of Aquatic Life[a]	Realized Detection Limit	Doris OF	Doris OF	Roberts OF	Roberts OF	Little Roberts OF	Little Roberts OF	Reference B OF	Reference B OF	Reference D OF	Reference D OF	Doris OF	Doris OF	Roberts OF	Roberts OF	Little Roberts OF	Little Roberts OF	Reference B OF	Reference B OF	Reference D OF	Reference D OF
Depth Zone:				Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Replicate:				1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Date Sampled:				26-Jun-11	26-Jun-11	26-Jun-11	26-Jun-11	26-Jun-11	26-Jun-11	26-Jun-11	26-Jun-11	26-Jun-11	26-Jun-11	23-Jul-11	23-Jul-11	23-Jul-11	23-Jul-11	23-Jul-11	23-Jul-11	23-Jul-11	23-Jul-11	23-Jul-11	23-Jul-11
ALS Sample ID:				L1024161-5	L1024161-6	L1024161-1	L1024161-2	L1024161-3	L1024161-4	L1024161-9	L1024161-10	L1024161-7	L1024161-8	L1035865-18	L1035865-19	L1035865-24	L1035865-25	L1035865-20	L1035865-21	L1035865-22	L1035865-23	L1035865-26	L1035865-27
Physical Tests																							
Conductivity	µS/cm		2.0	272	272	199	200	221	220	46.8	46.9	84.6	84.2	245	247	228	227	238	239	42.5	42.4	93.4	96.8
Hardness (as $CaCO_3$)	mg/L		0.50	52.5	51.1	31.8	33.8	37.5	38.1	14.1	14.2	17.3	17.1	48.5	49.1	37.1	37.9	42.5	42.4	13.2	13.2	19.2	19.0
pH	pH	6.5-9.0	0.10	7.60	7.61	7.36	7.35	7.47	7.50	7.31	7.29	7.25	7.25	7.63	7.68	7.58	7.59	7.63	7.61	7.35	7.34	7.42	6.83
Total Suspended Solids	mg/L	dependent on background levels	1.0	7.2	4.8	6.0	7.4	13.6	13.8	2.4	1.0	8.2	3.0	3.0	2.6	3.6	4.2	3.8	3.4	<1.0	<1.0	2.2	2.0
Turbidity	NTU	dependent on background levels	0.10	4.88	4.95	11.2	10.1	8.90	9.89	0.55	0.56	3.40	2.92	3.21	3.03	4.76	4.25	4.09	4.62	0.48	0.50	2.54	2.95
Anions and Nutrients																							
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	28.9	28.6	19.4	18.5	22.1	22.1	10.6	10.4	10.7	10.8	27.0	26.4	21.3	21.2	23.5	23.7	9.6	9.8	12.3	12.1
Ammonia (as N)	mg/L	pH- and temperature-dependent	0.0050	0.0074	0.0082	0.0080	0.0086	0.0062	0.0066	0.0054	0.0069	0.0085	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0057	0.0063	<0.0050	<0.0050
Bromide (Br^-)	mg/L		0.050 or 0.10	0.160	0.163	0.114	0.117	0.121	0.136	<0.050	<0.050	<0.050	<0.050	0.18	0.17	0.18	0.17	0.18	0.19	<0.10	<0.10	<0.10	<0.10
Chloride (Cl^-)	mg/L	short-term: 640; long-term: 120	0.50	65.4	65.5	46.6	47.8	53.0	52.8	6.50	6.47	18.0	17.9	57.8	57.9	54.6	54.5	56.5	56.7	5.92	5.92	19.5	19.5
Fluoride (F^-)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.056	0.055	0.045	0.046	0.048	0.046	<0.020	<0.020	0.036	0.034	0.054	0.054	0.048	0.047	0.050	0.051	0.020	0.021	0.036	0.037
Nitrate (as N)	mg/L	2.935[b]	0.0050	<0.0050	<0.0050	0.0128	0.0162	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0125	0.0112	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphorus	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0429	0.0238	0.0209	0.0213	0.0250	0.0278	0.0084	0.0055	0.0159	0.0096	0.0159	0.0176	0.0183	0.0191	0.0188	0.0176	0.0046	0.0042	0.0113	0.0099
Sulphate (SO_4^{2-})	mg/L		0.50	2.88	2.86	3.43	3.43	2.94	2.94	1.61	1.60	1.69	1.68	2.51	2.52	4.07	4.05	3.48	3.50	1.74	1.54	1.85	1.85
Cyanides																							
Total Cyanide	mg/L		0.0010 to 0.00125	0.0040	0.0050	<0.0010	<0.0013	0.0050	0.0057	0.0038	0.0020	0.0040	0.0043	0.0050	0.0050	0.0042	0.0042	0.0045	0.0043	0.0024	0.0024	0.0037	0.0037
Free Cyanide	mg/L	0.005	0.0010 or 0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Organic Carbon																							
Total Organic Carbon	mg/L		0.50	6.59	6.63	5.42	5.43	5.88	5.90	3.68	3.81	4.87	4.91	5.74	6.06	5.17	5.12	5.74	5.71	3.23	3.00	4.40	4.28
Total Metals																							
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030 or 0.015	**0.115**	**0.105**	**0.478**	**0.475**	**0.434**	**0.487**	0.0171	0.0165	**0.169**	**0.151**	0.0697	0.0779	**0.123**	**0.126**	**0.134**	**0.123**	<0.015	<0.015	**0.164**	**0.102**
Antimony (Sb)	mg/L		0.000010	0.000015	0.000015	0.000013	0.000014	0.000014	0.000016	<0.000010	<0.000010	<0.000010	<0.000010	0.000013	0.000014	0.000014	0.000014	0.000014	0.000014	<0.000010	<0.000010	<0.000010	<0.000010
Arsenic (As)	mg/L	0.005	0.000050	0.000271	0.000275	0.000263	0.000283	0.000277	0.000268	0.000078	0.000067	0.000111	0.000106	0.000267	0.000261	0.000298	0.000309	0.000299	0.000302	0.000082	0.000077	0.000150	0.000138
Barium (Ba)	mg/L		0.00010	0.00413	0.00387	0.00714	0.00697	0.00644	0.00679	0.00218	0.00210	0.00363	0.00312	0.00348	0.00369	0.00337	0.00342	0.00372	0.00377	0.00155	0.00163	0.00320	0.00255
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	0.0000154	0.0000133	0.0000143	0.0000159	<0.0000050	<0.0000050	0.0000060	0.0000062	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000051	<0.0000050
Bismuth (Bi)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.0050 to 0.030	<0.030	<0.030	<0.025	<0.025	<0.025	<0.025	<0.015	<0.015	<0.015	<0.020	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.010	<0.010	<0.015	<0.015
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	9.57	9.32	4.57	4.82	6.10	6.19	3.44	3.48	2.65	2.62	8.84	8.91	5.30	5.41	6.88	6.84	3.21	3.23	2.99	2.97
Cesium (Cs)	mg/L		0.0000050	0.0000053	0.0000054	0.0000203	0.0000222	0.0000249	0.0000262	<0.0000050	<0.0000050	0.0000075	0.0000056	<0.0000050	<0.0000050	0.0000062	0.0000066	0.0000075	0.0000070	<0.0000050	<0.0000050	0.0000087	0.0000055
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	<0.00050	0.00070	0.00075	0.00086	0.00094	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00051	<0.00050
Cobalt (Co)	mg/L		0.000050	0.000105	0.000099	0.000150	0.000164	0.000206	0.000223	<0.000050	<0.000050	0.000085	0.000056	0.000056	0.000058	0.000061	0.000060	0.000081	0.000076	<0.000050	<0.000050	0.000166	0.000081
Copper (Cu)	mg/L	≥0.002[e]	0.00050	0.00159	0.00149	0.00171	0.00164	0.00166	0.00184	0.00082	0.00088	0.00129	0.00120	0.00150	0.00172	0.00168	**0.00205**	0.00163	0.00172	0.00090	0.00089	0.00123	0.00117
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	0.000124	0.000134	0.000134	0.000147	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	**0.308**	**0.303**	**0.471**	**0.519**	**0.601**	**0.651**	0.071	0.072	0.234	0.204	0.152	0.160	0.181	0.188	0.227	0.216	0.053	0.044	**0.379**	0.199
Lead (Pb)	mg/L	≥0.001[f]	0.000050	0.000058	0.000061	0.000181	0.000162	0.000171	0.000203	<0.000050	<0.000050	0.000073	0.000065	<0.000050	0.000059	0.000063	0.000078	0.000060	0.000079	<0.000050	0.000058	0.000066	<0.000050
Lithium (Li)	mg/L		0.00020	0.00398	0.00386	0.00248	0.00261	0.00308	0.00310	0.00046	0.00045	0.00137	0.00131	0.00311	0.00313	0.00193	0.00200	0.00248	0.00242	0.00036	0.00036	0.00119	0.00117
Magnesium (Mg)	mg/L		0.10	6.95	6.76	4.96	5.30	5.40	5.49	1.34	1.35	2.59	2.55	6.42	6.53	5.80	5.93	6.16	6.15	1.26	1.26	2.86	2.81
Manganese (Mn)	mg/L		0.00020	0.0271	0.0258	0.0185	0.0212	0.0215	0.0214	0.00583	0.00576	0.0113	0.00494	0.0140	0.0153	0.00809	0.00849	0.0132	0.0131	0.00272	0.00257	0.0156	0.00864
Mercury (Hg)	mg/L	Inorganic Hg: 0.000026	0.000010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercury (Hg) (ultra low-level)	µg/L	Inorganic Hg: 0.026	0.00050	0.00110	0.00120	0.00150	0.00140	0.00140	0.00140	0.00110	0.00120	0.00240	0.00190	0.00120	0.00120	0.00120	0.00110	0.00120	0.00110	0.00090	0.00110	0.00120	0.00110
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000195	0.000191	0.000180	0.000188	0.000170	0.000186	<0.000050	<0.000050	0.000080	0.000072	0.000175	0.000174	0.000196	0.000188	0.000187	0.000180	<0.000050	<0.000050	0.000069	0.000067
Nickel (Ni)	mg/L	≥0.025[g]	0.00020	0.00071	0.00070	0.00089	0.00087	0.00096	0.00098	0.00025	0.00025	0.00059	0.00055	0.00062	0.00070	0.00064	0.00065	0.00068	0.00067	0.00020	<0.00020	0.00058	0.00049
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.4	2.4	<2.0	<2.0	<2.0	2.0	<2.0	<2.0	<2.0	<2.0	2.3	2.4	<2.0	2.1	2.2	2.1	<2.0	<2.0	<2.0	<2.0
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00179	0.00172	0.00184	0.00203	0.00206	0.00217	0.000856	0.000850	0.00115	0.00110	0.00146	0.00147	0.00134	0.00138	0.00148	0.00144	0.000744	0.000755	0.00126	0.00117
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.58	1.54	2.10	2.23	1.99	2.12	0.209	0.205	0.798	0.753	1.32	1.34	0.929	0.950	1.12	1.08	0.150	0.149	0.619	0.403
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	33.4	32.5	23.4	25.6	25.3	25.8	3.5	3.5	10.0	9.9	30.7	31.4	29.1	29.9	30.0	29.8	3.3	3.4	11.4	11.1
Strontium (Sr)	mg/L		0.000050	0.0482	0.0462	0.0286	0.0308	0.0332	0.0345	0.0160	0.0158	0.0155	0.0150	0.0433	0.0433	0.0326	0.0329	0.0380	0.0372	0.0147	0.0144	0.0169	0.0172
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	0.0000020	<0.0000020	0.0000069	0.0000060	0.0000056	0.0000054	<0.0000020	<0.0000020	0.0000025	0.0000023	0.0000020	<0.0000020	<0.0000020	0.0000022	0.0000022	0.0000022	<0.0000020	<0.0000020	0.0000028	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000638	0.0000544	0.000143	0.000165	0.000181	0.000217	0.0000193	0.0000163	0.0000948	0.0000889	0.0000442	0.0000469	0.0000603	0.0000615	0.0000638	0.0000631	<0.000020	<0.000020	0.0000731	0.0000516
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00363	0.00339	0.0148	0.0179	0.0195	0.0223	0.00042	0.00047	0.00527	0.00464	0.00217	0.00235	0.00387	0.00401	0.00453	0.00413	0.00023	0.00025	0.00609	0.00337
Tungsten (W)	mg/L		0.000010	0.000020	0.000020	<0.000010	<0.000010	0.000011	0.000012	<0.000010	<0.000010	<0.000010	<0.000010	0.000021	0.000023	0.000011	0.000010	0.000014	0.000014	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000377	0.0000370	0.0000534	0.0000578	0.0000552	0.0000553	0.0000436	0.0000432	0.0000443	0.0000422	0.0000369	0.0000390	0.0000563	0.0000562	0.0000506	0.0000490	0.0000451	0.0000428	0.0000504	0.0000445
Vanadium (V)	mg/L		0.000050	0.000283	0.000275	0.000754	0.000820	0.000948	0.00104	0.000057	0.000056	0.000296	0.000248	0.000193	0.000207	0.000293	0.000285	0.000326	0.000317	0.000051	<0.000050	0.000359	0.000225
Yttrium (Y)	mg/L		0.0000050	0.0000545	0.0000521	0.000130	0.000137	0.000152	0.000160	0.0000238	0.0000240	0.0000776	0.0000677	0.0000392	0.0000402	0.0000584	0.0000590	0.0000584	0.0000570	0.0000163	0.0000165	0.0000636	0.0000469
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050 or 0.00020	0.000099	0.000090	0.000183	0.000215	0.000211	0.000331	<0.000050	<0.000050	0.000117	0.000122	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Radiochemistry																							
Radium-226	Bq/L		0.005	<0.005	<0.005	<0.005	0.03	0.01	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	0.008	<0.005	<0.005

Notes:

Shaded cells indicate values that are both above analytical detection limits and exceed CCME guidelines for the protection of freshwater aquatic life.

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) Interim guideline.

c) Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotrophic; 0.004-0.01 = Oligotrophic; 0.01-0.02 = Mesotrophic; 0.02-0.035 = Meso-eutrophic; 0.035-0.1 = Eutrophic; >0.1 = Hyper-eutrophic.

d) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{\{0.86[\log(hardness)]-3.2\}}$ */ 1000.*

e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{\{0.8545[\ln(hardness)]-1.465\}}$ ** 0.0002. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(hardness)]-4.705\}}$ */ 1000. Lead guideline is a minimum of 0.001 mg/L regardless of hardness.*

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}}$ */ 1000. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.*

Annex A.3-1. Stream Water Quality Data, Doris North Project, 2011

Site ID:				Doris OF	Doris OF	Roberts OF	Roberts OF	Little Roberts OF	Little Roberts OF	Reference B OF	Reference B OF	Reference D OF	Reference D OF	Doris OF	Doris OF	Roberts OF	Roberts OF	Little Roberts OF	Little Roberts OF	Reference B OF	Reference B OF	Reference D OF	Reference D OF
Depth Zone:				Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Replicate:				1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Date Sampled:				23-Aug-11	23-Aug-11	23-Aug-11	23-Aug-11	23-Aug-11	23-Aug-11	20-Aug-11	20-Aug-11	21-Aug-11	21-Aug-11	23-Sep-11	23-Sep-11	23-Sep-11	23-Sep-11	23-Sep-11	23-Sep-11	18-Sep-11	18-Sep-11	23-Sep-11	23-Sep-11
ALS Sample ID:	Units	CCME Guideline for the Protection of Aquatic Life[a]	Realized Detection Limit	L1049431-1	L1049431-2	L1049431-3	L1049431-4	L1049431-7	L1049431-8	L1049435-12	L1049435-13	L1049435-3	L1049435-2	L1063068-8	L1063068-9	L1063068-6	L1063068-7	L1063068-3	L1063068-4	L1060789-4	L1060789-5	L1063068-1	L1063068-2
Physical Tests																							
Conductivity	µS/cm		2.0	254	251	236	234	260	260	44.7	44.8	103	103	268	267	251	252	262	263	49.3	49.4	112	112
Hardness (as $CaCO_3$)	mg/L		0.50	47.5	50.5	39.0	39.4	48.9	48.1	13.7	13.5	20.0	19.8	53.4	51.8	41.1	40.7	46.6	47.4	15.9	15.7	21.9	21.6
pH	pH	6.5-9.0	0.10	7.67	7.68	7.61	7.60	7.67	7.68	7.36	7.35	7.40	7.36	7.73	7.72	7.58	7.58	7.61	7.62	7.08	7.11	7.39	7.39
Total Suspended Solids	mg/L	dependent on background levels	1.0	11.4	11.0	13.2	11.6	20.0	19.2	<1.0	<1.0	<1.0	1.0	6.1	5.7	4.5	3.5	4.3	4.3	<1.0	<1.0	1.7	<1.0
Turbidity	NTU	dependent on background levels	0.10	10.6	10.7	11.2	11.8	19.0	18.8	0.47	0.48	1.80	1.73	7.08	7.24	5.21	4.58	5.66	6.24	1.67	0.75	2.24	2.25
Anions and Nutrients																							
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	28.2	28.0	21.4	21.3	26.6	26.2	10.5	10.1	12.7	12.2	28.5	27.4	21.6	21.6	25.2	25.5	10.8	10.7	12.8	12.8
Ammonia (as N)	mg/L	pH- and temperature-dependent	0.0050	0.0077	0.0157	0.0256	0.0163	0.0192	0.0161	0.0502	0.0176	<0.0050	<0.0050	<0.0050	0.0086	<0.0050	<0.0050	<0.0050	<0.0050	0.0100	<0.0050	<0.0050	<0.0050
Bromide (Br^-)	mg/L		0.050 or 0.10	0.189	0.176	0.179	0.173	0.197	0.197	<0.050	<0.050	<0.050	<0.050	0.192	0.226	0.210	0.221	0.236	0.210	<0.050	<0.050	0.070	0.069
Chloride (Cl^-)	mg/L	short-term: 640; long-term: 120	0.50	58.2	58.4	55.8	55.9	61.4	61.4	6.43	6.43	22.2	23.4	62.8	62.8	60.6	60.7	61.6	61.8	6.97	6.97	23.7	23.7
Fluoride (F^-)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.054	0.055	0.047	0.046	0.052	0.053	0.020	0.020	0.036	0.036	0.056	0.056	0.049	0.049	0.052	0.056	0.021	0.022	0.039	0.040
Nitrate (as N)	mg/L	2.935[b]	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0153	0.0146	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0058	0.0062	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphorus	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0315	0.0316	0.0229	0.0238	0.0361	0.0354	0.0048	0.0049	0.0076	0.0079	0.0282	0.0278	0.0215	0.0208	0.0228	0.0225	0.0044	0.0044	0.0091	0.0088
Sulphate (SO_4^{2-})	mg/L		0.50	2.73	2.71	4.47	4.47	3.78	3.78	1.67	1.67	2.09	2.11	3.45	3.47	4.90	4.93	4.79	5.15	2.13	2.13	2.62	2.63
Cyanides																							
Total Cyanide	mg/L		0.0010 to 0.00125	0.0034	0.0040	0.0030	0.0033	0.0031	0.0033	0.0029	0.0030	0.0035	0.0036	<0.0010	0.0014	0.0043	0.0054	0.0039	<0.0010	0.0026	0.0016	0.0042	0.0026
Free Cyanide	mg/L	0.005	0.0010 or 0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic Carbon																							
Total Organic Carbon	mg/L		0.50	6.78	6.44	5.23	5.02	6.05	6.07	3.25	3.37	4.65	4.74	5.43	5.33	4.58	4.81	4.69	4.99	6.44	3.92	3.77	3.84
Total Metals																							
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030 or 0.015	0.282	0.305	0.441	0.515	0.655	0.628	0.0126	0.0128	0.0669	0.0754	0.0669	0.0701	0.141	0.0950	0.0869	0.0837	0.0123	0.0106	0.0798	0.0748
Antimony (Sb)	mg/L		0.000010	0.000013	0.000014	0.000014	0.000014	0.000015	0.000016	<0.000010	<0.000010	0.000011	<0.000010	0.000015	0.000013	0.000016	0.000014	0.000014	0.000019	0.000011	<0.000010	<0.000010	<0.000010
Arsenic (As)	mg/L	0.005	0.000050	0.000430	0.000302	0.000276	0.000344	0.000390	0.000366	0.000080	0.000080	0.000127	0.000146	0.000292	0.000282	0.000251	0.000240	0.000260	0.000285	0.000082	0.000080	0.000131	0.000123
Barium (Ba)	mg/L		0.00010	0.00549	0.00608	0.00637	0.00703	0.00819	0.00798	0.00140	0.00137	0.00196	0.00213	0.00369	0.00354	0.00410	0.00343	0.00380	0.00356	0.00171	0.00158	0.00251	0.00252
Beryllium (Be)	mg/L		0.0000050	0.0000083	0.0000091	0.0000129	0.0000147	0.0000197	0.0000201	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.0050 to 0.030	0.0219	0.0237	0.0254	0.0252	0.0242	0.0243	0.0066	0.0064	0.0124	0.0120	0.0229	0.0220	0.0252	0.0243	0.0243	0.0251	0.0077	0.0068	0.0157	0.0155
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000052	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	8.80	9.40	5.71	5.74	8.36	8.26	3.35	3.30	3.11	3.04	10.2	9.88	5.92	5.87	7.98	8.08	3.85	3.79	3.39	3.32
Cesium (Cs)	mg/L		0.0000050	0.0000156	0.0000163	0.0000272	0.0000302	0.0000471	0.0000441	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000074	<0.0000050	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	0.00059	0.00069	0.00079	0.00094	0.00134	0.00125	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	0.000160	0.000173	0.000193	0.000210	0.000309	0.000280	<0.000050	<0.000050	<0.000050	<0.000050	0.000062	0.000065	0.000070	<0.000050	0.000060	0.000061	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	≥0.002[e]	0.00050	0.00155	0.00172	0.00179	0.00181	0.00192	0.00189	0.00077	0.00079	0.00092	0.00091	0.00154	0.00155	0.00153	0.00156	0.00151	0.00148	0.00091	0.00094	0.00126	0.00130
Gallium (Ga)	mg/L		0.000050	0.000091	0.000095	0.000145	0.000166	0.000216	0.000215	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.420	0.463	0.434	0.509	0.829	0.783	0.067	0.063	0.128	0.131	0.145	0.144	0.166	0.104	0.154	0.153	0.040	0.036	0.130	0.122
Lead (Pb)	mg/L	≥0.001[f]	0.000050	0.000112	0.000114	0.000167	0.000179	0.000231	0.000226	<0.000050	<0.000050	0.000051	<0.000050	<0.000050	<0.000050	0.000083	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00020	0.00372	0.00393	0.00268	0.00276	0.00392	0.00393	0.00043	0.00043	0.00129	0.00130	0.00350	0.00339	0.00237	0.00233	0.00294	0.00290	0.00048	0.00048	0.00131	0.00128
Magnesium (Mg)	mg/L		0.10	6.21	6.58	6.01	6.09	6.81	6.66	1.29	1.27	2.98	2.98	6.78	6.59	6.38	6.31	6.48	6.62	1.53	1.51	3.27	3.23
Manganese (Mn)	mg/L		0.00020	0.0291	0.0303	0.0107	0.0106	0.0178	0.0170	0.00227	0.00209	0.00466	0.00472	0.0250	0.0245	0.00644	0.00426	0.0105	0.0113	0.00206	0.00196	0.00512	0.00537
Mercury (Hg)	mg/L	Inorganic Hg: 0.000026	0.000010	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercury (Hg) (ultra low-level)	µg/L	Inorganic Hg: 0.026	0.00050	0.00174	0.00168	0.00213	0.00214	0.00196	0.00184	0.00074	0.00077	0.00060	0.00058	0.00197	0.00205	0.00170	0.00151	0.00155	0.00216	0.00086	0.00094	0.00147	0.00189
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000196	0.000206	0.000181	0.000189	0.000223	0.000214	<0.000050	<0.000050	0.000070	0.000070	0.000221	0.000212	0.000197	0.000208	0.000207	0.000202	0.000063	0.000062	0.000086	0.000082
Nickel (Ni)	mg/L	≥0.025[g]	0.00020	0.00080	0.00087	0.00080	0.00089	0.00112	0.00105	<0.00020	<0.00020	0.00034	0.00036	0.00069	0.00067	0.00068	0.00064	0.00068	0.00066	0.00021	0.00020	0.00044	0.00050
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.2	2.4	2.1	2.2	2.4	2.3	<2.0	<2.0	<2.0	<2.0	2.3	2.2	2.1	2.1	2.1	2.2	<2.0	<2.0	<2.0	<2.0
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00183	0.00196	0.00199	0.00218	0.00254	0.00251	0.000785	0.000767	0.00107	0.00108	0.00158	0.00152	0.00147	0.00139	0.00150	0.00148	0.000867	0.000867	0.00112	0.00109
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.84	2.09	1.60	1.92	2.23	2.23	0.155	0.148	0.278	0.306	1.48	1.45	1.06	0.922	1.24	1.27	0.183	0.177	0.493	0.462
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	28.7	30.3	30.0	30.1	31.2	30.7	3.3	3.2	12.0	12.0	30.9	29.9	32.3	32.2	31.1	31.7	4.2	4.2	13.3	13.1
Strontium (Sr)	mg/L		0.000050	0.0416	0.0433	0.0343	0.0339	0.0441	0.0429	0.0140	0.0140	0.0163	0.0168	0.0495	0.0477	0.0364	0.0364	0.0429	0.0422	0.0163	0.0158	0.0194	0.0190
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	0.0000052	0.0000045	0.0000057	0.0000061	0.0000079	0.0000076	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	0.0000023	<0.0000020
Thorium (Th)	mg/L		0.0000050	0.0000960	0.000111	0.000142	0.000181	0.000246	0.000230	0.0000125	0.0000112	0.0000294	0.0000366	0.0000262	0.0000266	0.0000539	0.0000410	0.0000378	0.0000378	0.0000119	0.0000115	0.0000453	0.0000453
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.0121	0.0137	0.0208	0.0239	0.0315	0.0301	0.00026	0.00026	0.00188	0.00201	0.00215	0.00216	0.00454	0.00237	0.00265	0.00255	0.00027	0.00026	0.00218	0.00205
Tungsten (W)	mg/L		0.000010	0.000017	0.000019	<0.000010	<0.000010	0.000012	0.000012	<0.000010	<0.000010	<0.000010	<0.000010	0.000014	0.000013	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000421	0.0000455	0.0000681	0.0000712	0.0000717	0.0000711	0.0000409	0.0000386	0.0000360	0.0000387	0.0000421	0.0000401	0.0000538	0.0000528	0.0000430	0.0000455	0.0000860	0.0000840	0.000176	0.000174
Vanadium (V)	mg/L		0.000050	0.000604	0.000666	0.000878	0.000999	0.00147	0.00142	0.000054	0.000056	0.000140	0.000141	0.000206	0.000204	0.000316	0.000177	0.000202	0.000202	<0.000050	<0.000050	0.000149	0.000153
Yttrium (Y)	mg/L		0.0000050	0.0000869	0.0000953	0.000147	0.000167	0.000199	0.000203	0.0000149	0.0000147	0.0000296	0.0000291	0.0000335	0.0000325	0.0000617	0.0000481	0.0000451	0.0000425	0.0000191	0.0000180	0.0000540	0.0000531
Zinc (Zn)	mg/L	0.03	0.0030	0.0047	0.0055	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050 or 0.00020	0.000174	0.000137	0.000315	0.000260	0.000225	0.000271	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000076	0.000067	0.000065	0.000129	<0.000050	0.000064	0.000065	0.000060
Radiochemistry																							
Radium-226	Bq/L		0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Notes:

Shaded cells indicate values that are both above analytical detection limits and exceed CCME guidelines for the protection of freshwater aquatic life.

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) Interim guideline.

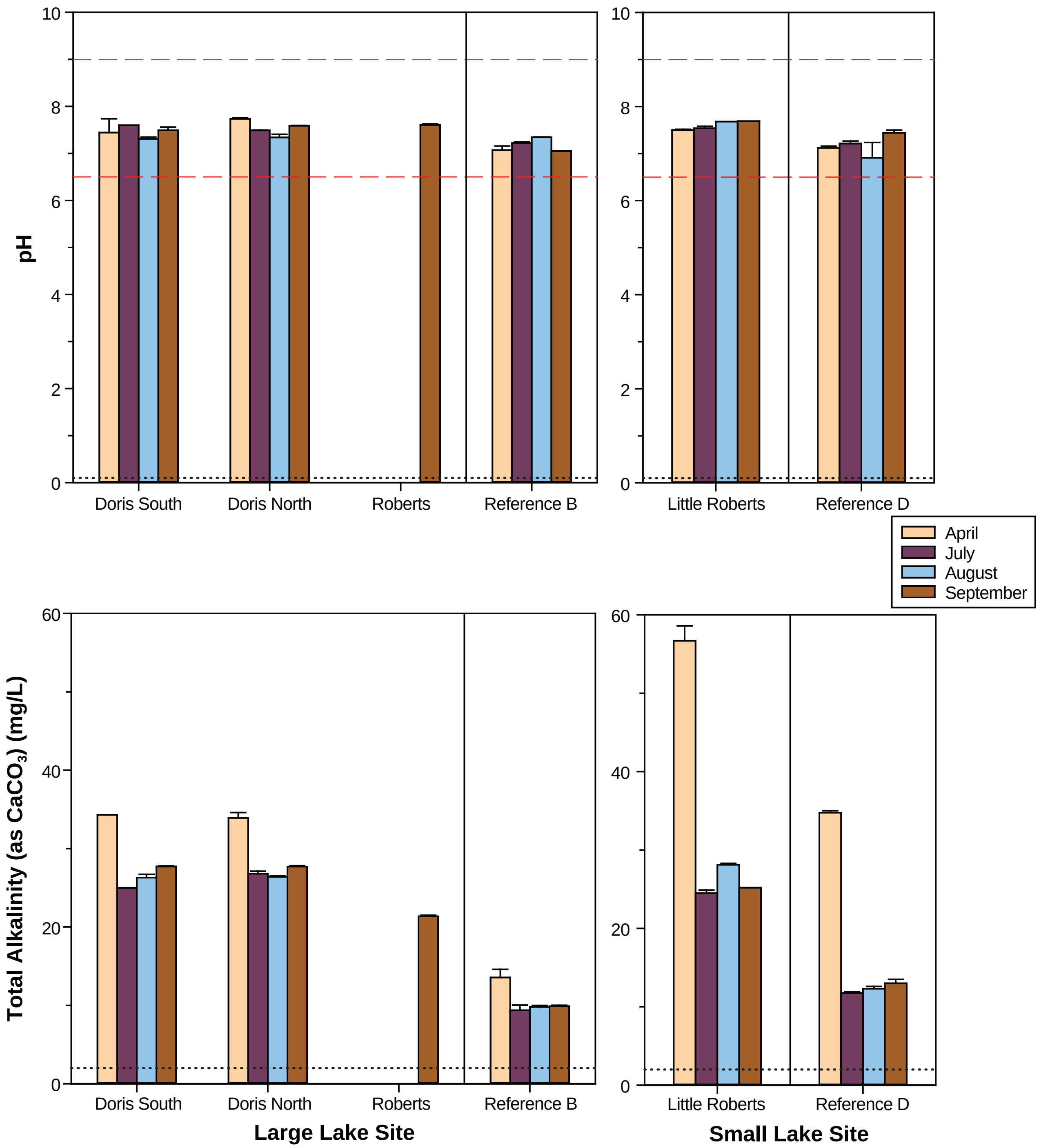
c) Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotrophic; 0.004-0.01 = Oligotrophic; 0.01-0.02 = Mesotrophic; 0.02-0.035 = Meso-eutrophic; 0.035-0.1 = Eutrophic; >0.1 = Hyper-eutrophic.

d) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{\{0.86[\log(hardness)]-3.2\}}$ */ 1000.*

e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{\{0.8545[\ln(hardness)]-1.465\}}$ ** 0.0002. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(hardness)]-4.705\}}$ */ 1000. Lead guideline is a minimum of 0.001 mg/L regardless of hardness.*

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}}$ */ 1000. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.*



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits.
Red dashed lines represent the CCME freshwater guideline pH range (6.5–9.0).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

Figure A.3-10

pH and Total Alkalinity in Lake Sites, Doris North Project, 2011

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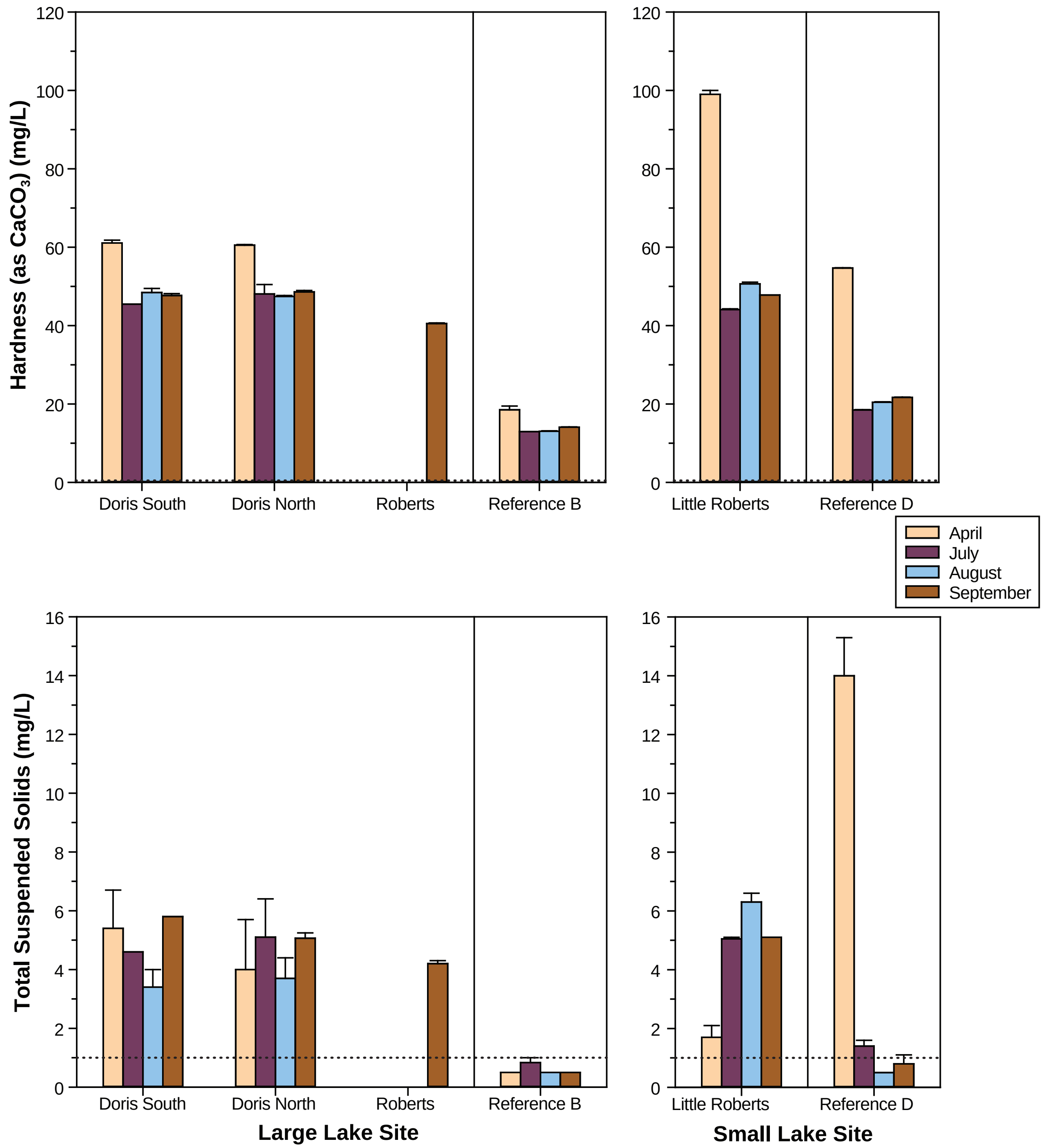

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guideline for total suspended solids is dependent upon background levels.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.
Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Hardness and Total Suspended Solids in Lake Sites, Doris North Project, 2011

Figure A.3-11

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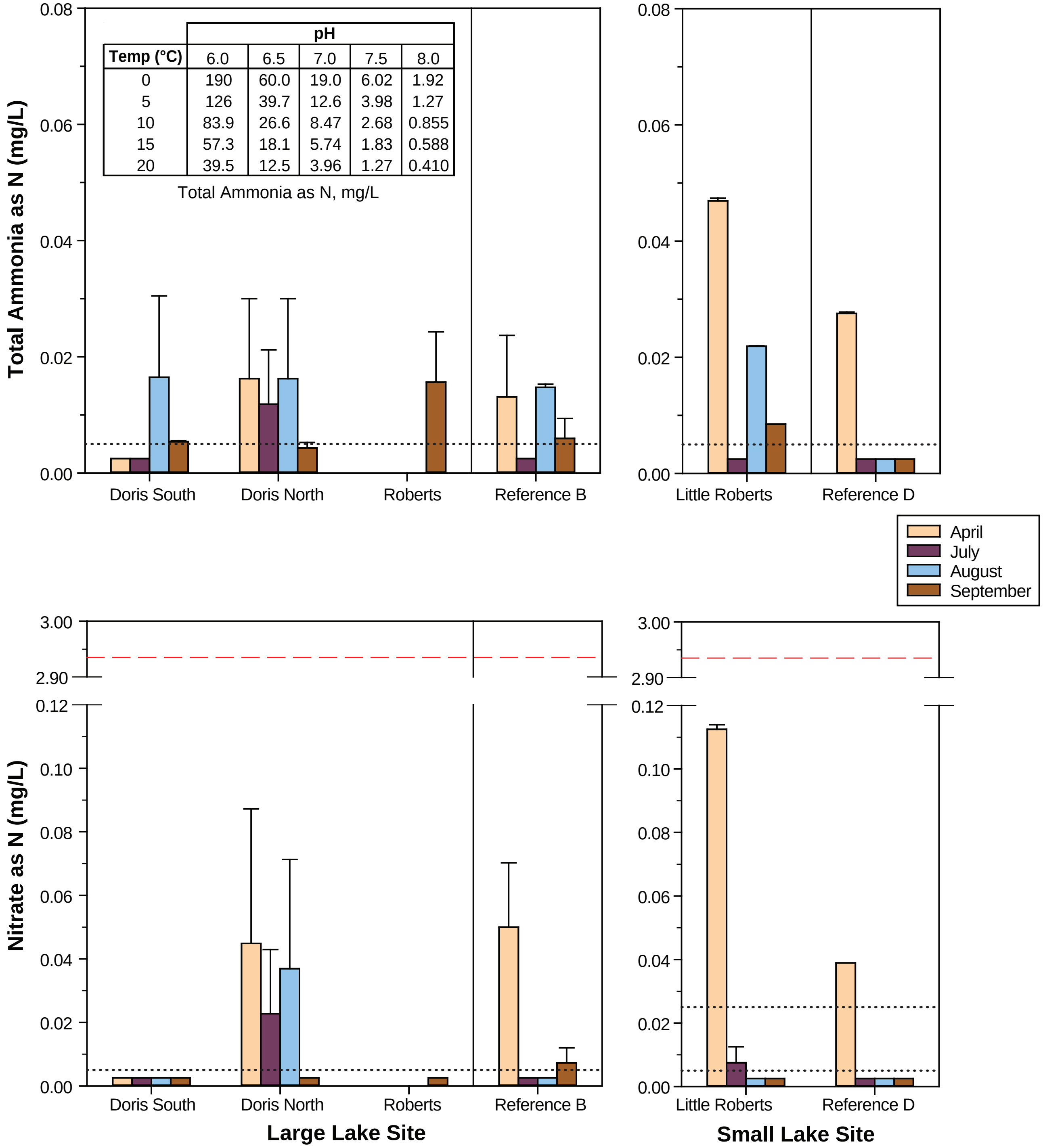

Temp (°C)	pH 6.0	6.5	7.0	7.5	8.0
0	190	60.0	19.0	6.02	1.92
5	126	39.7	12.6	3.98	1.27
10	83.9	26.6	8.47	2.68	0.855
15	57.3	18.1	5.74	1.83	0.588
20	39.5	12.5	3.96	1.27	0.410

Total Ammonia as N, mg/L

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The higher detection limit for nitrate as N of 0.025 mg/L applied to a single replicate collected in July from Little Roberts Lake;
both replicates collected in July from Little Roberts Lake were below applicable detection limits.
Inset table shows the pH- and temperature-dependent CCME freshwater guideline for total ammonia.
Red dashed line represents the interim CCME freshwater guideline for nitrate as N (2.935 mg/L).
Total ammonia and nitrate are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

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Total Ammonia and Nitrate Concentrations in Lake Sites, Doris North Project, 2011

Figure A.3-12

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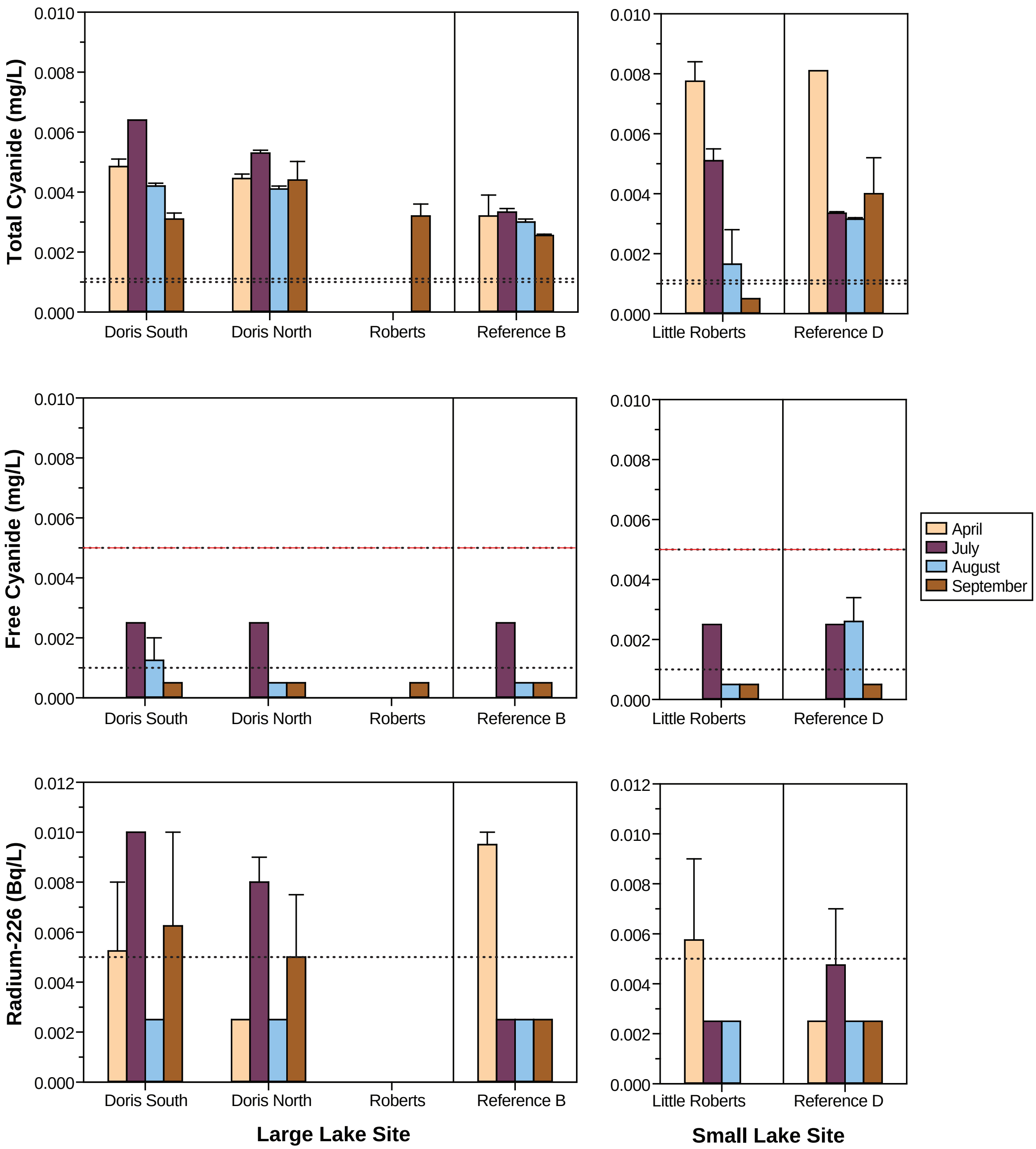

Notes: *Error bars represent the standard error of the mean.*
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The higher detection limit for free cyanide of 0.005 mg/L applied only to July samples; all free cyanide concentrations in July samples were below this detection limit.
Red dashed line represents the CCME freshwater guideline for free cyanide (0.005 mg/L).
Total cyanide and radium-226 are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Total Cyanide, Free Cyanide, and Radium-226 Concentrations in Lake Sites, Doris North Project, 2011

Figure A.3-13

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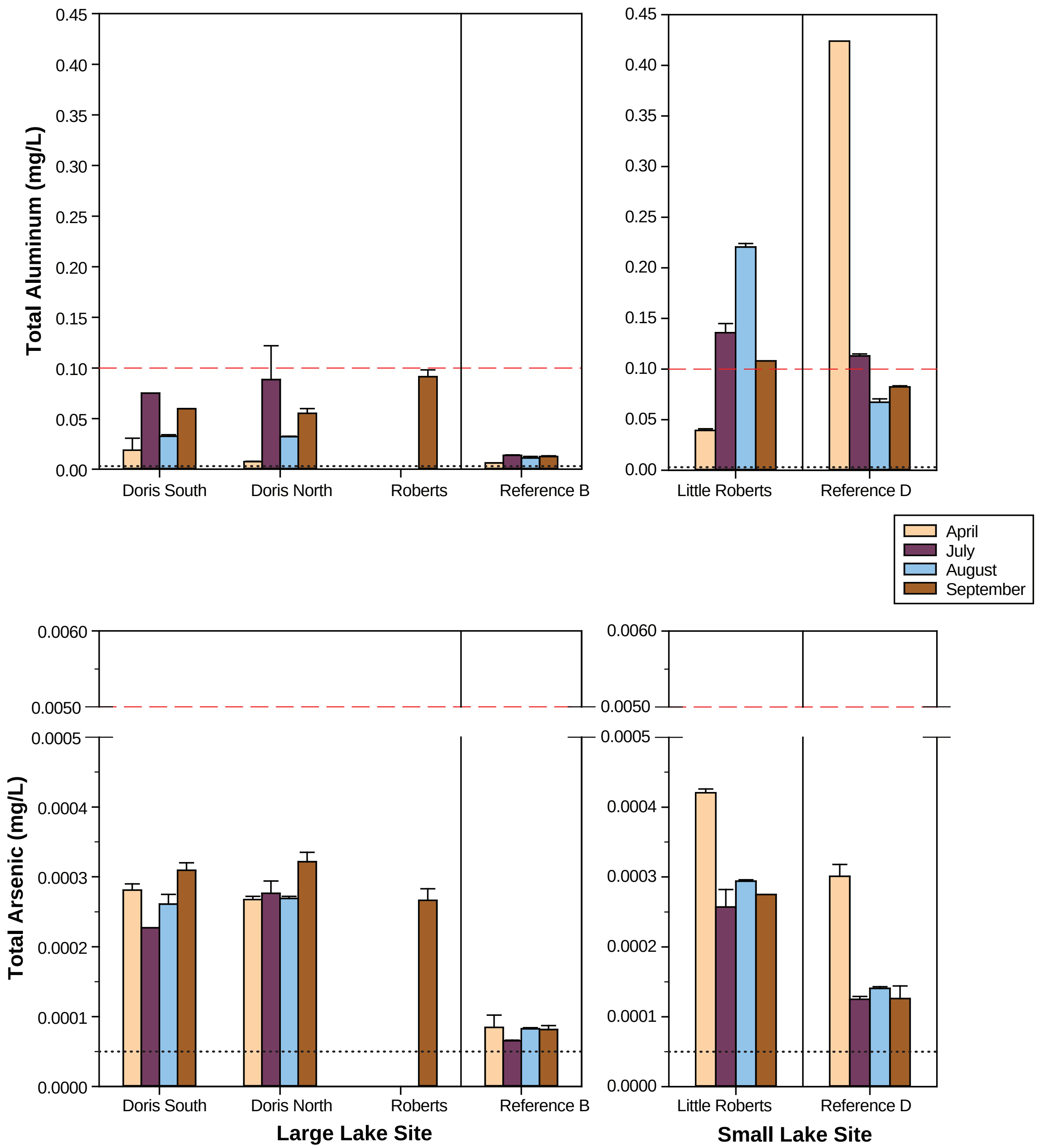

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed lines represent the pH-dependent CCME freshwater guideline for aluminum (0.005 mg/L at pH < 6.5; 0.1 mg/L at pH ≥ 6.5) and the CCME freshwater guideline for arsenic (0.005 mg/L).
pH was greater than 6.5 in all lake samples.
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Aluminum and Total Arsenic Concentrations in Lake Sites, Doris North Project, 2011

Figure A.3-14

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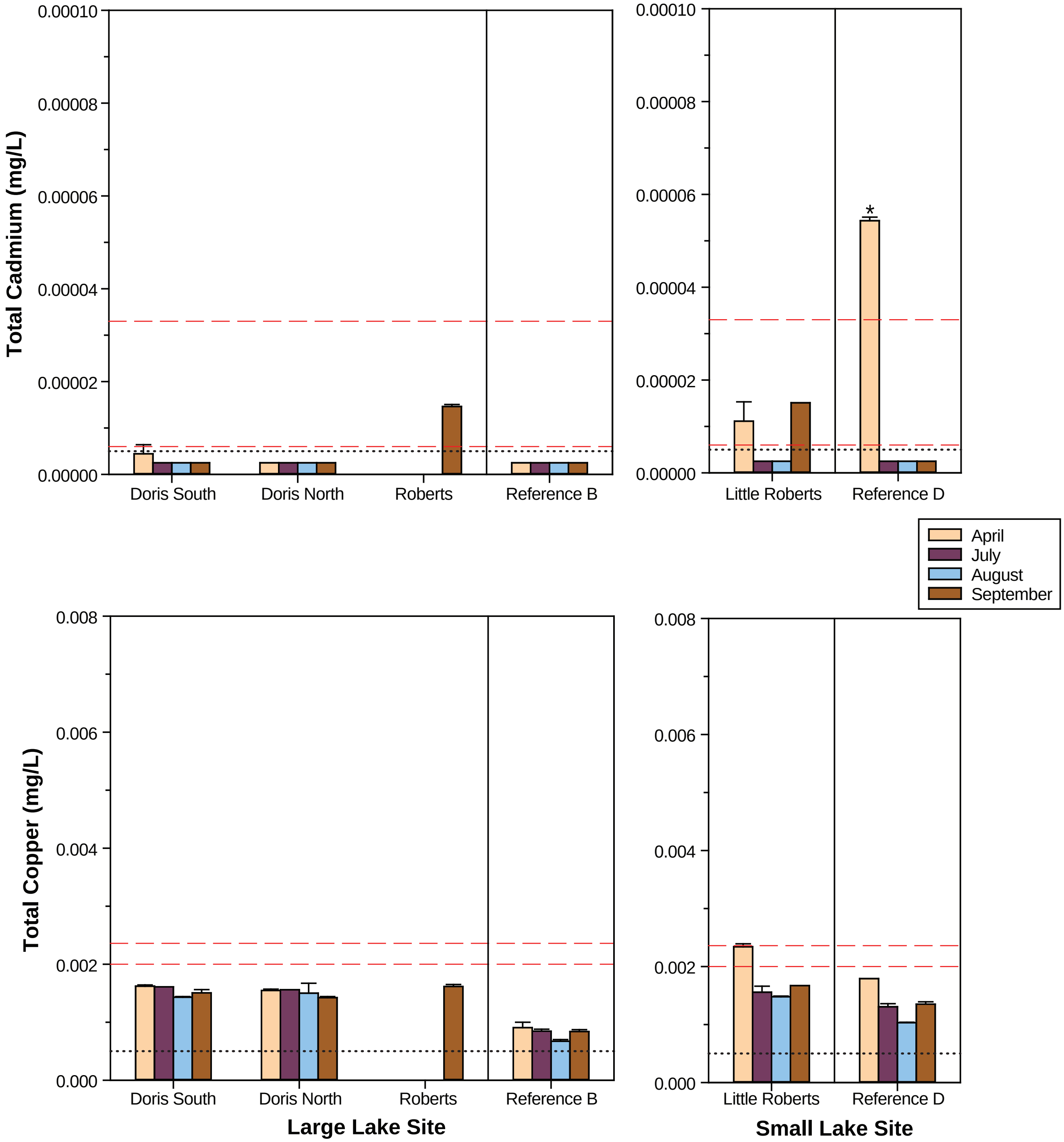

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guidelines for cadmium and copper are hardness dependent.
Red dashed lines represent the minimum and maximum site-specific CCME freshwater guidelines for cadmium (0.000006 and 0.000033 mg/L) and for copper (0.002 and 0.00236 mg/L) based on the hardness (as $CaCO_3$) range in lakes of 12.9 to 100 mg/L.
** Indicates mean cadmium and copper concentrations that are higher than the applicable CCME guideline.*
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

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Total Cadmium and Total Copper Concentrations in Lake Sites, Doris North Project, 2011

Figure A.3-15

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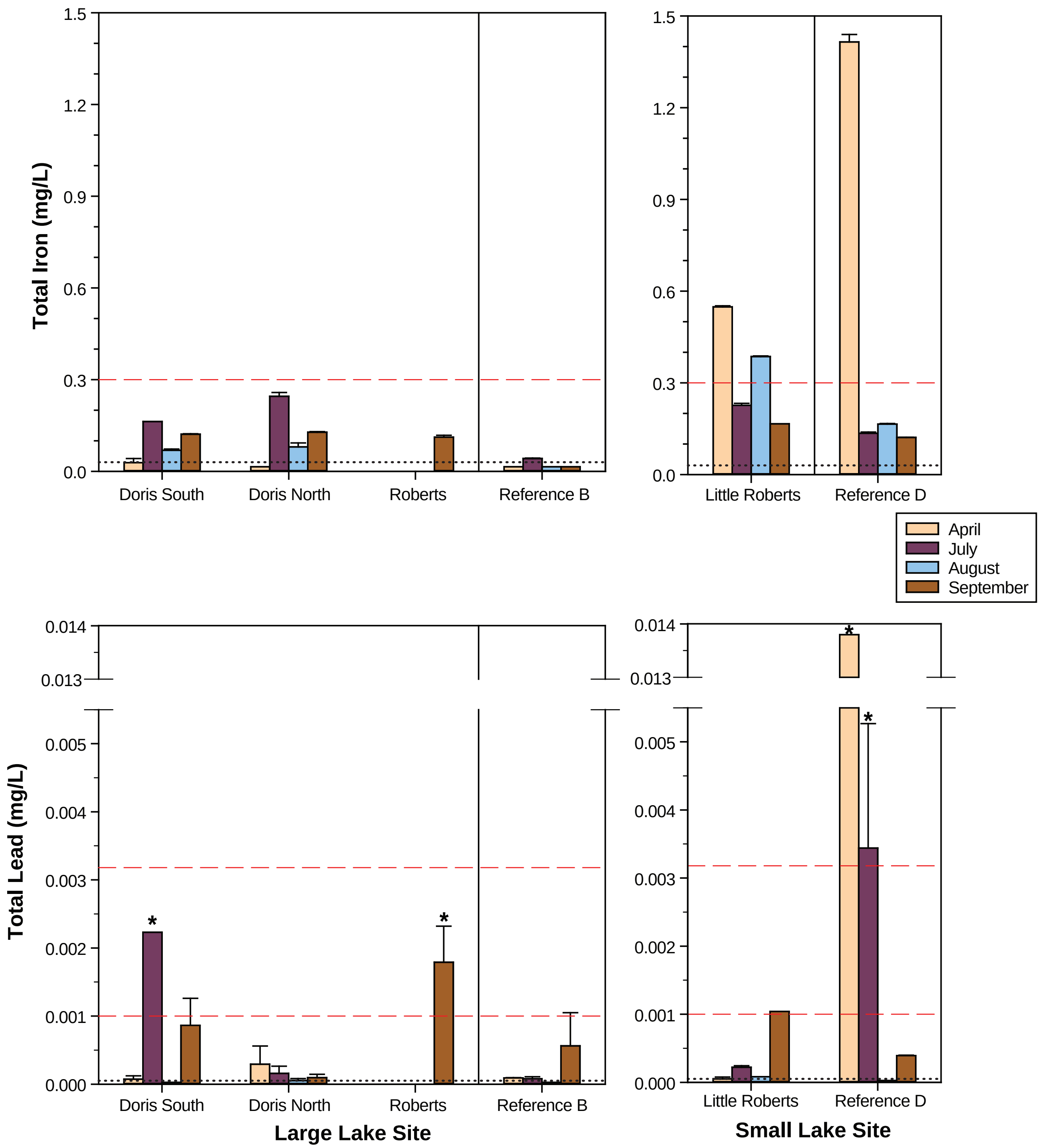

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME freshwater guideline for lead is hardness dependent.
Red dashed lines represent the CCME freshwater guideline for iron (0.3 mg/L) and the minimum and maximum site-specific CCME freshwater guideline for lead (0.001 and 0.00318 mg/L) based on the hardness (as $CaCO_3$) range in lakes of 12.9 to 100 mg/L.
** Indicates mean lead concentrations that are higher than the applicable CCME guideline.*
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Iron and Total Lead Concentrations in Lake Sites, Doris North Project, 2011

Figure A.3-16

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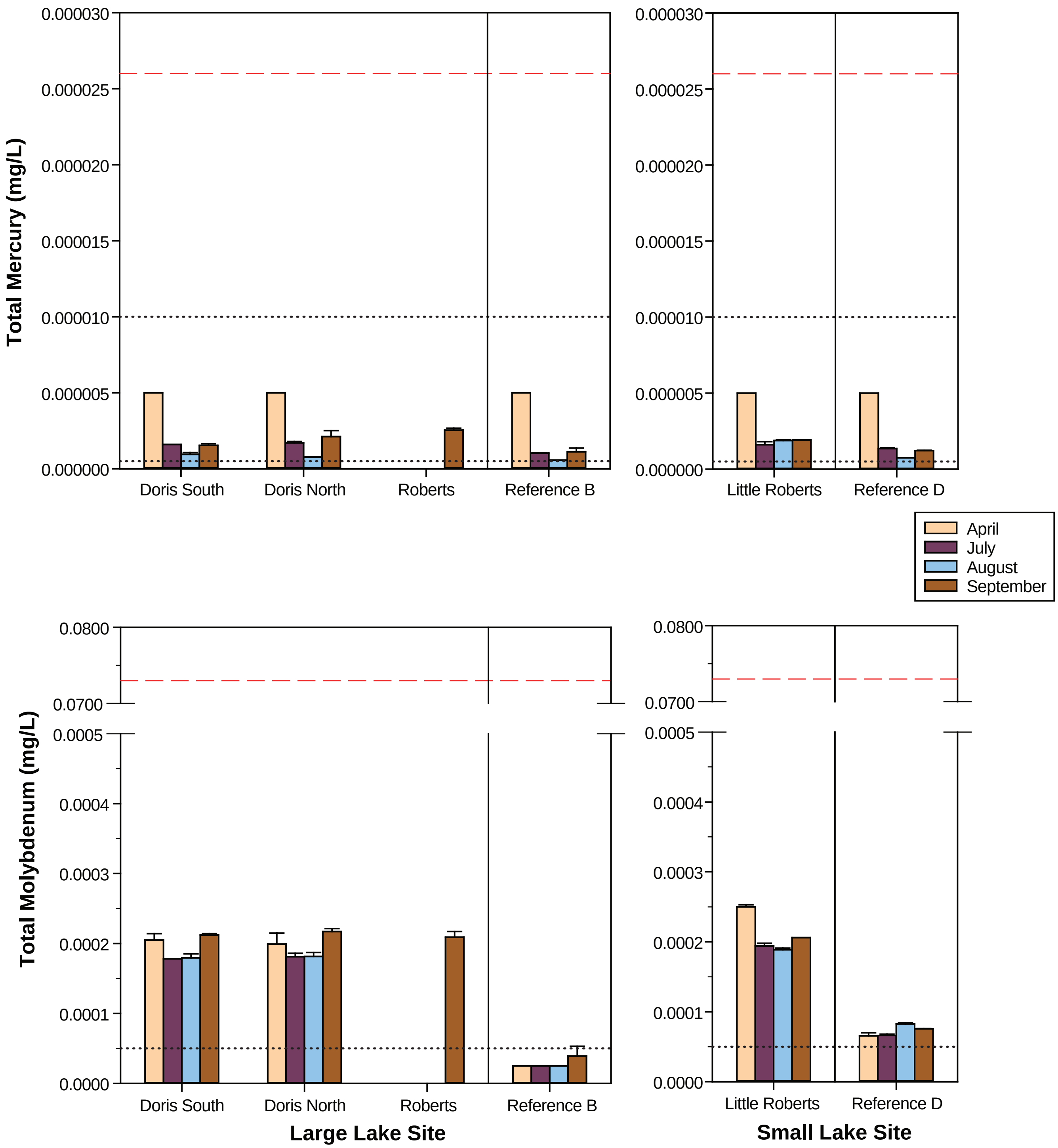

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The higher detection limit for total mercury of 0.00001 mg/L applied only to April samples; all total mercury concentrations in April samples were below this detection limit.
Red dashed lines represent the CCME freshwater guidelines for inorganic mercury (0.000026 mg/L) and molybdenum (0.073 mg/L).
Total mercury and total molybdenum are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

NEWMONT NORTH AMERICA

Total Mercury and Total Molybdenum Concentrations in Lake Sites, Doris North Project, 2011

Figure A.3-17

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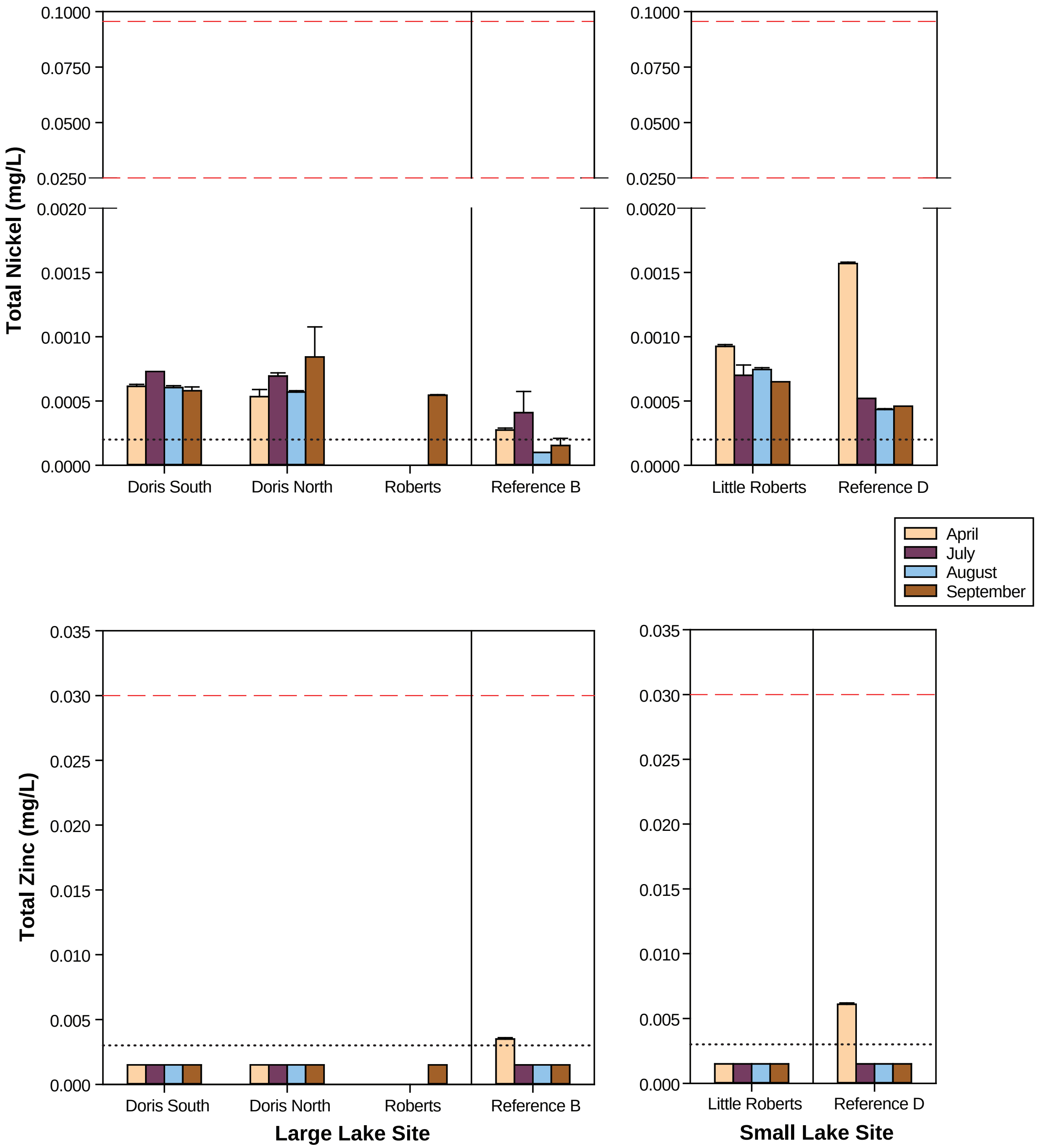

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME guideline for nickel is hardness dependent.
Red dashed lines represent the CCME freshwater guideline for zinc (0.03 mg/L) and the minimum and maximum site-specific CCME guideline for nickel (0.025 and 0.096 mg/L) based on the hardness (as CaCO3) range in lakes of 12.9 to 100 mg/L.
Total nickel and total zinc are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

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Total Nickel and Total Zinc Concentrations in Lake Sites, Doris North Project, 2011

Figure A.3-18

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Table A.3-3. Water Quality in Lake Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2011

Lake	Total Number of Samples Collected	CCME Guideline Value[a]:	pH	Chloride (Cl^-)	Fluoride (F^-)	Total Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Phosphorus	Free Cyanide	Aluminum (Al)-Total	Arsenic (As)-Total	Boron (B)-Total	Cadmium (Cd)-Total
			6.5-9.0	short-term: 640 mg/L long-term: 120 mg/L	Inorganic F: 0.12 mg/L[b]	pH- and temperature-dependent	2.935 mg/L[b]	0.06 mg/L	Trigger ranges from guidance framework[c]	0.005 mg/L	0.005 mg/L if pH<6.5; 0.1 mg/L if pH≥6.5	0.005 mg/L	short-term: 29 mg/L long-term: 1.5 mg/L	equation[b,d]
Large Lake Site														
Doris Lake South	7		0	0	0	0	0	0	Mesotrophic to Eutrophic	0	0	0	0	0
Doris Lake North	9		0	0	0	0	0	0	Mesotrophic to Meso-eutrophic	0	11.1	0	0	0
Roberts Lake	2		0	0	0	0	0	0	Mesotrophic to Meso-eutrophic	0	0	0	0	0
Reference Lake B	9		0	0	0	0	0	0	Ultra-oligotrophic to Oligotrophic	0	0	0	0	0
Small Lake Site														
Little Roberts Lake	7		0	28.6	0	0	0	0	Mesotrophic to Meso-eutrophic	0	71.4	0	0	0
Reference Lake D	8		0	0	0	0	0	0	Oligotrophic to Meso-eutrophic	0	50	0	0	25

Lake	Total Number of Samples Collected	CCME Guideline Value[a]:	Chromium (Cr)-Total	Copper (Cu)-Total	Iron (Fe)-Total	Lead (Pb)-Total	Mercury (Hg)-Total	Molybdenum (Mo)-Total	Nickel (Ni)-Total	Selenium (Se)-Total	Silver (Ag)-Total	Thallium (Tl)-Total	Uranium (U)-Total	Zinc (Zn)-Total
			Cr(VI): 0.001 mg/L Cr(III): 0.0089 mg/L[b]	≥0.002 mg/L[e]	0.3 mg/L	≥0.001 mg/L[f]	Inorganic Hg: 0.000026 mg/L	0.073 mg/L[b]	≥0.025 mg/L[g]	0.001 mg/L	0.0001 mg/L	0.0008 mg/L	short-term: 0.033 mg/L long-term: 0.015 mg/L	0.03 mg/L
Large Lake Site														
Doris Lake South	7		0	0	0	28.6	0	0	0	0	0	0	0	0
Doris Lake North	9		0	0	0	0	0	0	0	0	0	0	0	0
Roberts Lake	2		0	0	0	100	0	0	0	0	0	0	0	0
Reference Lake B	9		0	0	0	11.1	0	0	0	0	0	0	0	0
Small Lake Site														
Little Roberts Lake	7		0	14.3	57.1	0	0	0	0	0	0	0	0	0
Reference Lake D	8		25[h]	0	25	50	0	0	0	0	0	0	0	0

Values represent the percentages of 2011 samples that are both above detection limits and higher than CCME guidelines.

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) Interim guideline.

c) Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotriphic; 0.004-0.01 = Oligotrophic; 0.01-0.02 = Mesotrophic; 0.02-0.035 = Meso-eutrophic; 0.035-0.1 = Eutrophic; >0.1 = Hyper-eutrophic.

d) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{\{0.86[\log(hardness)]-3.2\}}/1000$.

e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{\{0.8545[\ln(hardness)]-1.465\}} * 0.0002$. *Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(hardness)]-4.705\}}/1000$. *Lead guideline is a minumum of 0.001 mg/L regardless of hardness.*

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}}/1000$. *Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.*

h) In these instances, total chromium concentrations were higher than the CCME guideline for hexavalent chromium (Cr(VI)) of 0.001 mg/L.

Table A.3-4. Water Quality in Lake Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2011

Lake Site	Total Number of Samples Collected	CCME Guideline Value[a]:	pH	Chloride (Cl^-)	Fluoride (F^-)	Total Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Total Phosphorus	Free Cyanide	Aluminum (Al)-Total	Arsenic (As)-Total	Boron (B)-Total	Cadmium (Cd)-Total
			6.5-9.0	short-term: 640 mg/L long-term: 120 mg/L	Inorganic F: 0.12 mg/L[b]	pH- and temperature-dependent	2.935 mg/L[b]	0.06 mg/L	Trigger ranges from guidance framework[c]	0.005 mg/L	0.005 mg/L if pH<6.5; 0.1 mg/L if pH≥6.5	0.005 mg/L	short-term: 29 mg/L long-term: 1.5 mg/L	equation[b,d]
Large Lake Site														
Doris Lake South	7		-	-	-	-	-	-	Mesotrophic to Eutrophic	-	-	-	-	-
Doris Lake North	9		-	-	-	-	-	-	Mesotrophic to Meso-eutrophic	-	-	-	-	-
Roberts Lake	2		-	-	-	-	-	-	Mesotrophic to Meso-eutrophic	-	-	-	-	-
Reference Lake B	9		-	-	-	-	-	-	Ultra-oligotrophic to Oligotrophic	-	-	-	-	-
Small Lake Site														
Little Roberts Lake	7		-	-	-	-	-	-	Mesotrophic to Meso-eutrophic	-	1.29	-	-	-
Reference Lake D	8		-	-	-	-	-	-	Oligotrophic to Meso-eutrophic	-	1.72	-	-	1.36

Lake Site	Total Number of Samples Collected	CCME Guideline Value[a]:	Chromium (Cr)-Total	Copper (Cu)-Total	Iron (Fe)-Total	Lead (Pb)-Total	Mercury (Hg)-Total	Molybdenum (Mo)-Total	Nickel (Ni)-Total	Selenium (Se)-Total	Silver (Ag)-Total	Thallium (Tl)-Total	Uranium (U)-Total	Zinc (Zn)-Total
			Cr(VI): 0.001 mg/L Cr(III): 0.0089 mg/L[b]	≥0.002 mg/L[e]	0.3 mg/L	≥0.001 mg/L[f]	Inorganic Hg: 0.000026 mg/L	0.073 mg/L[b]	≥0.025 mg/L[g]	0.001 mg/L	0.0001 mg/L	0.0008 mg/L	short-term: 0.033 mg/L long-term: 0.015 mg/L	0.03 mg/L
Large Lake Site														
Doris Lake South	7		-	-	-	-	-	-	-	-	-	-	-	-
Doris Lake North	9		-	-	-	-	-	-	-	-	-	-	-	-
Roberts Lake	2		-	-	-	1.78	-	-	-	-	-	-	-	-
Reference Lake B	9		-	-	-	-	-	-	-	-	-	-	-	-
Small Lake Site														
Little Roberts Lake	7		-	-	1.19	-	-	-	-	-	-	-	-	-
Reference Lake D	8		-	-	1.53	4.41	-	-	-	-	-	-	-	-

Values represent the factor by which average 2011 concentrations are higher than CCME guidelines; dashes represent average 2011 concentrations that are below CCME guidelines.

The average 2011 concentration of a particular parameter may be below the CCME guideline concentration even if a percentage of samples is higher than this guideline concentration.

Half the detection limit was substitued for values that were below the detection limit for the calculation of parameter averages.

For hardness-dependent guidelines, the average hardness over all sampling periods was used to determine the site-specific CCME guideline.

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) Interim guideline.

c) Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotriphic; 0.004-0.01 = Oligotrophic; 0.01-0.02 = Mesotrophic; 0.02-0.035 = Meso-eutrophic; 0.035-0.1 = Eutrophic; >0.1 = Hyper-eutrophic.

d) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{\{0.86[\log(hardness)]-3.2\}}$ */ 1000.*

e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{\{0.8545[\ln(hardness)]-1.465\}}$ ** 0.0002. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(hardness)]-4.705\}}$ */ 1000. Lead guideline is a minumum of 0.001 mg/L regardless of hardness.*

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}}$ */ 1000. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.*

Annex A.3-2. Lake Water Quality Data, Doris North Project, 2011

Site ID:				Doris Lake South	Doris Lake South	Doris Lake North	Doris Lake North	Reference Lake B	Reference Lake B	Little Roberts Lake	Little Roberts Lake	Reference Lake D	Reference Lake D	Doris Lake South	Doris Lake North	Doris Lake North	Reference Lake B	Reference Lake B	Reference Lake B	Little Roberts Lake	Little Roberts Lake	Reference Lake D	Reference Lake D
Depth Zone:				Surface	Deep	Surface	Deep	Surface	Deep	Surface	Surface	Surface	Surface	Surface	Surface	Deep	Surface	Deep	Deep	Surface	Surface	Surface	Surface
Depth Sampled (m):				2.7	5.0	2.4	11.3	2.5	8.4	2.0	2.0	2.0	2.0	1.0	1.0	11.0	1.0	9.0	9.0	1.0	1.0	1.0	1.0
Replicate:			Realized Detection Limit	1	1	1	1	1	1	1	2	1	2	1	1	1	1	1	2	1	2	1	2
Date Sampled:		CCME Guideline for the Protection of Aquatic Life[a]		24-Apr-11	24-Apr-11	24-Apr-11	24-Apr-11	22-Apr-11	22-Apr-11	22-Apr-11	22-Apr-11	22-Apr-11	22-Apr-11	19-Jul-11	19-Jul-11	19-Jul-11	18-Jul-11	18-Jul-11	18-Jul-11	20-Jul-11	20-Jul-11	20-Jul-11	20-Jul-11
ALS Sample ID:	Units			L998178-12	L998178-13	L998178-10	L998178-11	L998178-4	L998178-5	L998178-6	L998178-7	L998178-2	L998178-3	L1034068-9	L1034068-7	L1034068-8	L1034068-1	L1034068-2	L1034068-3	L1035341-1	L1035341-2	L1035341-3	L1035341-4
Physical Tests																							
Conductivity	µS/cm		2.0	331	335	332	332	65.5	57.3	594	597	250	252	237	242	258	40.5	41.2	41.1	239	234	87.7	88.4
Hardness (as $CaCO_3$)	mg/L		0.50	60.4	61.8	60.7	60.4	19.5	17.6	98.0	100	54.6	54.8	45.5	45.7	50.5	12.9	13.0	13.0	44.3	43.9	18.4	18.6
pH	pH	6.5-9.0	0.10	7.15	7.74	7.71	7.76	7.16	6.98	7.52	7.48	7.16	7.08	7.60	7.50	7.48	7.24	7.17	7.25	7.50	7.58	7.16	7.27
Total Suspended Solids	mg/L	dependent on background levels	1.0	6.7	4.1	5.7	2.3	<1.0	<1.0	2.1	1.3	12.7	15.3	4.6	6.4	3.8	1.0	1.0	<1.0	5.0	5.1	1.2	1.6
Turbidity	NTU	dependent on background levels	0.10	6.16	5.06	5.42	2.50	0.34	0.35	1.98	2.04	4.64	4.97	4.05	0.55	0.56	0.44	0.40	0.43	4.60	4.35	1.99	1.99
Anions and Nutrients																							
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	34.3	34.3	34.6	33.2	14.6	12.5	54.8	58.6	34.5	35.0	25.0	26.5	27.1	10.7	8.7	8.7	24.1	24.9	11.6	11.9
Ammonia (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	<0.0050	<0.0050	0.0300	0.0237	<0.0050	0.0474	0.0465	0.0278	0.0273	<0.0050	<0.0050	0.0212	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br^-)	mg/L		0.050	0.145	0.148	0.147	0.154	<0.050	<0.050	0.325	0.332	0.112	0.112	<0.050	0.173	0.194	<0.050	<0.050	<0.050	0.175	0.177	<0.050	0.059
Chloride (Cl^-)	mg/L	short-term: 640; long-term: 120	0.50	77.0	76.8	76.7	77.3	9.17	7.66	148	149	53.6	53.9	56.2	57.8	61.6	5.84	5.85	5.83	56.8	58.2	18.5	18.7
Fluoride (F^-)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.051	0.051	0.049	0.049	<0.020	<0.020	0.070	0.071	0.052	0.053	0.051	0.052	0.053	<0.020	<0.020	<0.020	0.052	0.062	0.034	0.034
Nitrate (as N)	mg/L	2.935[b]	0.0050 or 0.025	<0.0050	<0.0050	<0.0050	0.0872	0.0298	0.0702	0.114	0.111	0.0389	0.0389	<0.0050	<0.0050	0.0429	<0.0050	<0.0050	<0.0050	<0.0050	<0.025	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0026	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphorus	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0354	0.0289	0.0316	0.0201	0.0044	0.0053	0.0284	0.0283	0.0284	0.0298	0.0209	0.0252	0.0269	0.0031	0.0048	0.0044	0.0175	0.0188	0.0073	0.0077
Sulphate (SO_4^{2-})	mg/L		0.50	3.08	3.07	3.06	3.29	2.14	1.86	9.01	9.07	3.29	3.32	2.42	2.49	2.65	1.56	1.57	1.56	3.08	3.01	1.78	1.79
Cyanides																							
Total Cyanide	mg/L		0.0010 or 0.0011	0.0046	0.0051	0.0046	0.0043	0.0039	0.0025	0.0084	0.0071	0.0081	0.0081	0.0064	0.0054	0.0052	0.0034	0.0035	0.0031	0.0055	0.0047	0.0034	0.0033
Free Cyanide	mg/L	0.005	0.0010 or 0.0050	-	-	-	-	-	-	-	-	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Organic Carbon																							
Total Organic Carbon	mg/L		0.50	5.79	5.84	5.66	5.31	3.09	2.23	8.23	8.01	7.03	7.10	6.00	6.26	6.20	2.97	3.00	2.95	5.62	5.78	4.02	4.26
Total Metals																							
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0306	0.0070	0.0072	0.0078	0.0064	0.0061	0.0410	0.0378	0.424	0.424	0.0752	0.122	0.0552	0.0126	0.0146	0.0138	0.145	0.127	0.115	0.111
Antimony (Sb)	mg/L		0.000010	0.000023	0.000020	0.000023	0.000017	<0.000010	<0.000010	0.000028	0.000047	0.000050	0.000048	0.000016	0.000014	0.000013	<0.000010	<0.000010	<0.000010	0.000016	0.000017	0.000010	<0.000010
Arsenic (As)	mg/L	0.005	0.000050	0.000290	0.000272	0.000272	0.000263	0.000102	0.000067	0.000426	0.000415	0.000318	0.000284	0.000227	0.000259	0.000294	0.000065	0.000067	0.000064	0.000282	0.000232	0.000129	0.000121
Barium (Ba)	mg/L		0.00010	0.00306	0.00298	0.00279	0.00340	0.00323	0.00279	0.00793	0.00829	0.0106	0.0103	0.00354	0.00363	0.00356	0.00166	0.00164	0.00166	0.00396	0.00398	0.00258	0.00268
Beryllium (Be)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000142	0.0000140	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000060	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.0050 or 0.010	0.031	0.033	0.034	0.032	0.012	0.011	0.058	0.058	0.029	0.028	0.0232	0.0226	0.0242	0.0065	0.0061	0.0068	0.0240	0.0266	0.0131	0.0126
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	0.0000064	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000070	0.0000153	0.0000551	0.0000536	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)	mg/L		0.050	10.8	11.1	10.9	10.7	4.67	4.25	14.6	14.9	8.87	8.91	8.25	8.31	9.37	3.16	3.17	3.17	7.54	7.53	2.89	2.94
Cesium (Cs)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000287	0.0000253	<0.0000050	0.0000058	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000078	0.0000073	0.0000064	0.0000060
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00121	0.00115	<0.00050	<0.00050	<0.00050	0.00073	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000088	0.000079	0.000317	0.000303	0.000052	0.000082	0.000053	<0.000050	<0.000050	<0.000050	0.000078	0.000077	<0.000050	<0.000050
Copper (Cu)	mg/L	≥0.002[e]	0.00050	0.00164	0.00160	0.00157	0.00152	0.00100	0.00081	0.00229	0.00239	0.00179	0.00179	0.00161	0.00156	0.00156	0.00090	0.00085	0.00078	0.00166	0.00145	0.00125	0.00136
Gallium (Ga)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000142	0.000139	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.042	<0.030	<0.030	<0.030	<0.030	<0.030	0.552	0.545	1.44	1.39	0.163	0.233	0.258	0.040	0.043	0.044	0.233	0.220	0.139	0.131
Lead (Pb)	mg/L	≥0.001[f]	0.000050	0.000122	<0.000050	0.000560	<0.000050	0.000096	0.000084	<0.000050	0.000077	0.0138	0.0138	0.00223	0.000263	0.000054	0.000129	0.000084	<0.000050	0.000200	0.000244	0.00527	0.00161
Lithium (Li)	mg/L		0.00020	0.00413	0.00432	0.00425	0.00393	0.00061	0.00053	0.00549	0.00545	0.00348	0.00338	0.00336	0.00330	0.00375	0.00043	0.00041	0.00042	0.00288	0.00310	0.00127	0.00123
Magnesium (Mg)	mg/L		0.10	8.09	8.28	8.13	8.17	1.90	1.68	14.9	15.2	7.87	7.90	6.05	6.06	6.58	1.22	1.24	1.24	6.18	6.08	2.71	2.72
Manganese (Mn)	mg/L		0.00020	0.00437	0.00352	0.00332	0.00595	0.00068	0.0109	0.0758	0.0651	0.0994	0.105	0.0148	0.0250	0.0409	0.00249	0.00291	0.00299	0.0118	0.0105	0.00422	0.00418
Mercury (Hg)	mg/L	Inorganic Hg: 0.000026	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	-	-	-	-	-	-	-	-	-	-
Mercury (Hg) (ultra low-level)	µg/L	Inorganic Hg: 0.026	0.00050	-	-	-	-	-	-	-	-	-	-	0.00160	0.00160	0.00180	0.00110	0.00100	0.00100	0.00180	0.00140	0.00130	0.00140
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000196	0.000214	0.000215	0.000183	<0.000050	<0.000050	0.000247	0.000253	0.000070	0.000061	0.000178	0.000176	0.000186	<0.000050	<0.000050	<0.000050	0.000198	0.000190	0.000068	0.000064
Nickel (Ni)	mg/L	≥0.025[g]	0.00020	0.00060	0.00063	0.00059	0.00048	0.00026	0.00029	0.00091	0.00094	0.00158	0.00156	0.00073	0.00072	0.00067	0.00074	0.00026	0.00023	0.00078	0.00062	0.00052	0.00052
Phosphorus (P)	mg/L		0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.8	2.8	2.8	2.8	<2.0	<2.0	4.9	5.0	2.8	2.8	2.2	2.2	2.4	<2.0	<2.0	<2.0	2.2	2.1	<2.0	<2.0
Rhenium (Re)	mg/L		0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00175	0.00179	0.00173	0.00166	0.00108	0.000925	0.00291	0.00293	0.00333	0.00327	0.00146	0.00154	0.00155	0.000733	0.000711	0.000719	0.00159	0.00157	0.00119	0.00117
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.49	1.46	1.43	1.50	0.204	0.641	2.23	2.26	2.16	1.97	1.30	1.41	1.47	0.145	0.150	0.155	1.25	1.17	0.475	0.451
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	39.4	40.4	39.8	40.9	5.0	4.3	80.7	82.7	29.8	29.7	29.2	29.3	32.3	3.3	3.4	3.4	29.0	28.4	10.3	10.2
Strontium (Sr)	mg/L		0.000050	0.0523	0.0533	0.0531	0.0536	0.0222	0.0198	0.0898	0.0936	0.0522	0.0538	0.0393	0.0391	0.0466	0.0144	0.0148	0.0143	0.0394	0.0360	0.0160	0.0161
Tellurium (Te)	mg/L		0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	0.0000021	<0.0000020	<0.0000020	<0.0000020	0.0000079	0.0000073	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	0.0000033	0.0000045	0.0000021	0.0000020
Thorium (Th)	mg/L		0.0000050 to 0.000035	0.0000187	0.0000106	0.0000112	0.0000087	0.0000162	0.0000086	0.0000387	0.0000369	0.000223	0.000223	0.0000394	0.0000488	<0.000035	<0.000015	<0.000015	<0.000015	0.0000705	0.0000666	0.0000590	0.0000569
Tin (Sn)	mg/L		0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00149	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	0.00128	0.00102	0.0205	0.0201	0.00206	0.00414	0.00160	0.00026	0.00031	0.00031	0.00492	0.00420	0.00375	0.00357
Tungsten (W)	mg/L		0.000010 to 0.000060	0.000018	0.000023	0.000022	0.000034	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000040	<0.000040	<0.000040	<0.000040	<0.000040	<0.000040	<0.000050	<0.000060	<0.000050	<0.000050
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000414	0.0000408	0.0000411	0.0000372	0.0000472	0.0000261	0.0000606	0.0000611	0.0000852	0.0000827	0.0000360	0.0000375	0.0000341	0.0000465	0.0000447	0.0000448	0.0000492	0.0000449	0.0000353	0.0000347
Vanadium (V)	mg/L		0.000050	0.000115	0.000069	0.000071	0.000063	<0.000050	<0.000050	0.000188	0.000180	0.000984	0.000951	0.000208	0.000313	0.000159	<0.000050	<0.000050	<0.000050	0.000336	0.000296	0.000224	0.000214
Yttrium (Y)	mg/L		0.0000050	0.0000236	0.0000183	0.0000171	0.0000174	0.0000149	0.0000161	0.0000621	0.0000595	0.000238	0.000216	0.0000447	0.0000762	0.0000396	0.0000207	0.0000208	0.0000256	0.0000687	0.0000622	0.0000472	0.0000455
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	<0.0030	<0.0030	<0.0030	0.0036	0.0034	<0.0030	<0.0030	0.0060	0.0062	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000087	0.000081	0.000183	0.000200	0.000118	0.000107	0.000082	<0.000050	<0.000050	<0.000050	0.000118	0.000178	0.000090	0.000085
Radiochemistry																							
Radium-226	Bq/L		0.005	0.008	<0.005	<0.005	<0.005	0.01	0.009	<0.005	0.009	<0.005	<0.005	0.01	0.007	0.009	<0.005	<0.005	<0.005	<0.005	0.03*	<0.005	0.007

Notes:

Shaded cells indicate values that are both above analytical detection limits and exceed CCME guidelines for the protection of freshwater aquatic life.

** According to SRC Analytical laboratory goup, this sample did not meet the criteria for adequate preservation for radium-226 analysis; therefore the radium-226 result may not accurately reflect the concentration at the time of sampling. This result was excluded from all graphs and analyses.*

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) Interim guideline.

c) Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotrophic; 0.004-0.01 = Oligotrophic; 0.01-0.02 = Mesotrophic; 0.02-0.035 = Meso-eutrophic; 0.035-0.1 = Eutrophic; >0.1 = Hyper-eutrophic.

d) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{\{0.86[\log(hardness)]-3.2\}}$ */ 1000.*

e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{\{0.8545[\ln(hardness)]-1.465\}}$ ** 0.0002. Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(hardness)]-4.705\}}$ */ 1000. Lead guideline is a minimum of 0.001 mg/L regardless of hardness.*

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}}$ */ 1000. Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.*

Annex A.3-2. Lake Water Quality Data, Doris North Project, 2011

Site ID:	Units	CCME Guideline for the Protection of Aquatic Life[a]	Realized Detection Limit	Doris Lake South	Doris Lake South	Doris Lake South	Doris Lake South	Doris Lake North	Doris Lake North	Doris Lake North	Doris Lake North	Reference Lake B	Reference Lake B	Little Roberts Lake	Little Roberts Lake	Reference Lake D	Reference Lake D	Reference Lake D	Reference Lake D	Doris Lake South	Doris Lake South	Doris Lake North	Doris Lake North	Doris Lake North	Reference Lake B	Reference Lake B	Little Roberts Lake	Reference Lake D	Reference Lake D	Roberts Lake	Roberts Lake
Depth Zone:				Surface	Surface	Deep	Deep	Surface	Surface	Deep	Deep	Surface	Deep	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Deep	Deep	Surface	Deep	Surface	Surface	Surface	Surface	Surface
Depth Sampled:				1.0	1.0	7.0	7.0	1.0	1.0	12.0	12.0	1.0	9.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	9.0	9.0	1.0	8.0	1.0	1.0	1.0	0.5	0.5
Replicate:				1	1	1	1	1	1	1	1	1	1	1	2	1	2	1	2	1	2	1	1	2	1	1	1	1	2	1	2
Date Sampled:				16-Aug-11	21-Aug-11	16-Aug-11	21-Aug-11	16-Aug-11	21-Aug-11	16-Aug-11	21-Aug-11	20-Aug-11	20-Aug-11	23-Aug-11	23-Aug-11	17-Aug-11	17-Aug-11	21-Aug-11	21-Aug-11	19-Sep-11	19-Sep-11	19-Sep-11	19-Sep-11	19-Sep-11	18-Sep-11	18-Sep-11	24-Sep-11	26-Sep-11	26-Sep-11	24-Sep-11	24-Sep-11
ALS Sample ID:				L1047022-3	L1049435-10	L1047022-4	L1049435-11	L1047022-1	L1049435-6	L1047022-2	L1049435-9	L1049435-15	L1049435-14	L1049431-5	L1049431-6	L1047022-14	L1047022-15	L1049435-7	L1049435-8	L1062181-1	L1062181-2	L1062181-3	L1062181-4	L1062181-5	L1060789-2	L1060789-3	L1064723-3	L1064722-1	L1064722-2	L1064723-1	L1064723-2
Physical Tests																															
Conductivity	μS/cm		2.0	248	-	247	-	249	-	248	-	43.6	43.6	261	261	102	101	-	-	255	256	257	257	259	45.0	44.6	265	108	107	251	250
Hardness (as $CaCO_3$)	mg/L		0.50	49.5	-	47.4	-	47.7	-	47.2	-	12.9	13.2	51.1	50.2	20.3	20.6	-	-	48.2	47.2	49.1	47.9	48.8	14.0	14.2	47.8	21.8	21.6	40.7	40.4
pH	pH	6.5-9.0	0.10	7.35	-	7.27	-	7.41	-	7.27	-	7.35	7.34	7.68	7.68	7.24	6.58	-	-	7.43	7.56	7.58	7.60	7.58	7.04	7.06	7.69	7.50	7.38	7.59	7.63
Total Suspended Solids	mg/L	dependent on background levels	1.0	2.8	-	4.0	-	3.0	-	4.4	-	<1.0	<1.0	6.6	6.0	<1.0	<1.0	-	-	5.8	5.8	4.8	5.4	5.0	<1.0	<1.0	5.1	<1.0	1.1	4.3	4.1
Turbidity	NTU	dependent on background levels	0.10	4.05	-	5.75	-	4.20	-	4.97	-	0.51	0.44	7.86	7.99	1.77	2.01	-	-	7.82	7.07	7.42	6.73	6.87	0.66	0.49	5.68	1.98	2.06	4.11	4.65
Anions and Nutrients																															
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	26.7	-	25.9	-	26.5	-	26.3	-	10.0	9.6	27.9	28.3	12.6	12.0	-	-	27.6	27.8	27.7	27.5	27.9	9.8	10.0	25.2	13.5	12.5	21.2	21.5
Ammonia (as N)	mg/L	pH- and temperature-dependent	0.0050	<0.0050	-	0.0305	-	0.0300	-	<0.0050	-	0.0142	0.0153	0.0218	0.0220	<0.0050	<0.0050	-	-	0.0052	0.0056	0.0050	0.0055	<0.0050	0.0094	<0.0050	0.0085	<0.0050	<0.0050	0.0070	0.0243
Bromide (Br^-)	mg/L		0.050	0.188	-	0.180	-	0.187	-	0.152	-	<0.050	<0.050	0.196	0.206	0.070	0.056	-	-	0.220	0.210	0.214	0.207	0.207	<0.050	<0.050	0.206	0.058	0.067	0.212	0.215
Chloride (Cl^-)	mg/L	short-term: 640; long-term: 120	0.50	57.9	-	58.0	-	58.1	-	58.6	-	6.30	6.31	61.1	60.9	21.7	21.7	-	-	59.4	59.6	59.9	60.0	60.0	6.41	6.41	61.2	22.2	22.1	59.1	59.1
Fluoride (F^-)	mg/L	Inorganic fluorides: 0.12[b]	0.020	0.053	-	0.053	-	0.055	-	0.053	-	<0.020	<0.020	0.054	0.054	0.037	0.037	-	-	0.056	0.055	0.056	0.056	0.056	0.021	0.021	0.051	0.038	0.038	0.047	0.048
Nitrate (as N)	mg/L	2.935[b]	0.0050 or 0.025	<0.0050	-	<0.0050	-	0.0713	-	<0.0050	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0120	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite (as N)	mg/L	0.06	0.0010	<0.0010	-	<0.0010	-	<0.0010	-	<0.0010	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Total Phosphorus	mg/L	Trigger ranges from guidance framework[c]	0.0020	0.0190	-	0.0258	-	0.0178	-	0.0251	-	0.0041	0.0037	0.0267	0.0257	0.0075	0.0075	-	-	0.0298	0.0296	0.0293	0.0278	0.0277	0.0043	0.0040	0.0239	0.0074	0.0073	0.0197	0.0216
Sulphate (SO_4^{2-})	mg/L		0.50	2.48	-	2.48	-	2.51	-	2.51	-	1.61	1.60	3.11	3.09	1.96	1.96	-	-	2.71	2.72	2.72	2.74	2.75	1.67	1.68	4.70	2.42	2.40	4.63	4.62
Cyanides																															
Total Cyanide	mg/L		0.0010 or 0.0011	0.0043	-	0.0041	-	0.0042	-	0.0040	-	0.0031	0.0029	<0.0010	0.0028	0.0031	0.0032	-	-	0.0033	0.0029	0.0047	0.0053	0.0032	0.0025	0.0026	<0.0010	0.0028	0.0052	0.0028	0.0036
Free Cyanide	mg/L	0.005	0.0010 or 0.0050	<0.0010	-	0.0020	-	<0.0010	-	<0.0010	-	<0.0010	<0.0010	<0.0010	<0.0010	0.0034	0.0018	-	-	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic Carbon																															
Total Organic Carbon	mg/L		0.50	6.35	-	6.54	-	6.11	-	6.32	-	3.34	3.26	6.46	6.47	4.69	4.75	-	-	6.87	6.97	6.68	6.71	6.70	3.47	3.49	6.40	5.26	5.24	5.82	5.79
Total Metals																															
Aluminum (Al)	mg/L	0.005 if pH<6.5; 0.1 if pH≥6.5	0.0030	0.0311	-	0.0341	-	0.0315	-	0.0327	-	0.0127	0.0096	0.217	0.224	0.0639	0.0706	-	-	0.0600	0.0595	0.0459	0.0597	0.0601	0.0133	0.0118	0.108	0.0812	0.0835	0.0981	0.0846
Antimony (Sb)	mg/L		0.000010	0.000014	-	0.000015	-	0.000014	-	0.000013	-	<0.000010	<0.000010	0.000013	0.000013	<0.000010	<0.000010	-	-	0.000017	0.000015	0.000016	0.000015	0.000015	<0.000010	<0.000010	0.000019	0.000013	0.000014	0.000026	0.000018
Arsenic (As)	mg/L	0.005	0.000050	0.000275	-	0.000247	-	0.000266	-	0.000272	-	0.000084	0.000081	0.000292	0.000296	0.000143	0.000138	-	-	0.000320	0.000299	0.000348	0.000303	0.000314	0.000087	0.000076	0.000275	0.000144	0.000108	0.000250	0.000283
Barium (Ba)	mg/L		0.00010	0.00890	-	0.00360	-	0.0131	-	0.00450	-	0.00174	0.00177	0.00486	0.00480	0.00310	0.00283	-	-	0.00432	0.00316	0.00327	0.00305	0.00325	0.0221	0.00190	0.00422	0.00269	0.00240	0.00637	0.00319
Beryllium (Be)	mg/L		0.0000050	<0.0000050	-	<0.0000050	-	<0.0000050	-	<0.0000050	-	<0.0000050	<0.0000050	0.0000062	0.0000072	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)	mg/L		0.000050	<0.000050	-	<0.000050	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)	mg/L	short-term: 29; long-term: 1.5	0.0050 or 0.010	0.0207	-	0.0204	-	0.0203	-	0.0200	-	0.0067	0.0067	0.0233	0.0228	0.0117	0.0118	-	-	0.0295	0.0260	0.0281	0.0271	0.0281	0.0067	0.0075	0.0273	0.0136	0.0136	0.0285	0.0275
Cadmium (Cd)	mg/L	equation[b,d]	0.0000050	<0.0000050	-	<0.0000050	-	<0.0000050	-	<0.0000050	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000151	<0.0000050	<0.0000050	0.0000151	0.0000142
Calcium (Ca)	mg/L		0.050	9.03	-	8.63	-	8.68	-	8.58	-	3.16	3.21	9.43	9.29	3.15	3.18	-	-	8.99	8.76	9.17	8.94	9.11	3.36	3.40	8.11	3.39	3.36	5.79	5.75
Cesium (Cs)	mg/L		0.0000050	<0.0000050	-	<0.0000050	-	<0.0000050	-	<0.0000050	-	<0.0000050	<0.0000050	0.0000112	0.0000114	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000052	<0.0000050	<0.0000050	0.0000052	<0.0000050
Chromium (Cr)	mg/L	Cr(VI): 0.001; Cr(III): 0.0089[b]	0.00050	<0.00050	-	<0.00050	-	<0.00050	-	<0.00050	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	-	-	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	-	<0.000050	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	0.000114	0.000112	<0.000050	<0.000050	-	-	<0.000050	<0.000050	<0.000050	<0.000050	0.000050	<0.000050	<0.000050	0.000059	0.000055	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	≥0.002[e]	0.00050	0.00144	-	0.00142	-	0.00167	-	0.00133	-	0.00064	0.00070	0.00149	0.00147	0.00102	0.00104	-	-	0.00156	0.00145	0.00143	0.00139	0.00145	0.00087	0.00081	0.00167	0.00131	0.00139	0.00165	0.00158
Gallium (Ga)	mg/L		0.000050	<0.000050	-	<0.000050	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	0.000064	0.000067	<0.000050	<0.000050	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)	mg/L	0.3	0.030	0.065	-	0.073	-	0.067	-	0.093	-	<0.030	<0.030	0.388	0.384	0.167	0.163	-	-	0.123	0.120	0.127	0.126	0.132	<0.030	<0.030	0.166	0.122	0.121	0.118	0.106
Lead (Pb)	mg/L	≥0.001[f]	0.000050	<0.000050	-	<0.000050	-	0.000082	-	<0.000050	-	<0.000050	<0.000050	0.000083	0.000080	<0.000050	<0.000050	-	-	0.00126	0.000467	0.000068	<0.000050	0.000190	0.00105	0.000074	0.00104	0.000385	0.000399	0.00232	0.00126
Lithium (Li)	mg/L		0.00020	0.00307	-	0.00294	-	0.00294	-	0.00294	-	0.00043	0.00042	0.00378	0.00377	0.00120	0.00120	-	-	0.00358	0.00344	0.00363	0.00345	0.00367	0.00046	0.00046	0.00317	0.00139	0.00139	0.00249	0.00251
Magnesium (Mg)	mg/L		0.10	6.55	-	6.28	-	6.33	-	6.25	-	1.22	1.26	6.70	6.55	3.03	3.08	-	-	6.26	6.14	6.36	6.21	6.32	1.38	1.39	6.69	3.24	3.20	6.36	6.33
Manganese (Mn)	mg/L		0.00020	0.00715	-	0.00949	-	0.00734	-	0.0151	-	0.00144	0.00141	0.0134	0.0132	0.00906	0.00815	-	-	0.0233	0.0236	0.0284	0.0270	0.0283	0.00143	0.00141	0.00930	0.00392	0.00397	0.00409	0.00398
Mercury (Hg)	mg/L	Inorganic Hg: 0.000026	0.000010	<0.000010	-	<0.000010	-	<0.000010	-	<0.000010	-	-	-	-	-	<0.000010	<0.000010	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mercury (Hg) (ultra low-level)	μg/L	Inorganic Hg: 0.026	0.00050	-	0.00083	-	0.00107	-	0.00076	-	0.00078	0.00057	0.00057	0.00185	0.00192	-	-	0.00075	0.00073	0.00144	0.00164	0.00291	0.00176	0.00169	0.00137	0.00088	0.00192	0.00119	0.00124	0.00267	0.00241
Molybdenum (Mo)	mg/L	0.073[b]	0.000050	0.000185	-	0.000174	-	0.000187	-	0.000176	-	<0.000050	<0.000050	0.000186	0.000191	0.000084	0.000081	-	-	0.000214	0.000210	0.000219	0.000209	0.000223	0.000053	<0.000050	0.000206	0.000075	0.000076	0.000217	0.000201
Nickel (Ni)	mg/L	≥0.025[g]	0.00020	0.00059	-	0.00062	-	0.00056	-	0.00058	-	<0.00020	<0.00020	0.00073	0.00076	0.00044	0.00043	-	-	0.00061	0.00055	0.00131	0.00060	0.00062	0.00021	<0.00020	0.00065	0.00046	0.00046	0.00054	0.00055
Phosphorus (P)	mg/L		0.30	<0.30	-	<0.30	-	<0.30	-	<0.30	-	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	-	-	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)	mg/L		2.0	2.3	-	2.2	-	2.2	-	2.2	-	<2.0	<2.0	2.3	2.2	<2.0	<2.0	-	-	2.3	2.2	2.3	2.2	2.3	<2.0	<2.0	2.2	<2.0	<2.0	2.1	2.1
Rhenium (Re)	mg/L		0.0000050	<0.0000050	-	<0.0000050	-	<0.0000050	-	<0.0000050	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)	mg/L		0.000020	0.00146	-	0.00140	-	0.00141	-	0.00142	-	0.000724	0.000713	0.00170	0.00171	0.00116	0.00119	-	-	0.00153	0.00147	0.00152	0.00149	0.00156	0.000818	0.000830	0.00150	0.00112	0.00113	0.00144	0.00143
Selenium (Se)	mg/L	0.001	0.00020	<0.00020	-	<0.00020	-	<0.00020	-	<0.00020	-	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	-	-	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)	mg/L		0.050	1.23	-	1.21	-	1.19	-	1.23	-	0.132	0.140	1.68	1.61	0.323	0.336	-	-	1.34	1.31	1.31	1.32	1.35	0.162	0.158	1.38	0.560	0.540	0.923	0.883
Silver (Ag)	mg/L	0.0001	0.0000050	<0.0000050	-	<0.0000050	-	<0.0000050	-	<0.0000050	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	-	-	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)	mg/L		2.0	31.8	-	30.2	-	30.7	-	30.4	-	3.1	3.2	30.8	30.1	12.5	12.4	-	-	29.1	28.6	29.5	28.8	29.5	3.8	3.8	31.5	12.5	12.1	32.6	32.2
Strontium (Sr)	mg/L		0.000050	0.0404	-	0.0389	-	0.0394	-	0.0391	-	0.0139	0.0140	0.0450	0.0421	0.0170	0.0174	-	-	0.0433	0.0426	0.0435	0.0428	0.0433	0.0151	0.0151	0.0434	0.0187	0.0186	0.0380	0.0368
Tellurium (Te)	mg/L		0.000010	<0.000010	-	<0.000010	-	<0.000010	-	<0.000010	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	-	-	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)	mg/L	0.0008	0.0000020	<0.0000020	-	<0.0000020	-	<0.0000020	-	<0.0000020	-	<0.0000020	<0.0000020	0.0000030	0.0000030	<0.0000020	<0.0000020	-	-	0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	0.0000025	<0.0000020
Thorium (Th)	mg/L		0.0000050 to 0.000035	0.0000218	-	0.0000210	-	0.0000194	-	0.0000227	-	0.0000078	0.0000081	0.0000856	0.0000836	0.0000309	0.0000347	-	-	0.0000224	0.0000216	0.0000188	0.0000234	0.0000269	0.0000098	0.0000089	0.0000464	0.0000512	0.0000522	0.0000461	0.0000432
Tin (Sn)	mg/L		0.00020	<0.00020	-	<0.00020	-	0.00044	-	<0.00020	-	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	-	-	0.00040	<0.00020	<0.00020	<0.00020	<0.00020	0.00057	<0.00020	<0.00020	<0.00020	<0.00020	0.00021	<0.00020
Titanium (Ti)	mg/L		0.00020	0.00067	-	0.00072	-	0.00071	-	0.00075	-	<0.00020	0.00021	0.00865	0.00918	0.00177	0.00205	-	-	0.00182	0.00167	0.00135	0.00167	0.00172	0.00038	0.00025	0.00312	0.00219	0.00223	0.00260	0.00250
Tungsten (W)	mg/L		0.000010 to 0.000060	0.000015	-	0.000012	-	0.000020	-	0.000014	-	<0.000010	<0.000010	0.000014	0.000023	<0.000010	<0.000010	-	-	0.000016	0.000013	0.000016	0.000015	0.000016	<0.000010	<0.000010	0.000011	<0.000010	<0.000010	0.000016	<0.000010
Uranium (U)	mg/L	short-term: 0.033; long-term: 0.015	0.0000020	0.0000372	-	0.0000344	-	0.0000363	-	0.0000357	-	0.0000371	0.0000395	0.0000424	0.0000370	0.0000361	0.0000383	-	-	0.0000387	0.0000386	0.0000401	0.0000387	0.0000398	0.0000462	0.0000471	0.0000439	0.0000789	0.0000796	0.0000521	0.0000512
Vanadium (V)	mg/L		0.000050	0.000112	-	0.000112	-	0.000118	-	0.000119	-	<0.000050	<0.000050	0.000431	0.000445	0.000131	0.000156	-	-	0.000204	0.000200	0.000177	0.000192	0.000189	<0.000050	<0.000050	0.000227	0.000143	0.000150	0.000193	0.000184
Yttrium (Y)	mg/L		0.0000050	0.0000220	-	0.0000232	-	0.0000220	-	0.0000234	-	0.0000102	0.0000104	0.0000642	0.0000666	0.0000290	0.0000315	-	-	0.0000285	0.0000277	0.0000247	0.0000251	0.0000274	0.0000124	0.0000123	0.0000511	0.0000578	0.0000584	0.0000545	0.0000495
Zinc (Zn)	mg/L	0.03	0.0030	<0.0030	-	<0.0030	-	<0.0030	-	<0.0030	-	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	-	-	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	0.000054	-	0.000053	-	0.000055	-	0.000054	-	<0.000050	0.000066	0.000111	0.000109	0.000062	<0.000050	-	-	0.000057	0.000064	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000084	0.000094	0.000093	0.000096	0.000079
Radiochemistry																															
Radium-226	Bq/L		0.005	<0.005	-	<0.005	-	<0.005	-	<0.005	-	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-	0.01	<0.005	<0.005	<0.005	0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005

Notes:

Shaded cells indicate values that are both above analytical detection limits and exceed CCME guidelines for the protection of freshwater aquatic life.

** According to SRC Analytical laboratory goup, this sample did not meet the criteria for adequate preservation for radium-226 analysis; therefore the radium-226 result may not accurately reflect the concentration at the time of sampling. This result was excluded from all graphs and analyses.*

a) Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) Interim guideline.

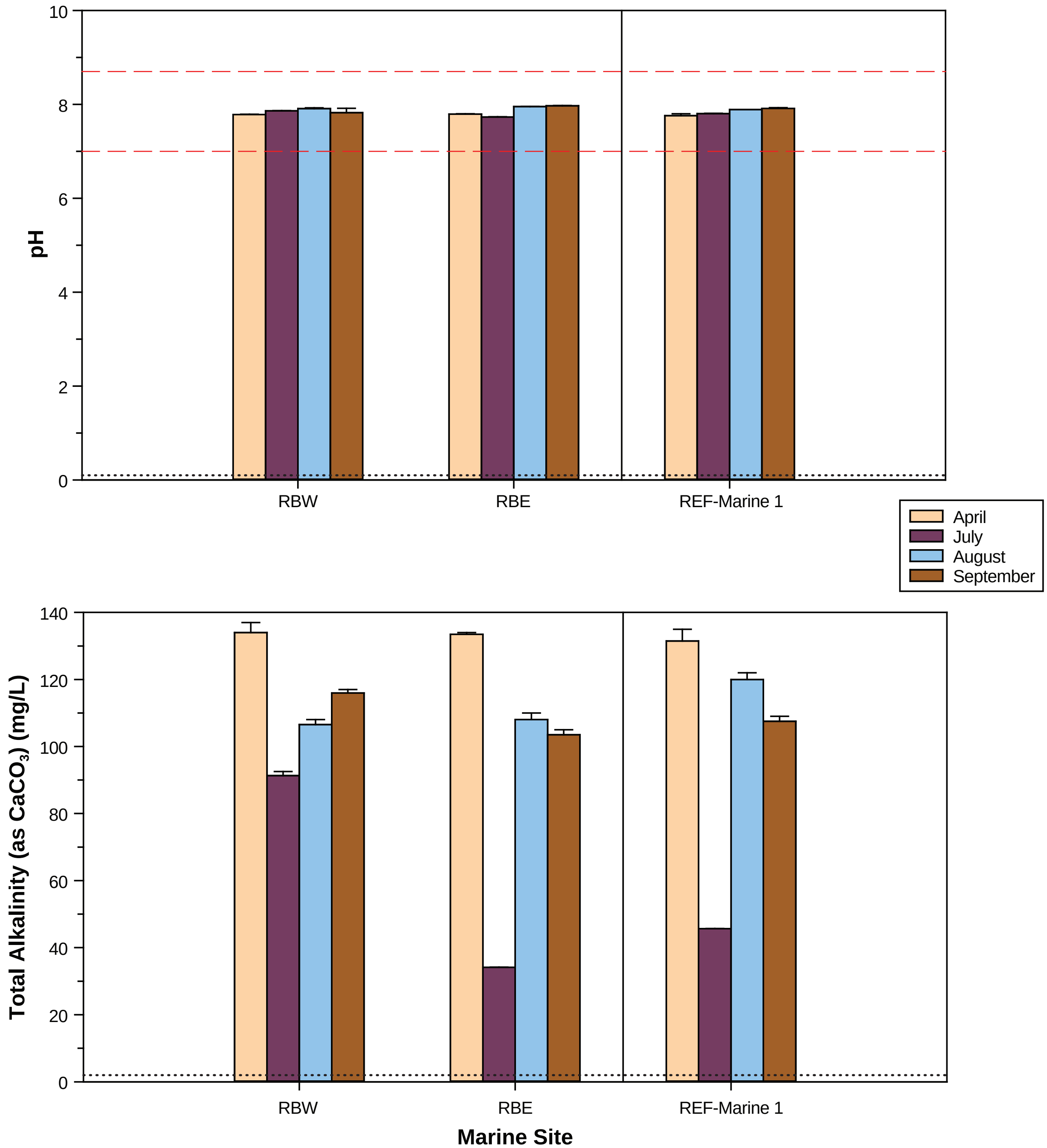
c) Total phosphorus trigger ranges for lakes and rivers (mg/L): <0.004 = Ultra-oligotrophic; 0.004-0.01 = Oligotrophic; 0.01-0.02 = Mesotrophic; 0.02-0.035 = Meso-eutrophic; 0.035-0.1 = Eutrophic; >0.1 = Hyper-eutrophic.

d) Guideline is hardness-dependent: cadmium guideline (mg/L) = $10^{\{0.86[\log(hardness)]-3.2\}} / 1000$.

e) Guideline is hardness-dependent: copper guideline (mg/L) = $e^{\{0.8545[\ln(hardness)]-1.465\}} * 0.0002$. *Copper guideline is a minimum of 0.002 mg/L regardless of water hardness.*

f) Guideline is hardness-dependent: lead guideline (mg/L) = $e^{\{1.273[\ln(hardness)]-4.705\}} / 1000$. *Lead guideline is a minimum of 0.001 mg/L regardless of hardness.*

g) Guideline is hardness-dependent: nickel guideline (mg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}} / 1000$. *Nickel guideline is a minimum of 0.025 mg/L regardless of water hardness.*



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits.
Red dashed lines represent the CCME marine and estuarine guideline pH range (7.0–8.7).
pH is a required parameter for water quality monitoring as per Schedule 5, s. 7(1)(c) of the MMER.
Total alkalinity is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.

NEWMONT NORTH AMERICA

pH and Total Alkalinity in Marine Sites, Doris North Project, 2011

Figure A.3-19

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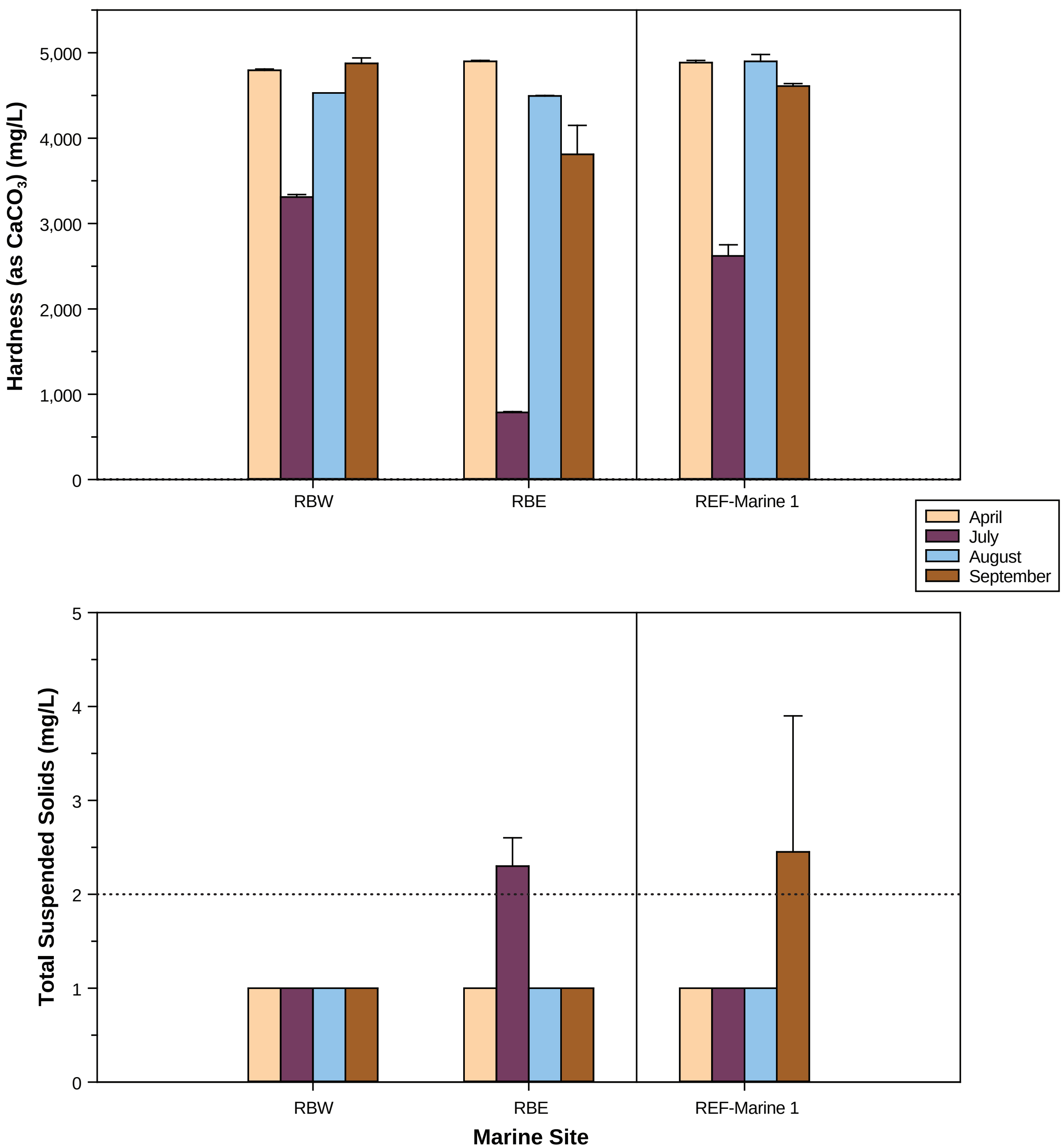

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The CCME marine guideline for total suspended solids is dependent upon background levels.
Hardness is a required parameter for effluent characterization and water quality monitoring as per Schedule 5, s. 4(1) and s. 7(1)(c) of the MMER.
Total suspended solids are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

Figure A.3-20

Hardness and Total Suspended Solids in Marine Sites, Doris North Project, 2011

NEWMONT NORTH AMERICA

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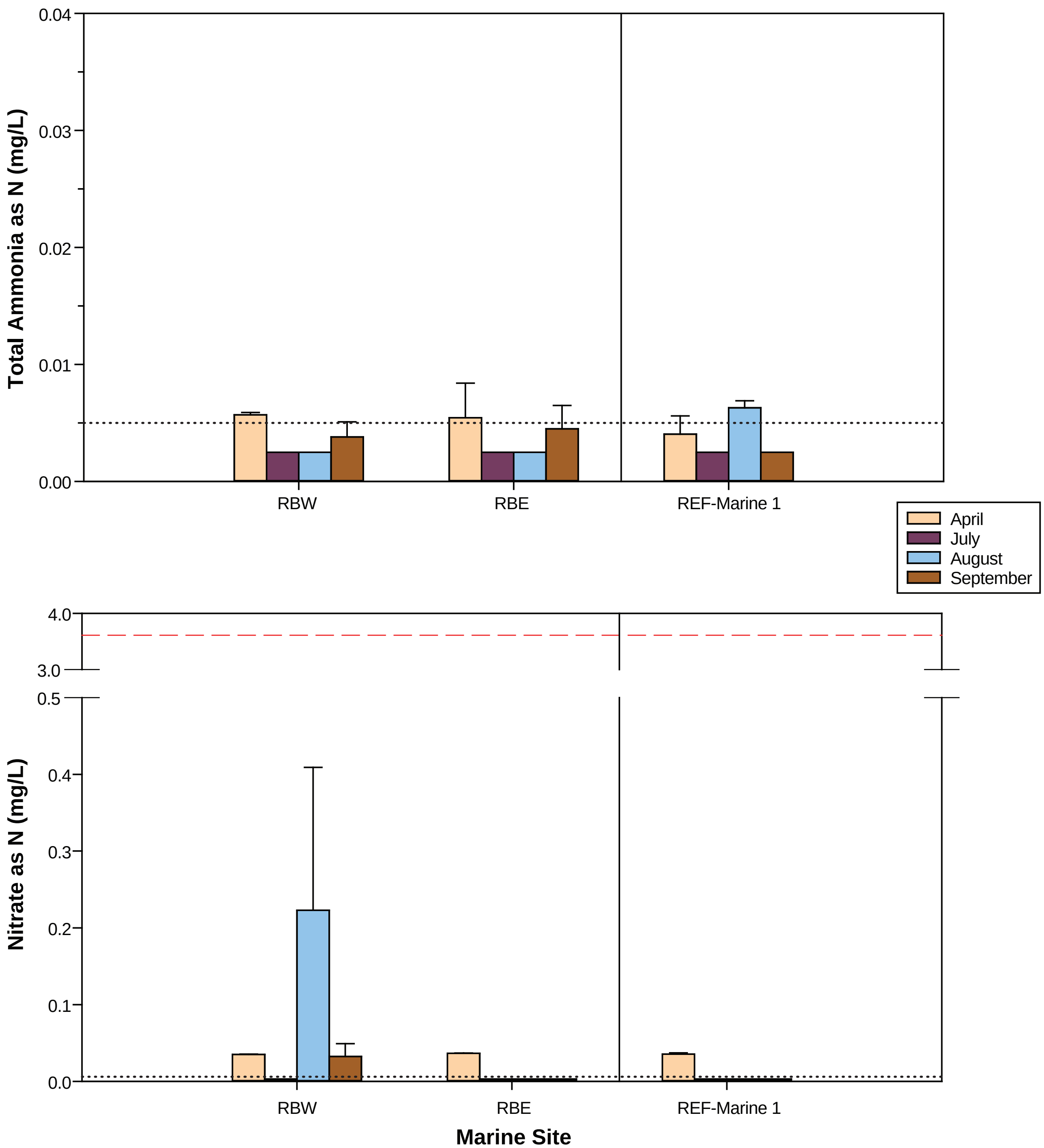

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed line represents the interim CCME marine guideline for nitrate as N (3.612 mg/L).
Total ammonia and nitrate are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

NEWMONT NORTH AMERICA

Total Ammonia and Nitrate Concentrations in Marine Sites, Doris North Project, 2011

Figure A.3-21

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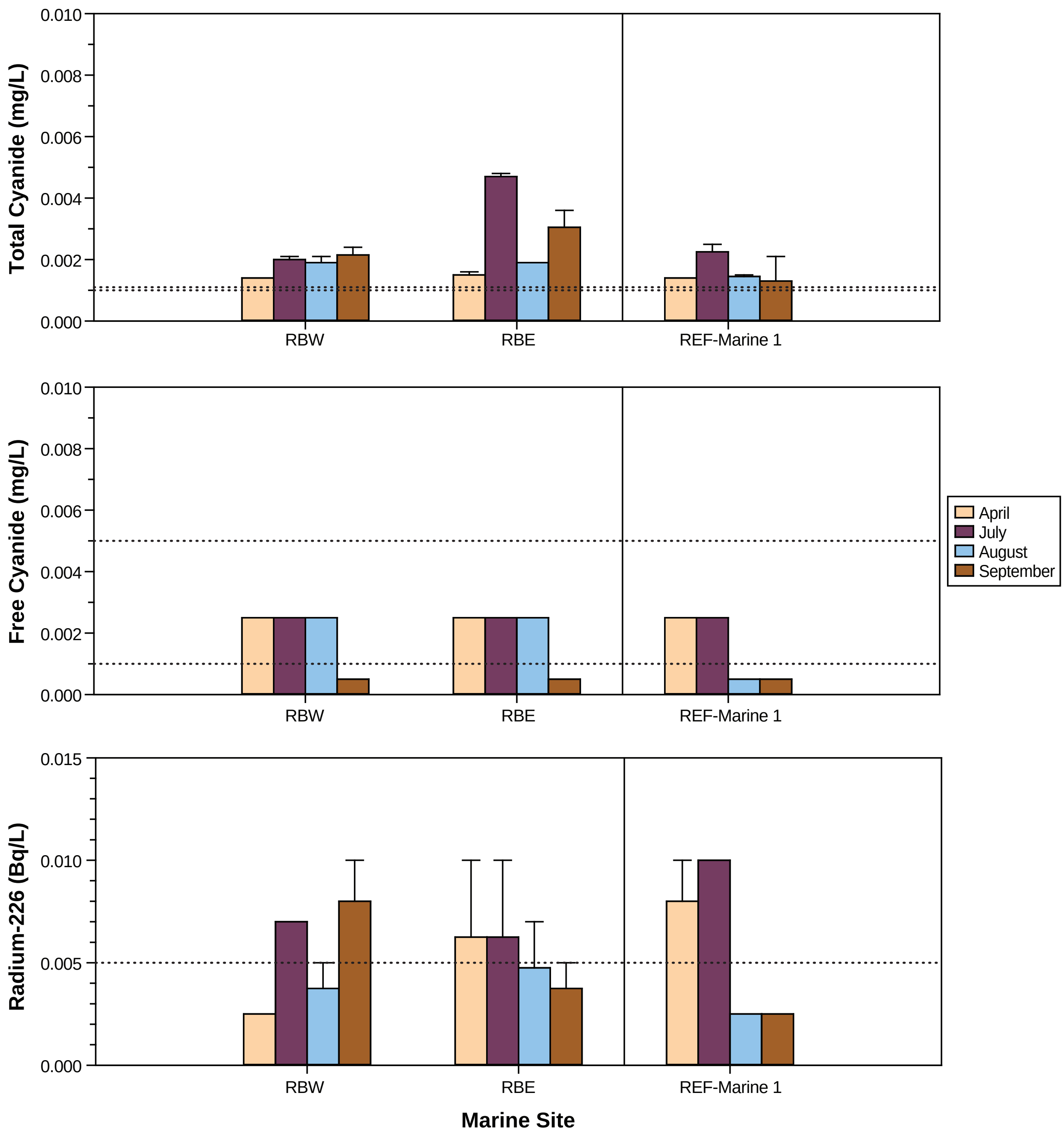


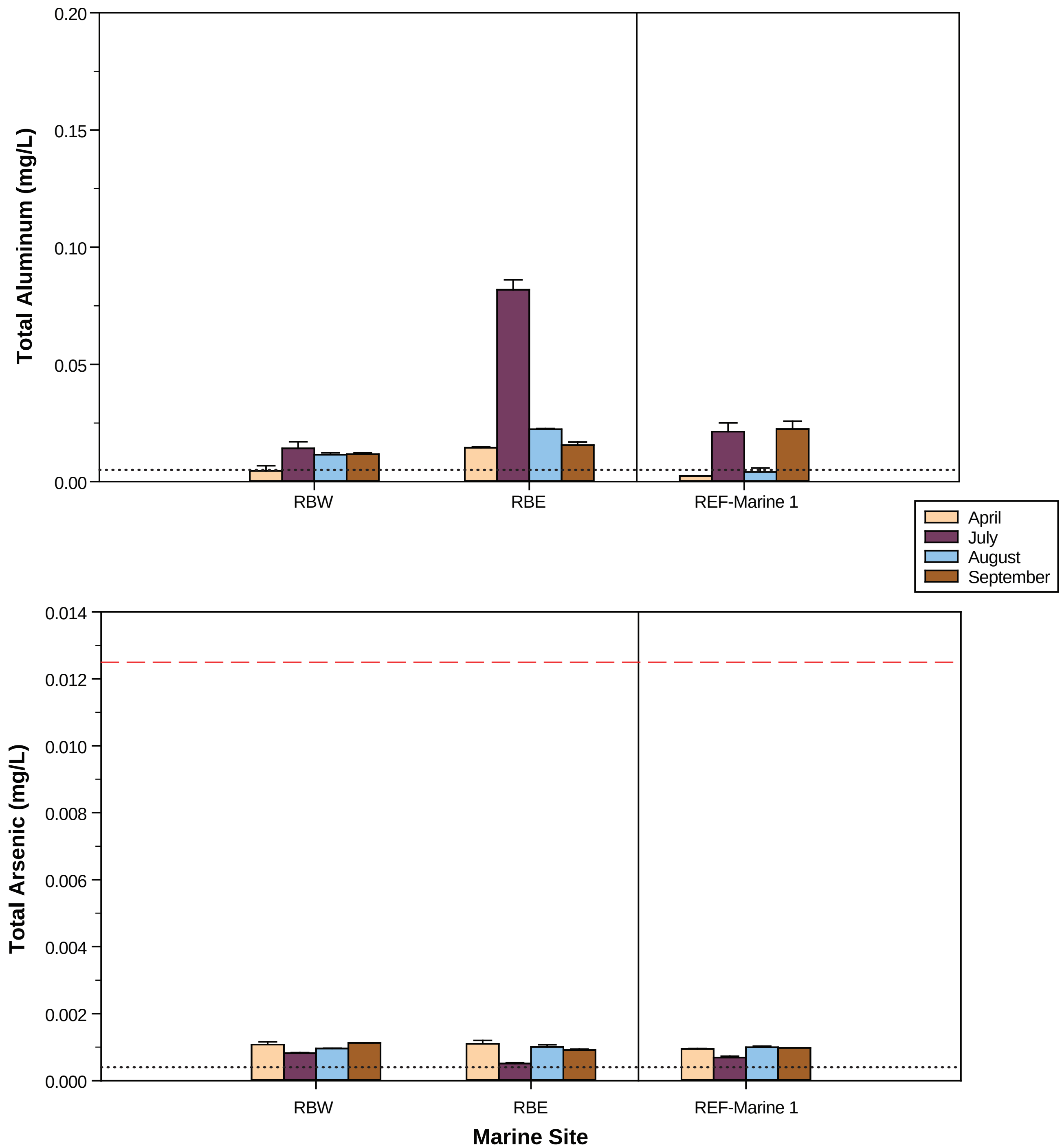
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Free cyanide concentrations in marine samples were always below the detection limit.
Total cyanide and radium-226 are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Cyanide, Free Cyanide, and Radium-226 Concentrations in Marine Sites, Doris North Project, 2011

Figure A.3-22

Rescan Engineers & Scientists



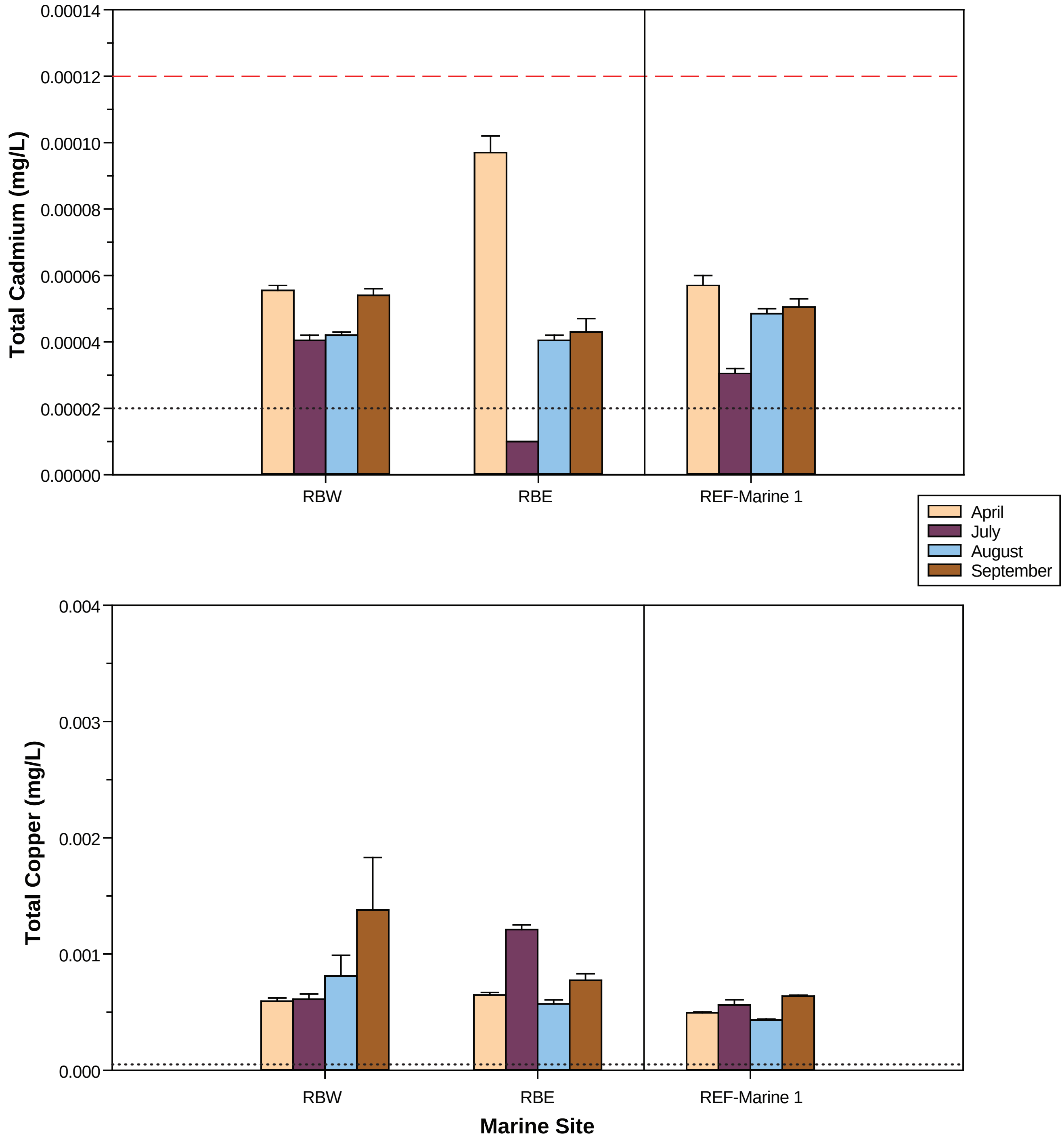
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed line represents the interim CCME marine guideline for arsenic (0.0125 mg/L).
Total aluminum is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total arsenic is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Aluminum and Total Arsenic Concentrations in Marine Sites, Doris North Project, 2011

Figure A.3-23

Rescan Engineers & Scientists



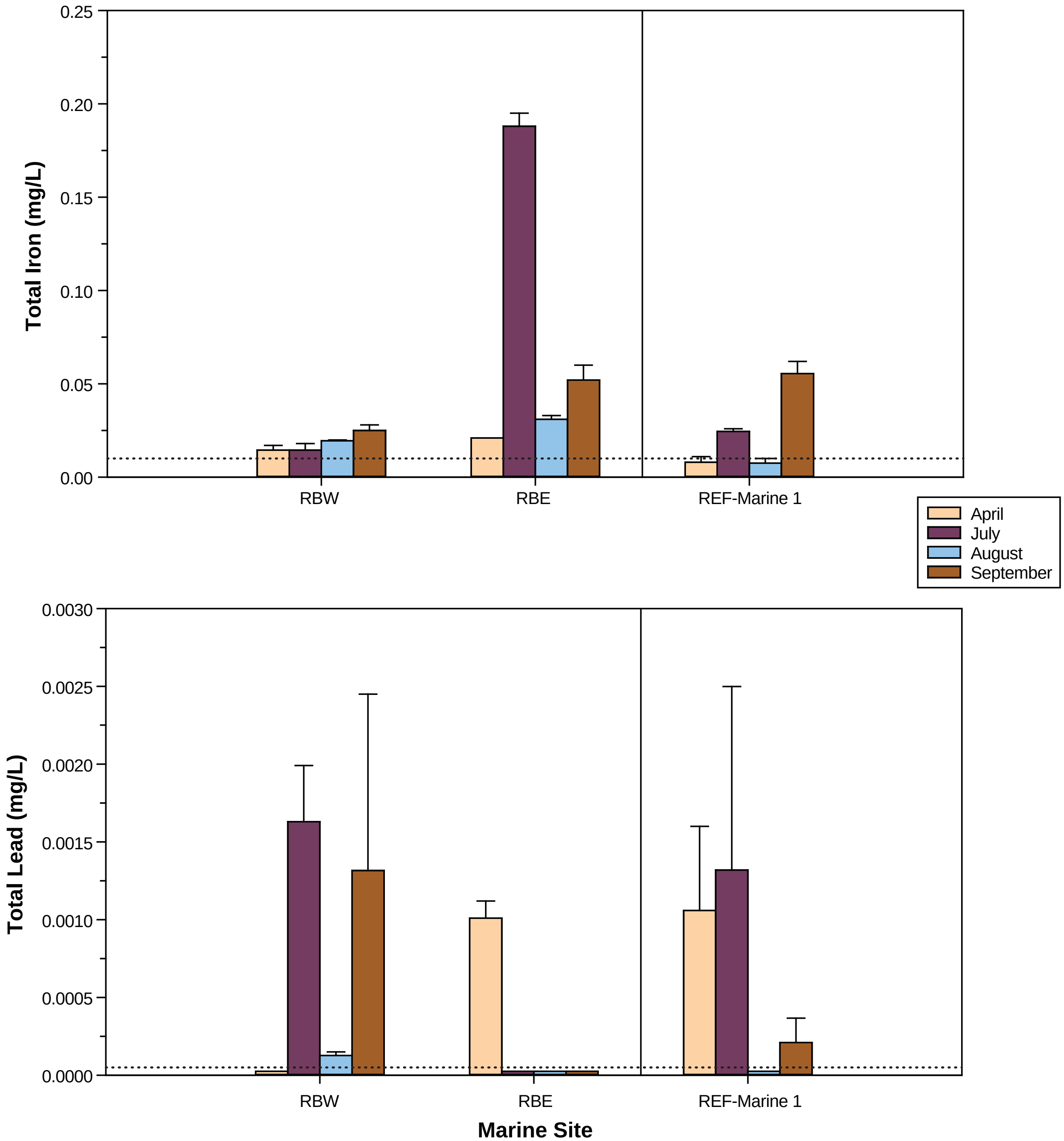
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Red dashed line represents the CCME marine guideline for cadmium (0.00012 mg/L).
Total cadmium is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total copper is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Cadmium and Total Copper Concentrations in Marine Sites, Doris North Project, 2011

Figure A.3-24

Rescan Engineers & Scientists



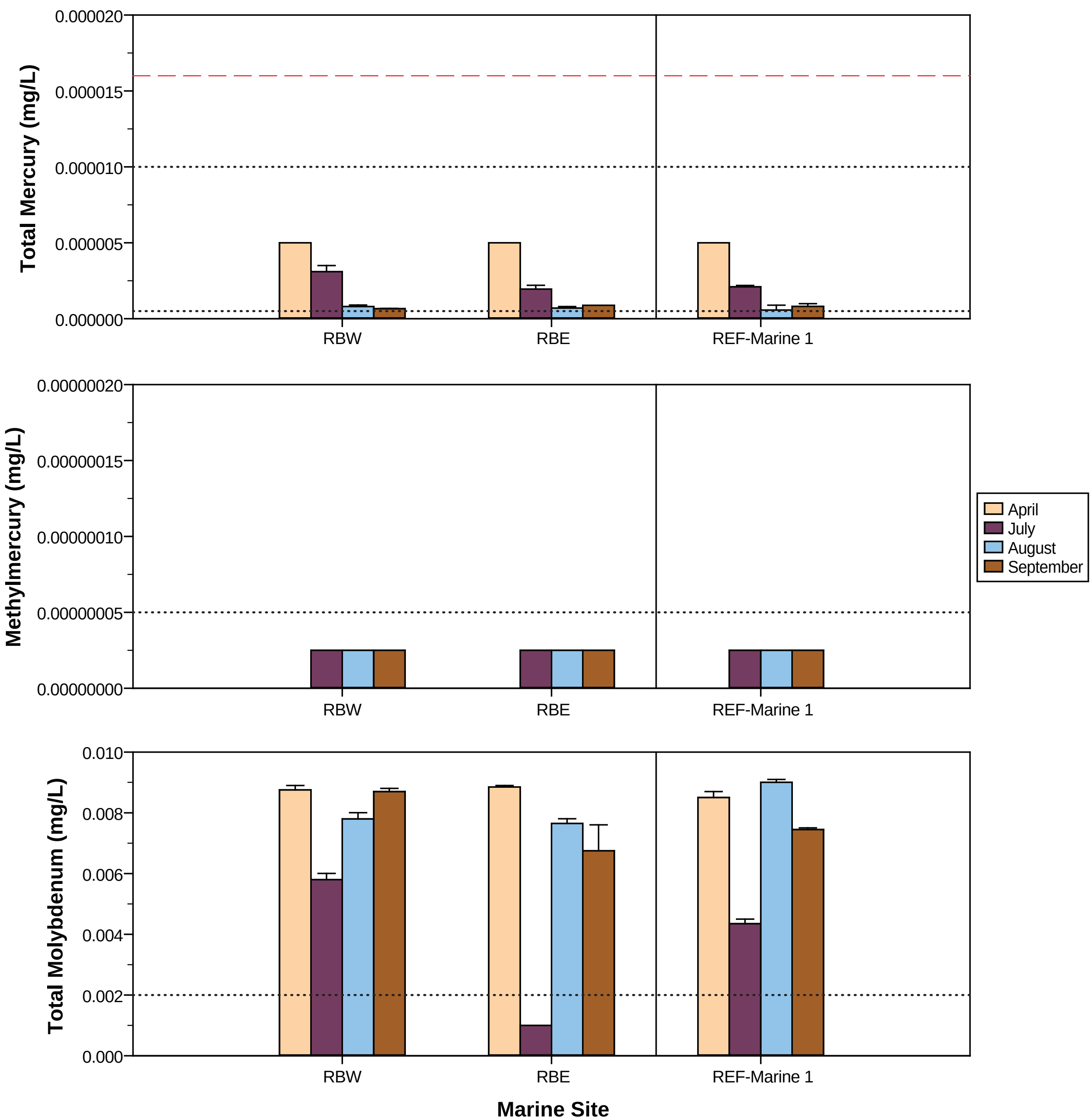
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Total iron is a required parameter for effluent characterization as per Schedule 5, s. 4(1) of the MMER.
Total lead is regulated as a deleterious substance in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Iron and Total Lead Concentrations in Marine Sites, Doris North Project, 2011

Figure A.3-25

Rescan Engineers & Scientists



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
The higher detection limit for total mercury of 0.00001 mg/L applied only to April samples; all total mercury concentrations in April samples were below this detection limit.
Red dashed line represents the interim CCME marine guideline for inorganic mercury (0.000016 mg/L).
Total mercury and total molybdenum are required parameters for effluent characterization as per Schedule 5, s. 4(1) of the MMER.

NEWMONT NORTH AMERICA

Total Mercury, Methylmercury, and Total Molybdenum Concentrations in Marine Sites, Doris North Project, 2011

Figure A.3-26

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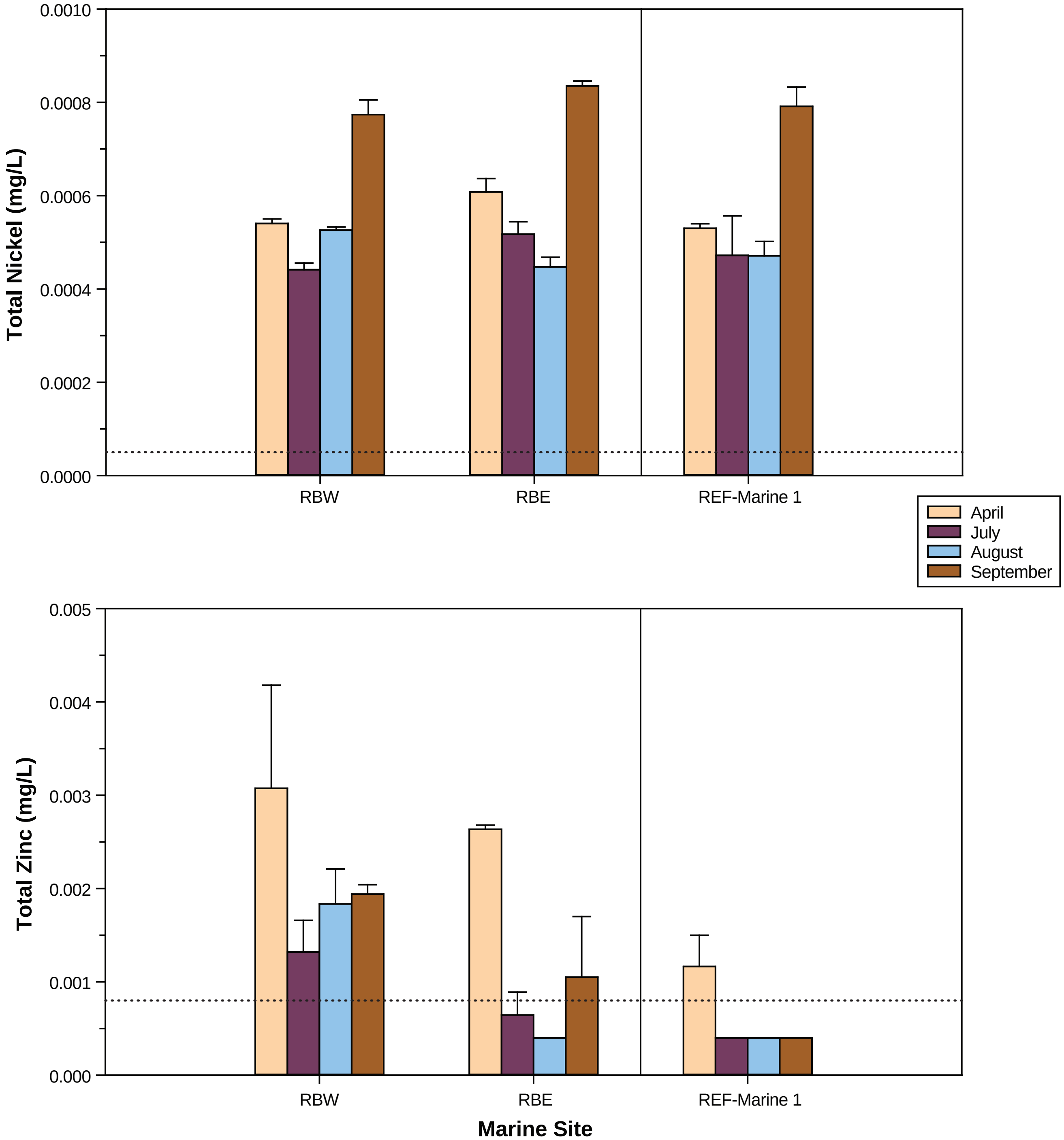

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent the analytical detection limits; values below the detection limit are plotted at half the applicable detection limit.
Total nickel and total zinc are regulated as deleterious substances in effluents as per Schedule 4 of the MMER.

NEWMONT NORTH AMERICA

Total Nickel and Total Zinc Concentrations in Marine Sites, Doris North Project, 2011

Figure A.3-27

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Annex A.3-3. Marine Water Quality Data, Doris North Project, 2011

Site ID:				RBW	RBW	RBE	RBE	REF-Marine 1	REF-Marine 1	RBW	RBW	RBE	RBE	REF-Marine 1	REF-Marine 1
Depth Zone:				Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Depth Sampled (m):				2.8	2.8	2.5	2.5	2.6	2.6	1.0	1.0	0.5	0.5	1.0	1.0
Replicate:				1	2	1	2	1	2	1	2	1	2	1	2
Date Sampled:		CCME Guideline for the	Realized Detection	24-Apr-11	24-Apr-11	23-Apr-11	23-Apr-11	23-Apr-11	23-Apr-11	23-Jul-11	23-Jul-11	22-Jul-11	22-Jul-11	22-Jul-11	22-Jul-11
ALS Sample ID:	Units	Protection of Aquatic Life[a]	Limit	L998223-15	L998223-16	L998223-3	L998223-4	L998223-2	L998223-1	L1035865-16	L1035865-17	L1035865-12	L1035865-11	L1035865-14	L1035865-13
Physical Tests															
Hardness (as $CaCO_3$)	mg/L		1.3 or 4.3	4780	4810	4890	4910	4860	4910	3280	3340	797	776	2490	2750
pH	pH	7.0-8.7	0.10	7.78	7.79	7.80	7.79	7.80	7.72	7.86	7.87	7.72	7.74	7.81	7.80
Salinity		<10% fluctuation[b]	1.0	26.2	26.0	26.3	26.1	26.4	26.5	18.4	18.2	4.5	4.5	14.4	14.4
Total Suspended Solids	mg/L	dependent on background levels	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.6	2.0	<2.0	<2.0
Turbidity	NTU	dependent on background levels	0.10	0.32	0.27	0.52	0.69	0.29	0.36	0.42	0.53	4.48	4.24	0.53	0.86
Anions and Nutrients															
Alkalinity, Total (as $CaCO_3$)	mg/L		2.0	131	137	133	134	128	135	92.5	90.1	34.1	34.2	45.7	45.6
Ammonia (as N)	mg/L		0.0050	0.0059	0.0055	0.0084	<0.0050	0.0056	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br^-)	mg/L		2.5 or 5.0	41.0	40.1	43.4	43.6	42.9	41.6	33.8	32.0	5.6	7.5	25.5	23.6
Chloride (Cl^-)	mg/L		25 or 50	15300	15100	15600	15500	15600	15900	10300	10100	2420	2420	7920	7920
Fluoride (F^-)	mg/L		0.75 or 1.0	0.90	0.94	0.95	0.90	0.89	0.83	6.83	6.40	<1.0	<1.0	<0.75	<0.75
Nitrate and Nitrite (as N)	mg/L		0.0060	0.0346	0.0354	0.0369	0.0385	0.0406	0.0364	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060
Nitrate (as N)	mg/L	3.612[b]	0.0060	0.0346	0.0354	0.0369	0.0362	0.0371	0.0337	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060
Nitrite (as N)	mg/L		0.0020	<0.0020	<0.0020	<0.0020	0.0023	0.0035	0.0027	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Total Phosphorus	mg/L		0.0020	0.0373	0.0377	0.0417	0.0412	0.0398	0.0410	0.0251	0.0240	0.0187	0.0186	0.0195	0.0217
Sulphate (SO_4^{2-})	mg/L		25 or 50	2110	2070	2140	2140	2140	2190	1460	1430	329	328	1100	1110
Cyanides															
Total Cyanide	mg/L		0.0010 or 0.0011	0.0014	0.0014	0.0016	0.0014	0.0014	0.0014	0.0021	0.0019	0.0048	0.0046	0.0025	0.0020
Free Cyanide	mg/L		0.0010 or 0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Organic / Inorganic Carbon															
Total Organic Carbon	mg/L		0.50	1.25	1.35	1.13	1.18	1.13	1.23	1.76	1.81	5.14	5.05	2.36	2.31
Total Metals															
Aluminum (Al)	mg/L		0.0050	0.0068	<0.0050	0.0149	0.0141	<0.0050	<0.0050	0.0170	0.0115	0.0861	0.0777	0.0251	0.0176
Antimony (Sb)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic (As)	mg/L	0.0125[b]	0.0004	0.00116	0.00099	0.00100	0.00120	0.00096	0.00093	0.00084	0.00080	0.00054	0.00048	0.00065	0.00073
Barium (Ba)	mg/L		0.0010	0.0114	0.0111	0.0121	0.0116	0.0112	0.0113	0.0086	0.0092	0.0049	0.0047	0.0071	0.0073
Beryllium (Be)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)	mg/L		0.10	3.88	3.78	3.80	3.67	3.62	3.55	2.45	2.63	0.59	0.68	1.90	2.02
Cadmium (Cd)	mg/L	0.00012	0.000020	0.000054	0.000057	0.000102	0.000092	0.000054	0.000060	0.000039	0.000042	<0.000020	<0.000020	0.000029	0.000032
Calcium (Ca)	mg/L		0.15 or 0.50	317	321	326	324	320	325	214	218	52.0	50.7	162	179
Cesium (Cs)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Chromium (Cr)	mg/L	Cr(VI): 0.0015; Cr(III): 0.056[b]	0.00010 to 0.00060	<0.00050	<0.00050	<0.00050	<0.00060	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000067	0.000058	<0.000050	<0.000050
Copper (Cu)	mg/L		0.000050	0.000567	0.000621	0.000628	0.000668	0.000485	0.000502	0.000655	0.000568	0.00125	0.00117	0.000606	0.000517
Gallium (Ga)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Iron (Fe)	mg/L		0.010	0.017	0.012	0.021	0.021	<0.010	0.011	0.018	0.011	0.195	0.181	0.026	0.023
Lead (Pb)	mg/L		0.000050	<0.000050	<0.000050	0.00112	0.000899	0.000517	0.00160	0.00199	0.00127	<0.000050	<0.000050	0.00250	0.000137
Lithium (Li)	mg/L		0.020	0.141	0.139	0.142	0.136	0.133	0.135	0.090	0.096	0.023	0.024	0.069	0.074
Magnesium (Mg)	mg/L		0.30 or 1.0	968	974	989	995	987	995	668	679	162	158	508	559
Manganese (Mn)	mg/L		0.000050	0.00214	0.00185	0.00153	0.00196	0.00184	0.00198	0.00221	0.00207	0.00835	0.00858	0.00192	0.00195
Mercury (Hg)	mg/L	Inorganic Hg: 0.000016[b]	0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	-	-	-	-	-	-
Mercury (Hg) (ultra low-level)	µg/L	Inorganic Hg: 0.016[b]	0.00050	-	-	-	-	-	-	0.00270	0.00350	0.00220	0.00170	0.00220	0.00200
Molybdenum (Mo)	mg/L		0.0020	0.0089	0.0086	0.0089	0.0088	0.0083	0.0087	0.0056	0.0060	<0.0020	<0.0020	0.0042	0.0045
Nickel (Ni)	mg/L		0.000050	0.000531	0.000550	0.000579	0.000637	0.000520	0.000540	0.000456	0.000427	0.000544	0.000491	0.000557	0.000387
Phosphorus (P)	mg/L		1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Potassium (K)	mg/L		6.0 or 20	297	299	304	309	308	310	208	209	48.0	47.0	157	171
Rhenium (Re)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Rubidium (Rb)	mg/L		0.0050	0.0929	0.0898	0.0935	0.0891	0.0874	0.0881	0.0586	0.0626	0.0140	0.0151	0.0446	0.0477
Selenium (Se)	mg/L		0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
Silicon (Si)	mg/L		0.15 or 0.50	<0.50	0.50	<0.50	<0.50	0.53	0.55	<0.50	<0.50	0.97	0.95	<0.50	<0.50
Silver (Ag)	mg/L		0.00010 or 0.00040	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)	mg/L		6.0 or 20	8910	8940	8970	9050	9040	9100	5920	5970	1310	1270	4440	4880
Strontium (Sr)	mg/L		0.010 to 0.050	5.59	5.69	5.90	5.42	5.69	5.61	4.17	4.20	0.913	0.888	3.11	3.44
Tellurium (Te)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Thallium (Tl)	mg/L		0.000050	0.000121	0.000121	0.000200	0.000173	0.000201	0.000203	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Thorium (Th)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Tin (Sn)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Titanium (Ti)	mg/L		0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0057	<0.0050	<0.0050	<0.0050
Tungsten (W)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Uranium (U)	mg/L		0.000050	0.00222	0.00238	0.00255	0.00241	0.00229	0.00245	0.00153	0.00160	0.000406	0.000397	0.00118	0.00130
Vanadium (V)	mg/L		0.00050	0.00071	0.00074	0.00085	0.00081	0.00075	0.00075	0.00055	0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Yttrium (Y)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)	mg/L		0.00080	0.00418	0.00197	0.00268	0.00259	0.00083	0.00150	0.00166	0.00098	<0.00080	0.00089	<0.00080	<0.00080
Zirconium (Zr)	mg/L		0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00140	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Speciated Metals															
Methylmercury (Total)	µg/L		0.000050	-	-	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry															
Radium-226	Bq/L		0.005	<0.005	<0.005	0.01	<0.005	0.006	0.01	0.007	0.007	0.01	<0.005	0.01	0.01

Site ID:	RBW	RBW	RBE	RBE	REF-Marine 1	REF-Marine 1	RBW	RBW	RBE	RBE	REF-Marine 1	REF-Marine 1
Depth Zone:	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface	Surface
Depth Sampled (m):	1.0	1.0	0.5	0.5	1.0	1.0	1.0	1.0	0.5	0.5	1.0	1.0
Replicate:	1	2	1	2	1	2	1	2	1	2	1	2
Date Sampled:	14-Aug-11	14-Aug-11	14-Aug-11	14-Aug-11	19-Aug-11	19-Aug-11	20-Sep-11	20-Sep-11	20-Sep-11	20-Sep-11	25-Sep-11	25-Sep-11
ALS Sample ID:	L1046432-3	L1046432-4	L1046432-1	L1046432-2	L1049435-16	L1049435-1	L1062230-1	L1062230-2	L1062230-3	L1062230-4	L1066144-1	L1066144-2
Physical Tests												
Hardness (as $CaCO_3$)	4530	4530	4490	4500	4820	4980	4940	4810	3470	4150	4640	4580
pH	7.89	7.93	7.96	7.95	7.89	7.89	7.73	7.92	7.96	7.98	7.90	7.93
Salinity	23.6	23.6	23.4	23.4	27.3	27.0	25.5	26.0	20.9	21.8	23.5	24.4
Total Suspended Solids	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	3.9	<2.0
Turbidity	0.56	0.76	0.89	1.25	0.56	0.47	1.06	0.41	1.27	1.34	1.14	1.03
Anions and Nutrients												
Alkalinity, Total (as $CaCO_3$)	105	108	106	110	118	122	117	115	102	105	106	109
Ammonia (as N)	<0.0050	<0.0050	<0.0050	<0.0050	0.0069	0.0057	0.0051	<0.0050	0.0065	<0.0050	<0.0050	<0.0050
Bromide (Br^-)	47.1	45.8	46.3	46.7	52.0	50.2	51.6	52.0	41.5	42.9	46.8	48.1
Chloride (Cl^-)	13500	13500	13200	13400	15000	15100	14800	14800	11800	12200	13400	13800
Fluoride (F^-)	0.80	0.99	1.05	0.88	1.04	0.96	1.01	0.91	<0.75	<0.75	0.95	0.86
Nitrate and Nitrite (as N)	0.409	0.0369	<0.0060	<0.0060	<0.0060	<0.0060	0.0158	0.0491	<0.0060	<0.0060	<0.0060	<0.0060
Nitrate (as N)	0.409	0.0369	<0.0060	<0.0060	<0.0060	<0.0060	0.0158	0.0491	<0.0060	<0.0060	<0.0060	<0.0060
Nitrite (as N)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Total Phosphorus	0.0282	0.0280	0.0263	0.0264	0.0447	0.0428	0.0347	0.0337	0.0288	0.0337	0.0318	0.0331
Sulphate (SO_4^{2-})	1920	1920	1870	1890	2130	2140	2090	2090	1670	1730	1910	1970
Cyanides												
Total Cyanide	0.0017	0.0021	0.0019	0.0019	0.0015	0.0014	0.0019	0.0024	0.0036	0.0025	<0.0010	0.0021
Free Cyanide	<0.0050	<0.0050	<0.0050	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon												
Total Organic Carbon	1.85	1.81	2.03	1.92	1.48	1.46	1.53	1.62	2.49	2.32	1.78	19.0
Total Metals												
Aluminum (Al)	0.0123	0.0107	0.0220	0.0227	<0.0050	0.0058	0.0124	0.0111	0.0169	0.0143	0.0258	0.0190
Antimony (Sb)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic (As)	0.00095	0.00097	0.00094	0.00107	0.00096	0.00103	0.00112	0.00113	0.00089	0.00094	0.00098	0.00098
Barium (Ba)	0.0150	0.0101	0.0098	0.0101	0.0123	0.0123	0.0090	0.0104	0.0066	0.0088	0.0070	0.0071
Beryllium (Be)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Boron (B)	3.27	3.23	3.16	3.28	3.91	3.76	3.47	3.65	2.45	3.11	3.32	3.42
Cadmium (Cd)	0.000043	0.000041	0.000042	0.000039	0.000050	0.000047	0.000056	0.000052	0.000039	0.000047	0.000048	0.000053
Calcium (Ca)	295	298	293	293	336	337	322	314	224	266	310	299
Cesium (Cs)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Chromium (Cr)	<0.00040	<0.00040	<0.00040	<0.00040	<0.00010	<0.00010	<0.00050	<0.00050	<0.00050	<0.00050	<0.00020	<0.00020
Cobalt (Co)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000053	<0.000050
Copper (Cu)	0.000989	0.000635	0.000534	0.000605	0.000439	0.000426	0.000926	0.00183	0.000830	0.000718	0.000646	0.000627
Gallium (Ga)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Iron (Fe)	0.020	0.019	0.029	0.033	<0.010	0.010	0.028	0.022	0.060	0.044	0.062	0.049
Lead (Pb)	0.000150	0.000103	<0.000050	<0.000050	<0.000050	<0.000050	0.00245	0.000182	<0.000050	<0.000050	0.000052	0.000367
Lithium (Li)	0.125	0.125	0.123	0.126	0.151	0.147	0.134	0.136	0.089	0.114	0.129	0.132
Magnesium (Mg)	921	918	913	914	968	1000	1000	978	706	846	940	932
Manganese (Mn)	0.00220	0.00237	0.00268	0.00285	0.00155	0.00149	0.00213	0.00217	0.00470	0.00360	0.00242	0.00235
Mercury (Hg)	-	-	-	-	-	-	-	-	-	-	-	-
Mercury (Hg) (ultra low-level)	0.00090	0.00070	0.00080	0.00060	<0.00050	0.00089	0.00065	0.00068	0.00087	0.00089	0.00064	0.00099
Molybdenum (Mo)	0.0080	0.0076	0.0075	0.0078	0.0091	0.0089	0.0086	0.0088	0.0059	0.0076	0.0074	0.0075
Nickel (Ni)	0.000519	0.000533	0.000427	0.000468	0.000502	0.000440	0.000743	0.000805	0.000846	0.000825	0.000750	0.000833
Phosphorus (P)	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Potassium (K)	273	272	269	271	301	311	302	298	211	252	300	287
Rhenium (Re)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Rubidium (Rb)	0.0802	0.0795	0.0797	0.0801	0.0957	0.0945	0.0894	0.0939	0.0604	0.0771	0.0794	0.0794
Selenium (Se)	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
Silicon (Si)	<0.50	<0.50	<0.50	<0.50	0.53	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Silver (Ag)	<0.00040	<0.00040	<0.00040	<0.00040	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)	7890	7840	7780	7830	8660	8920	8500	8370	5880	7110	8450	8060
Strontium (Sr)	5.23	5.19	5.17	5.19	5.89	6.04	5.69	5.59	4.00	4.75	5.88	5.58
Tellurium (Te)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Thallium (Tl)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Thorium (Th)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Tin (Sn)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Titanium (Ti)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Tungsten (W)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Uranium (U)	0.00206	0.00204	0.00198	0.00214	0.00242	0.00248	0.00210	0.00213	0.00147	0.00179	0.00210	0.00220
Vanadium (V)	0.00065	0.00064	0.00075	0.00071	0.00069	0.00072	0.00077	0.00079	0.00056	0.00067	0.00072	0.00070
Yttrium (Y)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)	0.00221	0.00146	<0.00080	<0.00080	<0.00080	<0.00080	0.00204	0.00184	0.00170	<0.00080	<0.00080	<0.00080
Zirconium (Zr)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.00120	<0.00050	<0.00050
Speciated Metals												
Methylmercury (Total)	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Radiochemistry												
Radium-226	<0.005	0.005	0.007	<0.005	<0.005	<0.005	0.006	0.01	0.005	<0.005	<0.005	<0.005

Notes:

a) Canadian water quality guidelines for the protection of marine aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) Interim guideline.

No parameters exceeded CCME guidelines for the protection of marine aquatic life.

Annex A.3-4. QA/QC Blank Data for Water Quality Sampling, Doris North Project, 2011

Blank Type:			Field Blank (Marine)	Equipment Blank (Lakes)	Travel Blank (Lakes)	Travel Blank (Streams)	Field Blank (Streams)	Equipment Blank (Lakes)	Travel Blank (Lakes)	Field Blank (Lakes)	Equipment Blank (Marine)	Travel Blank (Lakes)	Field Blank (Marine)	Equipment Blank (Marine)	Equipment Blank (Lakes)	Travel Blank (Lakes)	Field Blank (Lakes)	Field Blank (Streams)	Travel Blank (Streams/Lakes)	Equipment Blank (Lakes)	Travel Blank (Streams)	Field Blank (Streams)	Equipment Blank (Marine)	Field Blank (Marine)	Travel Blank (Marine)
Date Sampled:		Realized Detection Limit	24-Apr-11	21-Apr-11	22-Apr-11	26-Jun-11	26-Jun-11	18-Jul-11	19-Jul-11	19-Jul-11	21-Jul-11	21-Jul-11	22-Jul-11	14-Aug-11	17-Aug-11	17-Aug-11	17-Aug-11	21-Aug-11	21-Aug-11	17-Sep-11	23-Sep-11	23-Sep-11	20-Sep-11	20-Sep-11	20-Sep-11
ALS Sample ID:	Units		L998223-14	L998178-8	L998178-9	L1024161-11	L1024161-12	L1034068-4	L1034068-5	L1034068-6	L1035341-5	L1035341-6	L1035865-15	L1044719-4	L1047022-16	L1047022-17	L1047022-18	L1049435-4	L1049435-5	L1060789-1	L1063068-5	L1063068-10	L1062230-5	L1062230-6	L1062230-7
Physical Tests																									
Conductivity	µS/cm	2.0	-	<2.0	<2.0	<2.0	<2.0	**13.3**	<2.0	<2.0	-	<2.0	-	-	<2.0	<2.0	<2.0	<2.0	<2.0	**251**	<2.0	<2.0	-	-	-
Hardness (as $CaCO_3$)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	**0.64**	<0.50	<0.50	**1.97**	<0.50	<0.50
pH	pH	0.10	**5.63**	**5.97**	**5.88**	**5.69**	**5.61**	**4.64**	**5.53**	**5.49**	**4.37**	**5.63**	**5.93**	**5.51**	**5.35**	**5.59**	**5.51**	**5.62**	**6.07**	**3.24**	**5.70**	**5.60**	**3.14**	**5.39**	**5.60**
Salinity		1.0	<1.0	-	-	-	-	-	-	-	<1.0	-	<1.0	<1.0	-	-	-	-	-	-	-	-	<1.0	<1.0	<1.0
Total Suspended Solids	mg/L	1.0 or 2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	**2.0**	<1.0	<2.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	<2.0	<2.0
Turbidity	NTU	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**0.71**	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**0.15**	**0.20**	<0.10	<0.10	**0.10**	**0.10**	<0.10	<0.10
Anions and Nutrients																									
Alkalinity, Total (as $CaCO_3$)	mg/L	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Ammonia (as N)	mg/L	0.0050	<0.0050	<0.0050	**0.0306**	<0.0050	<0.0050	**0.0155**	**0.0108**	<0.0050	**0.0376**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	**0.0290**	**0.0175**	<0.0050	**0.0202**	<0.0050	<0.0050	**0.0231**	<0.0050	<0.0050
Bromide (Br^-)	mg/L	0.050 or 0.10	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.10	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl^-)	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	**1.93**	<0.50	<0.50	**2.75**	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	**2.44**	<0.50	<0.50
Fluoride (F^-)	mg/L	0.20	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Nitrate and Nitrite (as N)	mg/L	0.0060	<0.0060	-	-	-	-	-	-	-	<0.0060	-	<0.0060	**0.121**	-	-	-	-	-	-	-	-	**13.1**	<0.0060	<0.0060
Nitrate (as N)	mg/L	0.0050 or 0.0060	<0.0060	**0.0180**	<0.0050	<0.0050	<0.0050	**0.0119**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0060	**0.121**	**0.0539**	<0.0050	<0.0050	<0.0050	<0.0050	**9.13**	<0.0050	<0.0050	**13.1**	<0.0060	<0.0060
Nitrite (as N)	mg/L	0.0010 or 0.0020	<0.0020	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0020	<0.0020	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	**0.0015**	<0.0010	<0.0010	**0.0079**	<0.0020	<0.0020
Total Phosphorus	mg/L	0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Sulphate (SO_4^{2-})	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Cyanides																									
Total Cyanide	mg/L	0.0010 to 0.00125	<0.0010	<0.0010	<0.0010	<0.0013	<0.0010	**0.0108**	<0.0010	<0.0010	**0.0127**	<0.0011	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	**0.0181**	<0.0013	<0.0010	**0.204**	<0.0011	<0.0010
Free Cyanide	mg/L	0.0010 or 0.0050	<0.0050	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0010	**0.0018**	**0.0016**	**0.0020**	<0.0010	<0.0010	<0.0010	-	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon																									
Total Organic Carbon	mg/L	0.50	<0.50	<0.50	<0.50	<0.50	<0.50	**0.57**	<0.50	<0.50	**0.99**	<0.50	<0.50	**0.64**	<0.50	<0.50	<0.50	<0.50	<0.50	**3.90**	<0.50	<0.50	**7.85**	<0.50	<0.50
Total Metals																									
Aluminum (Al)	mg/L	0.0030 or 0.0050	<0.0050	<0.0030	<0.0030	<0.0030	<0.0030	**0.111**	<0.0030	<0.0030	**0.0467**	<0.0030	<0.0050	<0.0050	**0.0078**	<0.0030	<0.0030	<0.0030	<0.0030	**0.0777**	<0.0030	<0.0030	**0.153**	<0.0050	<0.0050
Antimony (Sb)	mg/L	0.000010 or 0.00050	<0.00050	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.00050	<0.000010	<0.00050	<0.00050	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.00050	<0.00050	<0.00050
Arsenic (As)	mg/L	0.000050 or 0.00040	<0.00040	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00040	<0.000050	<0.00040	<0.00040	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00040	<0.00040	<0.00040
Barium (Ba)	mg/L	0.00010 or 0.0010	<0.0010	**0.00065**	<0.00010	<0.00010	<0.00010	**0.00037**	<0.00010	<0.00010	<0.0010	<0.00010	<0.0010	**0.0084**	**0.00256**	<0.00010	<0.00010	<0.00010	<0.00010	**0.0328**	<0.00010	<0.00010	**0.0479**	<0.0010	<0.0010
Beryllium (Be)	mg/L	0.0000050 or 0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.0000050	<0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050
Bismuth (Bi)	mg/L	0.000050 or 0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.000050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050	**0.000141**	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050
Boron (B)	mg/L	0.0050 or 0.10	<0.10	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	**0.0111**	**0.0103**	<0.10	<0.0050	<0.10	<0.10	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.10	<0.10	<0.10
Cadmium (Cd)	mg/L	0.0000050 or 0.000020	<0.000020	<0.0000050	<0.0000050	<0.0000050	<0.0000050	**0.0000123**	<0.0000050	<0.0000050	<0.000020	<0.0000050	<0.000020	<0.000020	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.000020	<0.000020	<0.000020
Calcium (Ca)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	**0.126**	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	**0.255**	<0.050	<0.050	**0.478**	<0.050	<0.050
Cesium (Cs)	mg/L	0.0000050 or 0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.0000050	<0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050
Chromium (Cr)	mg/L	0.00010 or 0.00050	<0.00010	<0.00050	<0.00050	<0.00050	<0.00050	**0.0128**	<0.00050	<0.00050	**0.0459**	<0.00050	<0.00050	<0.00010	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	**0.000173**	<0.000050	<0.000050	**0.00166**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	**0.000051**	<0.000050	<0.000050
Copper (Cu)	mg/L	0.000050 or 0.0005	<0.000050	<0.00050	<0.00050	<0.00050	<0.00050	**0.00121**	<0.00050	<0.00050	**0.00128**	<0.00050	<0.000050	**0.000080**	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	**0.00209**	<0.00050	<0.00050	**0.00314**	<0.000050	<0.000050
Gallium (Ga)	mg/L	0.000050 or 0.0005	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.000050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050
Iron (Fe)	mg/L	0.010 or 0.030	<0.010	<0.030	<0.030	<0.030	<0.030	**0.069**	<0.030	<0.030	**0.130**	<0.030	<0.010	<0.010	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	**0.020**	<0.010	<0.010
Lead (Pb)	mg/L	0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	**0.00352**	<0.000050	<0.000050	**0.000061**	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	**0.000220**	<0.000050	<0.000050	**0.000625**	<0.000050	<0.000050
Lithium (Li)	mg/L	0.00020 or 0.020	<0.020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.020	<0.00020	<0.020	<0.020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.020	<0.020	<0.020
Magnesium (Mg)	mg/L	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	**0.19**	<0.10	<0.10
Manganese (Mn)	mg/L	0.000050 or 0.00020	<0.000050	<0.00020	<0.00020	<0.00020	<0.00020	**0.00363**	<0.00020	<0.00020	**0.00360**	<0.00020	<0.000050	**0.000212**	**0.00041**	<0.00020	<0.00020	<0.00020	<0.00020	**0.00043**	<0.00020	<0.00020	**0.000581**	<0.000050	<0.000050
Mercury (Hg)	mg/L	0.000010	<0.000010	<0.000010	<0.000010	-	-	-	-	-	-	-	-	-	<0.000010	-	<0.000010	-	-	-	-	-	-	-	-
Mercury (Hg) (ultra low-level)	µg/L	0.00050	-	-	-	<0.00050	<0.00050	**0.00060**	<0.00050	<0.00050	**0.00060**	<0.00050	<0.00050	<0.00050	-	<0.00050	-	<0.00050	<0.00050	**0.00067**	<0.00050	<0.00050	**0.00211**	<0.00050	<0.00050
Molybdenum (Mo)	mg/L	0.000050 or 0.0020	<0.0020	<0.000050	<0.000050	<0.000050	<0.000050	**0.000062**	<0.000050	<0.000050	<0.0020	<0.000050	<0.0020	<0.0020	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.0020	<0.0020	<0.0020
Nickel (Ni)	mg/L	0.000050 or 0.00020	<0.000050	<0.00020	<0.00020	<0.00020	<0.00020	**0.0410**	<0.00020	<0.00020	**0.0486**	<0.00020	<0.000050	<0.000050	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	**0.000298**	<0.000050	<0.000050
Phosphorus (P)	mg/L	0.30 or 1.0	<1.0	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<1.0	<0.30	<1.0	<1.0	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<1.0	<1.0	<1.0
Potassium (K)	mg/L	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Rhenium (Re)	mg/L	0.0000050 or 0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.0000050	<0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050
Rubidium (Rb)	mg/L	0.000020 or 0.0050	<0.0050	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.0050	<0.000020	<0.0050	<0.0050	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.0050	<0.0050	<0.0050
Selenium (Se)	mg/L	0.00020 or 0.00040	<0.00040	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00040	<0.00020	<0.00040	<0.00040	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00040	<0.00040	<0.00040
Silicon (Si)	mg/L	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	**0.073**	<0.050	<0.050	**0.085**	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	**0.050**	<0.050	<0.050	<0.050	<0.050	<0.050
Silver (Ag)	mg/L	0.0000050 or 0.00010	<0.00010	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00010	<0.0000050	<0.00010	<0.00010	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00010	<0.00010	<0.00010
Sodium (Na)	mg/L	2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Strontium (Sr)	mg/L	0.000050 to 0.010	<0.010	<0.000050	<0.000050	<0.000050	<0.000050	**0.000249**	<0.000050	<0.000050	<0.0050	<0.000050	<0.0050	<0.0050	**0.000054**	<0.000050	<0.000050	<0.000050	<0.000050	**0.000236**	<0.000050	<0.000050	<0.0050	<0.0050	<0.0050
Tellurium (Te)	mg/L	0.000010 or 0.00050	<0.00050	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.00050	<0.000010	<0.00050	<0.00050	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.00050	<0.00050	<0.00050
Thallium (Tl)	mg/L	0.0000020 or 0.000050	<0.000050	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.000050	<0.0000020	<0.000050	<0.000050	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.000050	<0.000050	<0.000050
Thorium (Th)	mg/L	0.0000050 or 0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.0000050	<0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050
Tin (Sn)	mg/L	0.00020 or 0.0010	<0.0010	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.0010	<0.00020	<0.0010	<0.0010	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	**0.00722**	<0.00020	<0.00020	**0.0089**	<0.0010	<0.0010
Titanium (Ti)	mg/L	0.00020 or 0.0050	<0.0050	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.0050	<0.00020	<0.0050	<0.0050	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.0050	<0.0050	<0.0050
Tungsten (W)	mg/L	0.000010 or 0.0010	<0.0010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.0010	<0.000010	<0.0010	<0.0010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	**0.000029**	<0.000010	<0.000010	<0.0010	<0.0010	<0.0010
Uranium (U)	mg/L	0.0000020 or 0.000050	<0.000050	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.000050	<0.0000020	<0.000050	<0.000050	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.000050	<0.000050	<0.000050
Vanadium (V)	mg/L	0.000050 or 0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.000050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050
Yttrium (Y)	mg/L	0.0000050 or 0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.0000050	<0.00050	<0.00050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.00050	<0.00050	<0.00050
Zinc (Zn)	mg/L	0.00080 or 0.0030	<0.00080	**0.0041**	<0.0030	<0.0030	<0.0030	**0.0465**	<0.0030	<0.0030	**0.0329**	<0.0030	<0.00080	<0.00080	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	**0.0069**	<0.0030	<0.0030	**0.00985**	<0.00080	<0.00080
Zirconium (Zr)	mg/L	0.000050 or 0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.000050	<0.00050	<0.00050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.00050	<0.00050	<0.00050
Speciated Metals																									
Methylmercury (Total)	µg/L	0.000050	-	-	-	-	-	-	-	-	<0.000050	<0.000050	<0.000050	<0.000050	-	-	-	-	<0.000050	-	-	-	**0.000328**	<0.000050	<0.000050
Radiochemistry																									
Radium-226	Bq/L	0.005	-	**0.01**	-	-	-	**0.01**	<0.005	<0.005	<0.005	-	-	<0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	-	-	<0.005	-	-

Note:

Bold values represent concentrations that are higher than analytical detection limits.

A.4 2011 SEDIMENT QUALITY

The following sections present the sediment quality data collected in August 2011 from stream, lake, and marine sites. Only the parameters that were subjected to an evaluation of effects (see main body of AEMP report) are shown graphically. All sediment quality parameters were screened against CCME sediment quality guidelines for the protection of aquatic life (CCME 2011a). CCME guidelines for sediments include interim sediment quality guidelines (ISQGs) and probable effects levels (PELs). The more conservative ISQGs are levels below which adverse biological effects are rarely observed. The higher PELs correspond to concentrations above which negative effects would be expected (CCME 2011a). CCME guidelines are included in all graphs, tables, and annexes.

A.4.1 Stream Data

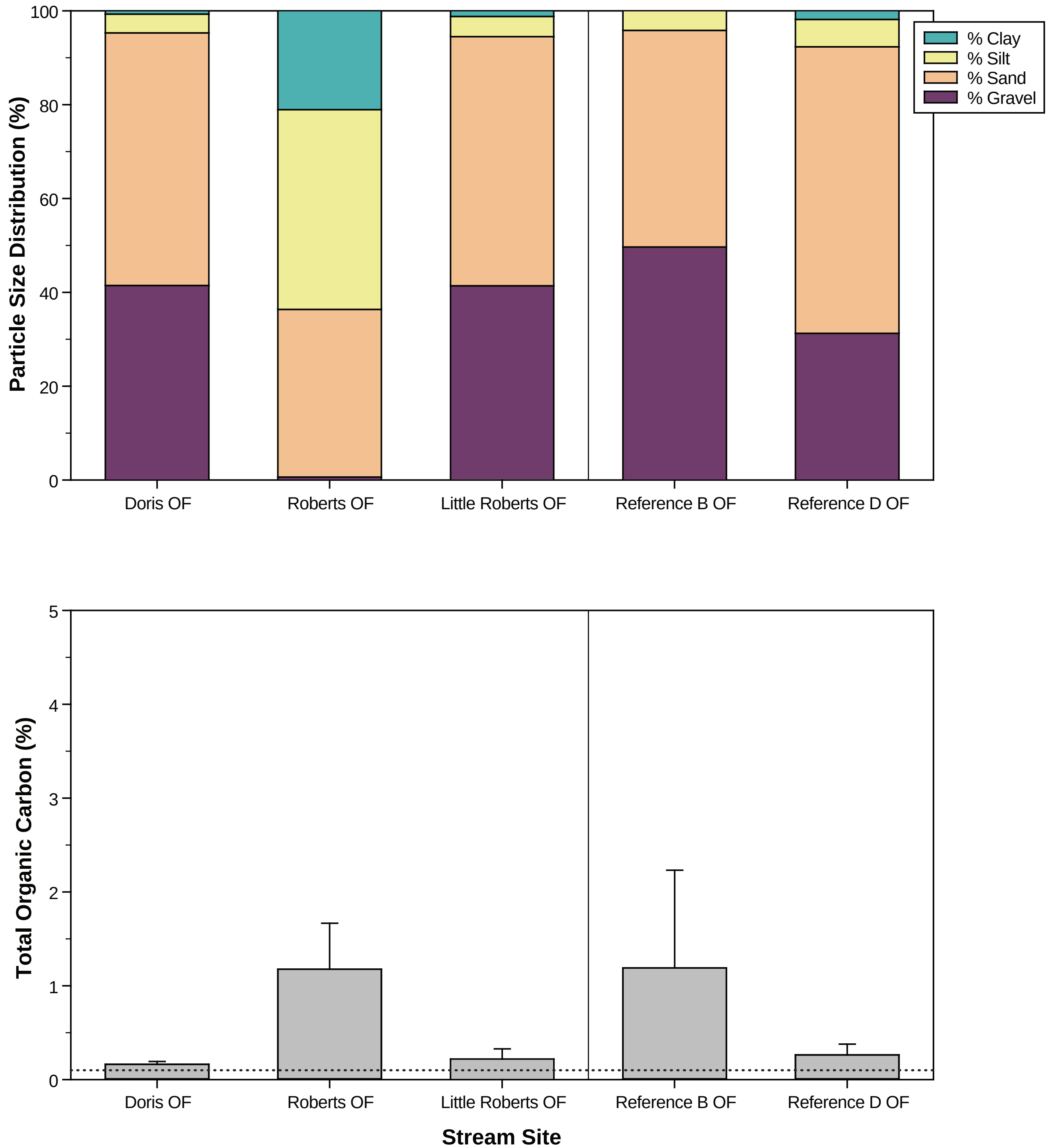
Figures A.4-1 to A.4-5 show select sediment quality parameter concentrations in the AEMP streams. Table A.4-1 presents the percentage of stream sediment samples in which metal concentrations were higher than CCME guidelines, and Table A.4-2 provides the factor by which average 2011 sediment metal concentrations were higher than CCME guidelines. Annex A.4-1 presents the raw stream sediment quality data.

A.4.2 Lake Data

Figures A.4-6 to A.4-10 show select sediment quality parameter concentrations in the surveyed lakes. Table A.4-3 presents the percentage of lake sediment samples in which metal concentrations were higher than CCME guidelines, and Table A.4-4 provides the factor by which average 2011 sediment metal concentrations were higher than CCME guidelines. Annex A.4-2 presents the raw lake sediment quality data.

A.4.3 Marine Data

Figures A.4-11 to A.4-15 show select sediment quality parameter concentrations in the AEMP marine sites. Table A.4-5 presents the percentage of marine sediment samples in which metal concentrations were higher than CCME guidelines, and Table A.4-6 provides the factor by which average 2011 sediment metal concentrations were higher than CCME guidelines. Annex A.4-3 presents the raw marine sediment quality data.



Notes: Error bars represent the standard error of the mean.
Stacked bars represent the mean of replicate samples.
Black dotted line represents the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Particle size distribution and total organic carbon content of sediments are required parameters as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

NEWMONT NORTH AMERICA

Particle Size Distribution and Total Organic Carbon Concentration in Stream Sediments, Doris North Project, August 2011

Figure A.4-1

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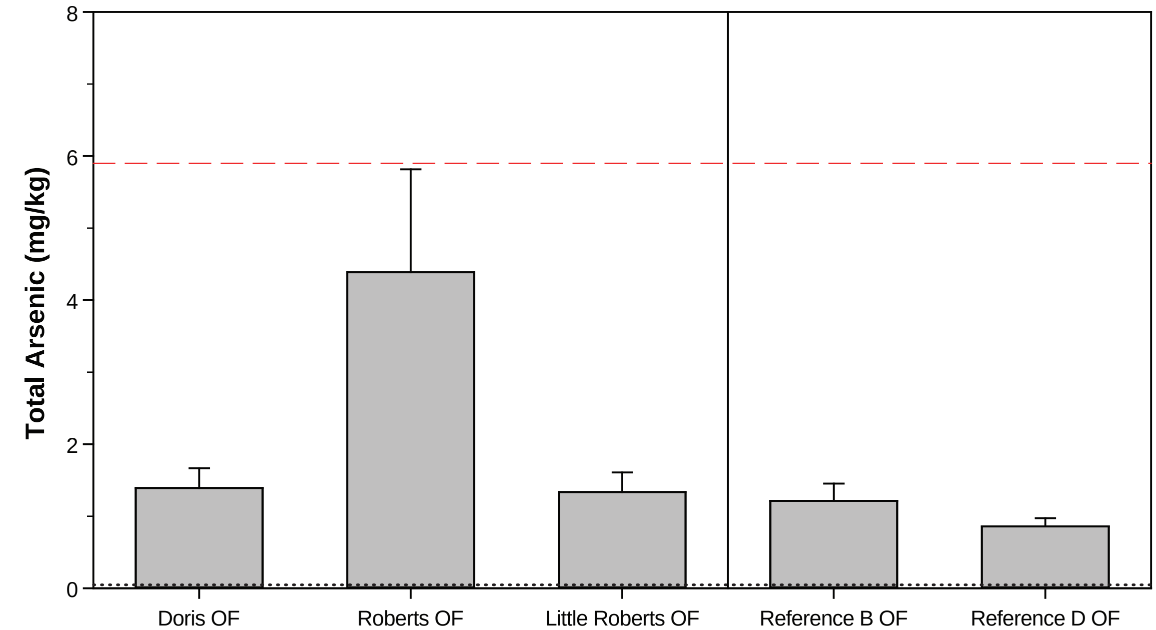
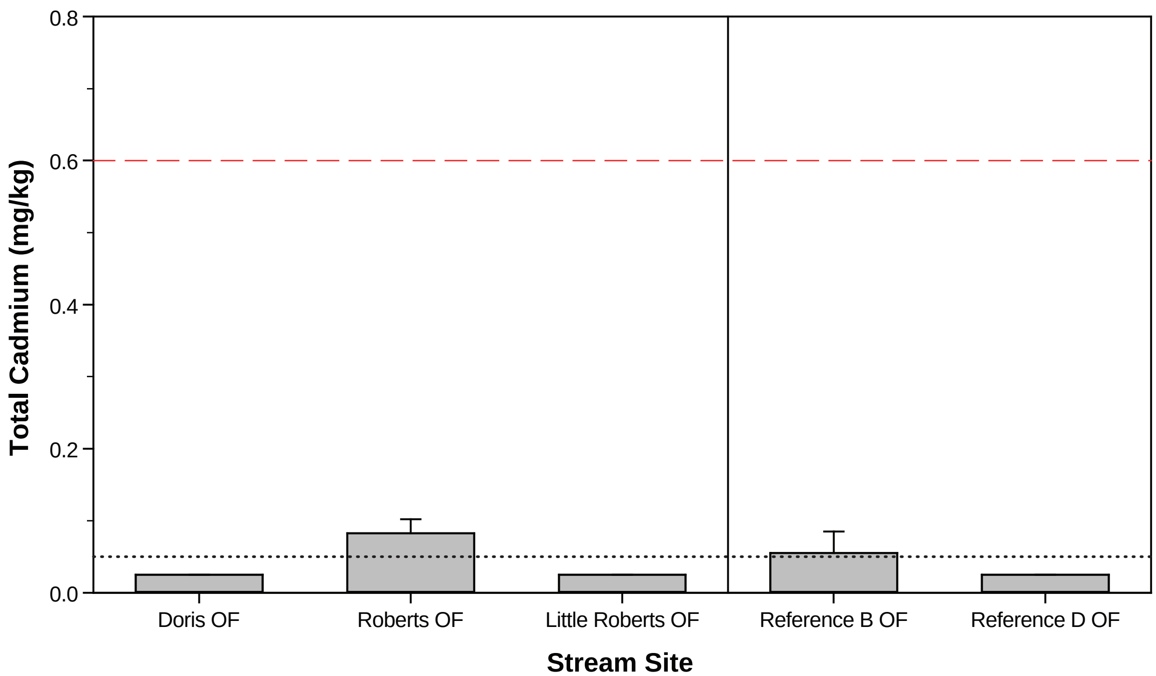




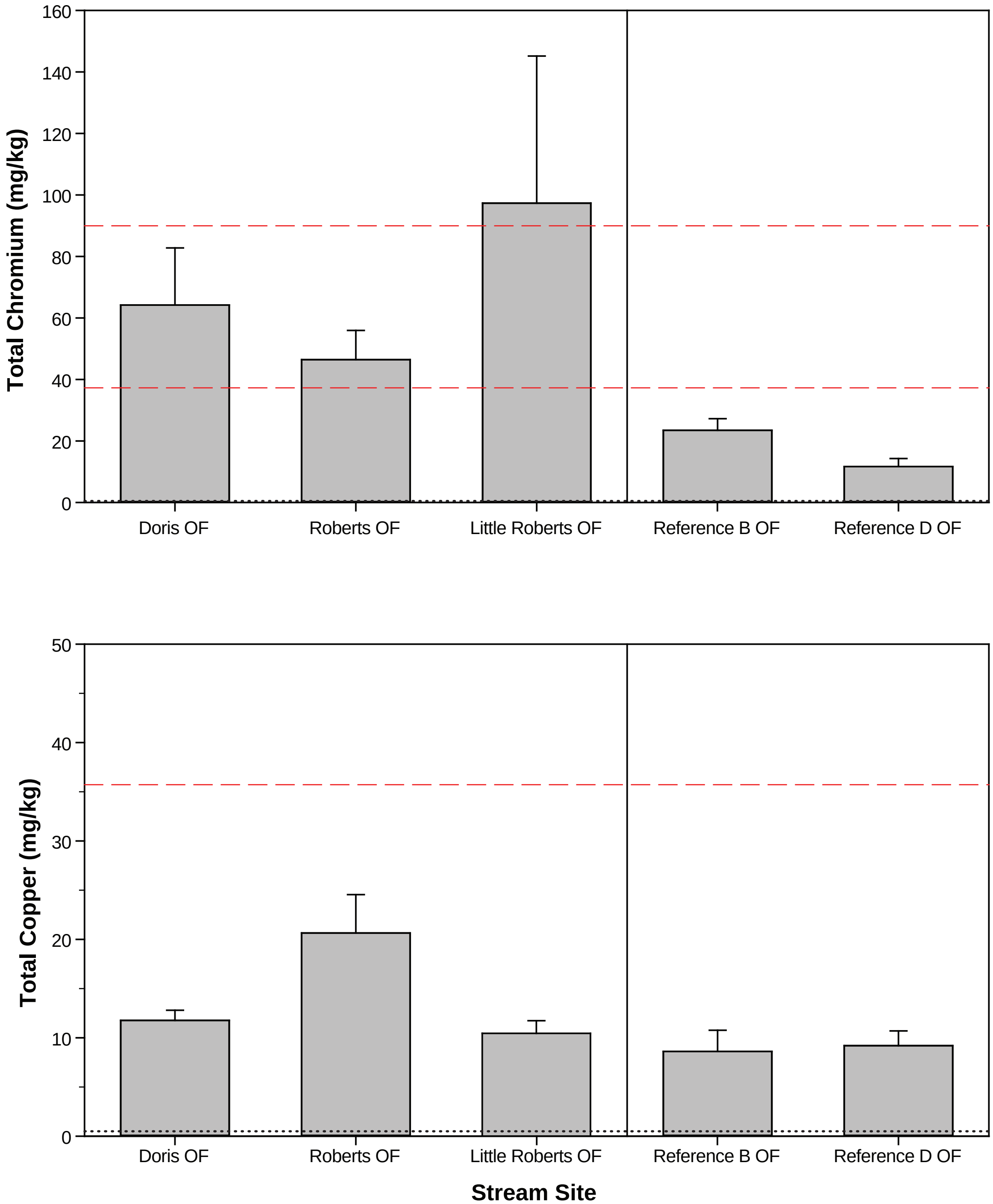
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for arsenic (5.9 mg/kg) and cadmium (0.6 mg/kg); probable effects levels (PELs) for arsenic (17 mg/kg) and cadmium (3.5 mg/kg) are not shown.

NEWMONT NORTH AMERICA

Total Arsenic and Total Cadmium Concentrations in Stream Sediments, Doris North Project, August 2011

Figure A.4-2

Rescan Engineers & Scientists



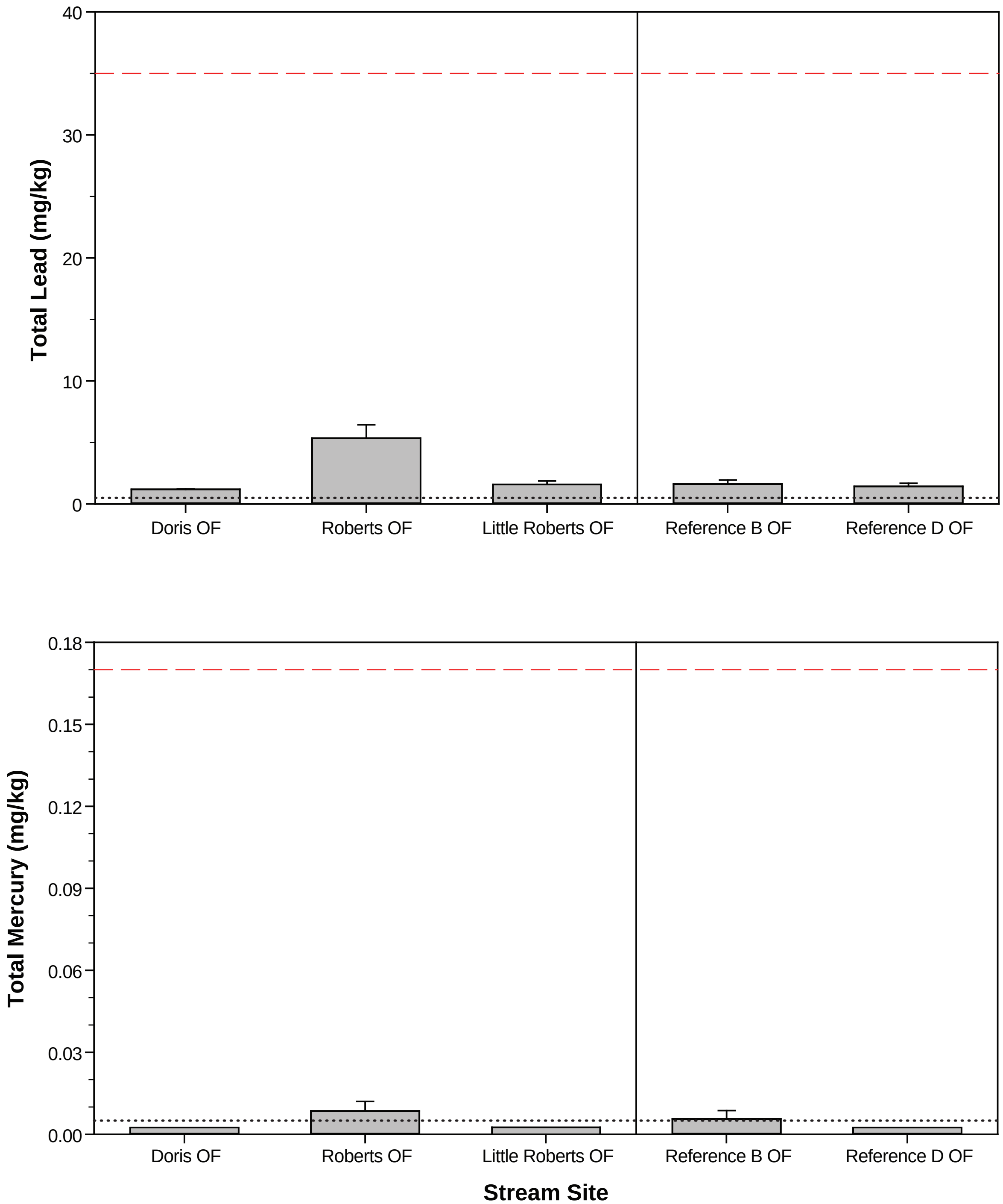
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for chromium (37.3 mg/kg) and copper (35.7 mg/kg) and the probable effects level (PEL) for chromium (90 mg/kg); the PEL for copper (197 mg/kg) is not shown.

NEWMONT NORTH AMERICA

Total Chromium and Total Copper Concentrations in Stream Sediments, Doris North Project, August 2011

Figure A.4-3

Rescan Engineers & Scientists



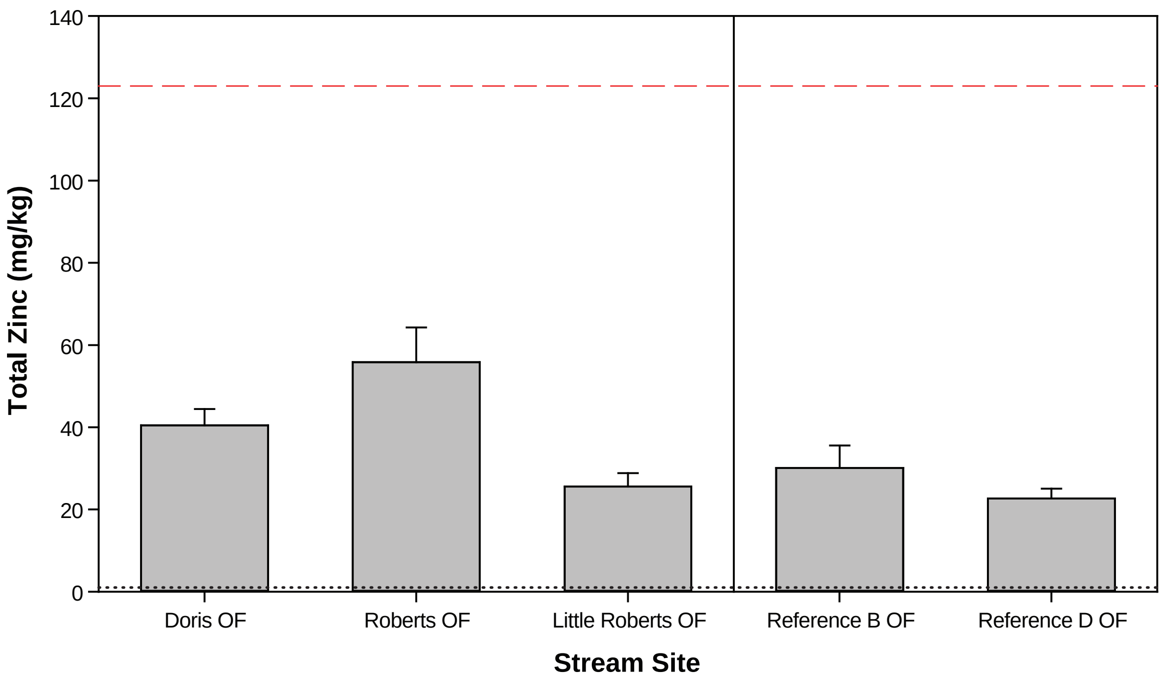
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for lead (35 mg/kg) and mercury (0.17 mg/kg); probable effects levels (PELs) for lead (91.3 mg/kg) and mercury (0.486 mg/kg) are not shown.

NEWMONT NORTH AMERICA

Total Lead and Total Mercury Concentrations in Stream Sediments, Doris North Project, August 2011

Figure A.4-4

Rescan Engineers & Scientists



Notes: Error bars represent the standard error of the mean.
Black dotted line represents the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed line represents the CCME freshwater interim sediment quality guideline (ISQG) for zinc (123 mg/kg); the probable effects level (PEL) for zinc (315 mg/kg) is not shown.

NEWMONT NORTH AMERICA

Total Zinc Concentrations in Stream Sediments, Doris North Project, August 2011

Figure A.4-5

Rescan Engineers & Scientists

Table A.4-1. Sediment Quality in AEMP Stream Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2011

Stream Site	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Percent of Samples Higher Than ISQG[b] Guidelines						
			Arsenic (As) 5.9	Cadmium (Cd) 0.6	Chromium (Cr) 37.3	Copper (Cu) 35.7	Lead (Pb) 35	Mercury (Hg) 0.17	Zinc (Zn) 123
Doris Outflow	3		0	0	66.7	0	0	0	0
Roberts Outflow	3		33.3	0	66.7	0	0	0	0
Little Roberts Outflow	3		0	0	100	0	0	0	0
Reference B Outflow	3		0	0	0	0	0	0	0
Reference D Outflow	3		0	0	0	0	0	0	0

Stream Site	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Percent of Samples Higher Than PEL[c] Guidelines						
			Arsenic (As) 17	Cadmium (Cd) 3.5	Chromium (Cr) 90	Copper (Cu) 197	Lead (Pb) 91.3	Mercury (Hg) 0.486	Zinc (Zn) 315
Doris Outflow	3		0	0	33.3	0	0	0	0
Roberts Outflow	3		0	0	0	0	0	0	0
Little Roberts Outflow	3		0	0	33.3	0	0	0	0
Reference B Outflow	3		0	0	0	0	0	0	0
Reference D Outflow	3		0	0	0	0	0	0	0

Notes:

Values represent the percentages of 2011 samples that are higher than CCME guidelines.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Council of Ministers of the Environment, Updated January 2011.

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Table A.4-2. Sediment Quality in AEMP Stream Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2011

Stream Site	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Factor by which Average Concentrations are Higher Than ISQG[b] Guidelines						
			Arsenic (As) 5.9	Cadmium (Cd) 0.6	Chromium (Cr) 37.3	Copper (Cu) 35.7	Lead (Pb) 35	Mercury (Hg) 0.17	Zinc (Zn) 123
Doris Outflow	3		-	-	1.72	-	-	-	-
Roberts Outflow	3		-	-	1.25	-	-	-	-
Little Roberts Outflow	3		-	-	2.61	-	-	-	-
Reference B Outflow	3		-	-	-	-	-	-	-
Reference D Outflow	3		-	-	-	-	-	-	-

Stream Site	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Factor by which Average Concentrations are Higher Than PEL[c] Guidelines						
			Arsenic (As) 17	Cadmium (Cd) 3.5	Chromium (Cr) 90	Copper (Cu) 197	Lead (Pb) 91.3	Mercury (Hg) 0.486	Zinc (Zn) 315
Doris Outflow	3		-	-	-	-	-	-	-
Roberts Outflow	3		-	-	-	-	-	-	-
Little Roberts Outflow	3		-	-	1.08	-	-	-	-
Reference B Outflow	3		-	-	-	-	-	-	-
Reference D Outflow	3		-	-	-	-	-	-	-

Notes:

Values represent the factor by which average 2011 concentrations are higher than CCME guidelines; dashes represent average 2011 concentrations that are below CCME guidelines.

The average 2011 concentration of a particular parameter may be below the CCME guideline concentration even if a percentage of samples is higher than this guideline concentration.

Half the detection limit was substitued for values that were below the detection limit for the calculation of parameter averages.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Council of Ministers of the Environment, Updated January 2011.

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Annex A.4-1. Stream Sediment Quality Data, Doris North Project, 2011

Site ID:		CCME Guidelines for the Protection of Aquatic Life[a]			Doris OF	Doris OF	Doris OF	Roberts OF	Roberts OF	Roberts OF	Little Roberts OF	Little Roberts OF	Little Roberts OF
Replicate:					1	2	3	1	2	3	1	2	3
Date Sampled:				Realized Detection Limit	27-Aug-11	27-Aug-11	27-Aug-11	27-Aug-11	27-Aug-11	27-Aug-11	28-Aug-11	28-Aug-11	28-Aug-11
ALS Sample ID:	Unit	ISQG[b]	PEL[c]		L1053787-7	L1053787-8	L1053787-9	L1053787-10	L1053787-11	L1053787-12	L1053787-1	L1053787-2	L1053787-3
Physical Tests													
Moisture	%			0.25	-	-	-	-	-	-	-	-	-
pH	pH			0.10	7.39	7.28	7.21	6.59	6.28	6.04	7.44	6.95	6.70
Particle Size													
% Gravel (>2 mm)	%			0.10	41.5	48.3	34.6	1.81	<0.10	<0.10	46.5	22.7	55.1
% Sand (2.0 mm - 0.063 mm)	%			0.10	54.6	45.6	61.3	11.5	38.6	57.1	47.2	74.9	37.2
% Silt (0.063 mm - 4 µm)	%			0.10	3.39	5.36	3.33	46.7	48.9	32.1	5.04	1.85	5.95
% Clay (<4 µm)	%			0.10	0.53	0.79	0.76	40.0	12.4	10.8	1.32	0.57	1.72
Anions & Nutrients													
Total Nitrogen	%			0.020	0.028	0.028	0.022	0.071	0.194	0.099	0.029	<0.020	0.046
Organic / Inorganic Carbon													
Total Organic Carbon	%			0.10	0.21	0.17	0.11	0.37	2.06	1.10	0.19	<0.10	0.42
Plant Available Nutrients													
Available Ammonium-N	mg/kg			1.0 or 1.6	1.7	2.5	2.8	2.3	5.6	1.7	3.8	1.1	3.0
Available Nitrate-N	mg/kg			2.0 to 6.0	<2.0	<2.0	<2.0	<4.0	<6.0	<4.0	<2.0	<2.0	<2.0
Available Nitrite-N	mg/kg			0.40 to 1.2	<0.40	<0.40	<0.40	<0.80	<1.2	<0.80	<0.40	<0.40	<0.40
Available Phosphate-P	mg/kg			2.0	2.7	3.8	7.7	4.4	<2.0	<2.0	3.0	2.1	2.5
Metals													
Aluminum (Al)	mg/kg			50	9580	12400	9220	19500	13900	9900	7150	4600	6800
Antimony (Sb)	mg/kg			0.10	<0.10	<0.10	<0.10	0.16	<0.10	<0.10	<0.10	<0.10	<0.10
Arsenic (As)	mg/kg	5.9	17	0.050	1.03	1.93	1.22	7.23	3.24	2.69	1.44	0.824	1.75
Barium (Ba)	mg/kg			0.50	15.4	19.1	18.0	109	79.3	52.4	88.2	16.4	31.0
Beryllium (Be)	mg/kg			0.20	<0.20	<0.20	<0.20	0.60	0.39	0.29	<0.20	<0.20	<0.20
Bismuth (Bi)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	<0.050	<0.050	<0.050	0.118	0.079	0.051	<0.050	<0.050	<0.050
Calcium (Ca)	mg/kg			50	2080	2740	1850	5700	4320	2970	2470	1680	2720
Chromium (Cr)	mg/kg	37.3	90	0.50	33.4	97.6	61.7	63.6	45.0	30.9	193	50.4	48.7
Cobalt (Co)	mg/kg			0.10	8.01	13.4	8.20	12.0	8.95	6.87	7.39	4.81	5.48
Copper (Cu)	mg/kg	35.7	197	0.50	10.6	13.8	10.9	27.7	20.0	14.2	13.0	8.80	9.75
Iron (Fe)	mg/kg			50	22000	34200	23400	31700	22000	15900	15900	12100	15500
Lead (Pb)	mg/kg	35	91.3	0.50	1.17	1.27	1.12	7.37	5.06	3.62	1.56	1.10	2.10
Lithium (Li)	mg/kg			1.0	13.6	14.4	13.5	39.0	23.3	17.6	15.0	9.4	12.1
Magnesium (Mg)	mg/kg			20	6850	8040	6500	14800	10300	7270	5920	3940	5780
Manganese (Mn)	mg/kg			1.0	294	364	220	367	355	235	202	120	180
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0145	0.0087	<0.0050	<0.0050	<0.0050
Molybdenum (Mo)	mg/kg			0.50	0.51	5.92	1.10	4.84	0.98	0.75	4.09	1.03	0.79
Nickel (Ni)	mg/kg			0.50	19.9	49.3	33.8	31.5	23.4	17.1	92.8	26.9	24.7
Phosphorus (P)	mg/kg			50	379	561	437	678	583	448	408	289	409
Potassium (K)	mg/kg			100	630	790	770	6130	3470	2300	1250	700	1350
Selenium (Se)	mg/kg			0.20	<0.20	<0.20	<0.20	0.34	<0.20	<0.20	<0.20	<0.20	<0.20
Silver (Ag)	mg/kg			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			100	130	140	110	1300	680	450	330	250	680
Strontium (Sr)	mg/kg			0.50	8.39	8.12	6.80	36.4	24.2	16.9	13.2	8.18	13.8
Sulphur (S)	mg/kg			500	<500	<500	<500	7400	900	700	600	<500	<500
Thallium (Tl)	mg/kg			0.050	<0.050	<0.050	<0.050	0.247	0.162	0.118	<0.050	<0.050	0.057
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	347	346	365	1430	1030	698	475	382	485
Uranium (U)	mg/kg			0.050	0.294	0.314	0.276	2.33	1.23	0.875	0.516	0.335	0.568
Vanadium (V)	mg/kg			0.20	34.1	42.4	34.5	72.1	51.5	36.0	33.7	33.4	29.7
Zinc (Zn)	mg/kg	123	315	1.0	36.8	48.4	36.2	68.8	58.7	40.0	28.7	19.0	28.9
Speciated Metals													
Methylmercury	mg/kg			0.000050	<0.000050	<0.000050	0.000067	<0.000050	0.000338	0.000276	<0.000050	<0.000050	<0.000050

Notes:

Shaded cells indicate values that exceed CCME guidelines.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Annex A.4-1. Stream Sediment Quality Data, Doris North Project, 2011

Site ID:		CCME Guidelines for the Protection of Aquatic Life[a]			Reference B OF	Reference B OF	Reference B OF	Reference D OF	Reference D OF	Reference D OF
Replicate:					1	2	3	1	2	3
Date Sampled:				Realized Detection Limit	20-Aug-11	20-Aug-11	20-Aug-11	21-Aug-11	21-Aug-11	21-Aug-11
ALS Sample ID:	Unit	ISQG[b]	PEL[c]		L1049435-23	L1049435-24	L1049435-25	L1049435-17	L1049435-18	L1049435-19
Physical Tests										
Moisture	%			0.25	28.7	17.6	20.8	13.2	10.3	25.5
pH	pH			0.10	6.49	6.88	6.82	6.92	6.82	6.12
Particle Size										
% Gravel (>2 mm)	%			0.10	46.6	48.9	53.5	15.0	42.9	35.9
% Sand (2.0 mm - 0.063 mm)	%			0.10	42.7	50.2	45.6	71.1	55.3	56.8
% Silt (0.063 mm - 4 µm)	%			0.10	10.6	0.81	0.89	11.2	1.35	5.00
% Clay (<4 µm)	%			0.10	0.10	<0.10	<0.10	2.59	0.47	2.29
Anions & Nutrients										
Total Nitrogen	%			0.020	0.348	0.023	0.027	0.021	<0.020	0.045
Organic / Inorganic Carbon										
Total Organic Carbon	%			0.10	3.27	0.14	0.16	0.18	0.12	0.49
Plant Available Nutrients										
Available Ammonium-N	mg/kg			1.0 or 1.6	7.5	<1.6	<1.6	<1.0	<1.0	4.4
Available Nitrate-N	mg/kg			2.0 to 6.0	<4.0	<2.0	<2.0	<2.0	<2.0	<2.0
Available Nitrite-N	mg/kg			0.40 to 1.2	<0.80	<0.40	<0.40	<0.40	<0.40	<0.40
Available Phosphate-P	mg/kg			2.0	9.3	<2.0	5.0	3.7	3.2	7.2
Metals										
Aluminum (Al)	mg/kg			50	7470	5660	7020	6540	5060	6990
Antimony (Sb)	mg/kg			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Arsenic (As)	mg/kg	5.9	17	0.050	1.69	1.04	0.912	1.09	0.749	0.738
Barium (Ba)	mg/kg			0.50	30.2	14.6	15.3	31.2	15.9	25.3
Beryllium (Be)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Bismuth (Bi)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.115	<0.050	<0.050	<0.050	<0.050	<0.050
Calcium (Ca)	mg/kg			50	2280	1460	1850	2080	1700	2090
Chromium (Cr)	mg/kg	37.3	90	0.50	27.6	16.0	26.9	14.3	6.48	14.3
Cobalt (Co)	mg/kg			0.10	10.0	5.99	6.16	6.46	4.28	4.34
Copper (Cu)	mg/kg	35.7	197	0.50	12.9	6.49	6.43	11.5	6.40	9.69
Iron (Fe)	mg/kg			50	18300	12100	13300	13400	10800	10900
Lead (Pb)	mg/kg	35	91.3	0.50	2.28	1.24	1.32	1.44	0.97	1.87
Lithium (Li)	mg/kg			1.0	13.9	11.2	12.5	14.9	12.7	15.8
Magnesium (Mg)	mg/kg			20	5860	4710	5640	5440	4270	4840
Manganese (Mn)	mg/kg			1.0	614	308	187	619	200	131
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0118	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Molybdenum (Mo)	mg/kg			0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Nickel (Ni)	mg/kg			0.50	19.2	11.1	14.9	14.0	6.58	9.85
Phosphorus (P)	mg/kg			50	542	343	341	403	380	367
Potassium (K)	mg/kg			100	650	580	580	1110	760	1020
Selenium (Se)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Silver (Ag)	mg/kg			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			100	130	<100	<100	180	120	200
Strontium (Sr)	mg/kg			0.50	11.0	5.10	6.50	9.04	7.45	10.9
Sulphur (S)	mg/kg			500	1100	<500	500	700	600	600
Thallium (Tl)	mg/kg			0.050	0.079	<0.050	<0.050	0.059	<0.050	0.053
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	487	386	473	440	289	428
Uranium (U)	mg/kg			0.050	1.31	0.395	0.527	0.641	0.497	0.702
Vanadium (V)	mg/kg			0.20	28.3	22.2	23.5	30.3	19.9	24.7
Zinc (Zn)	mg/kg	123	315	1.0	40.8	22.8	26.7	25.8	18.0	24.2
Speciated Metals										
Methylmercury	mg/kg			0.000050	-	-	-	-	-	-

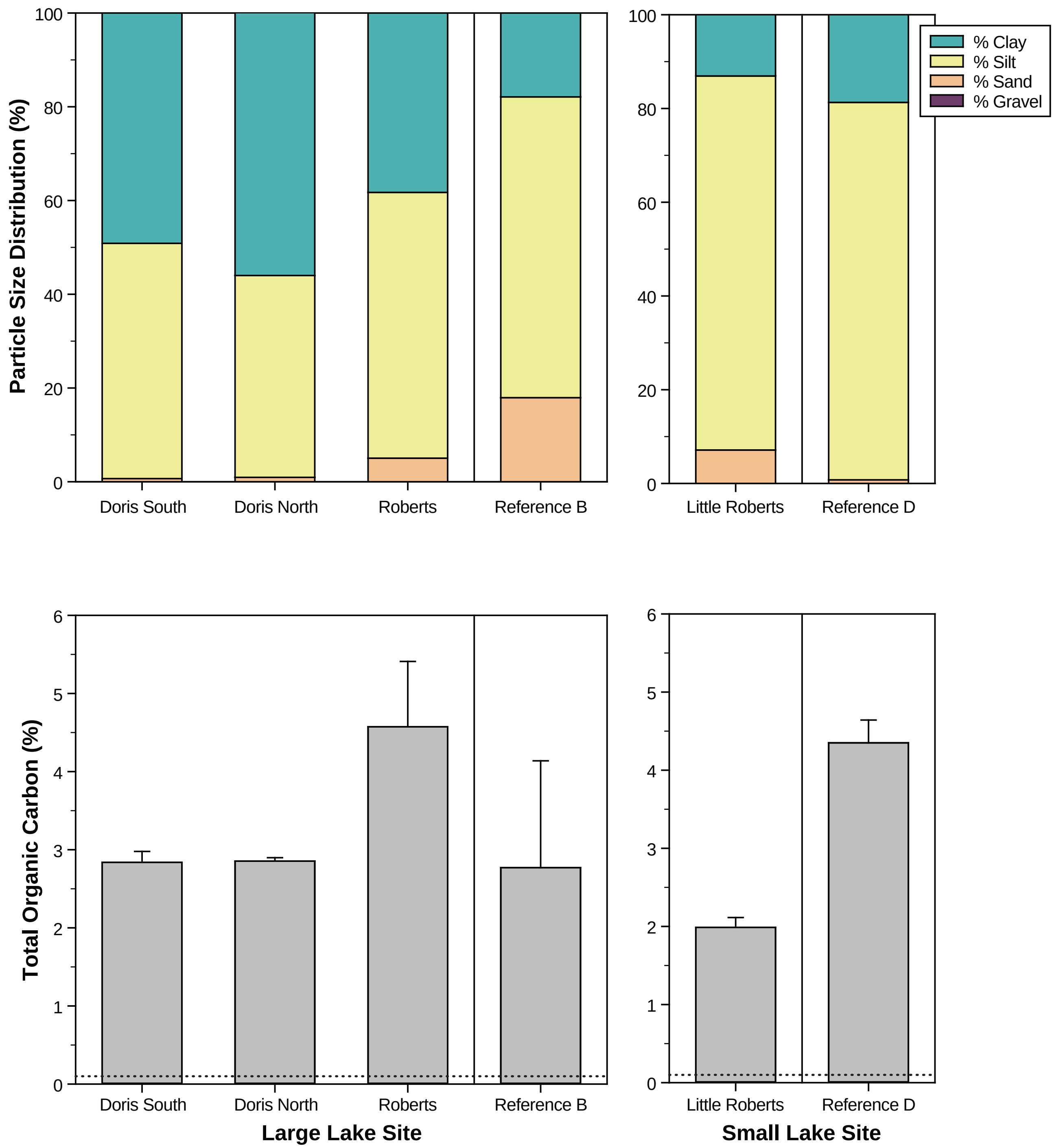
Notes:

Shaded cells indicate values that exceed CCME guidelines.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level



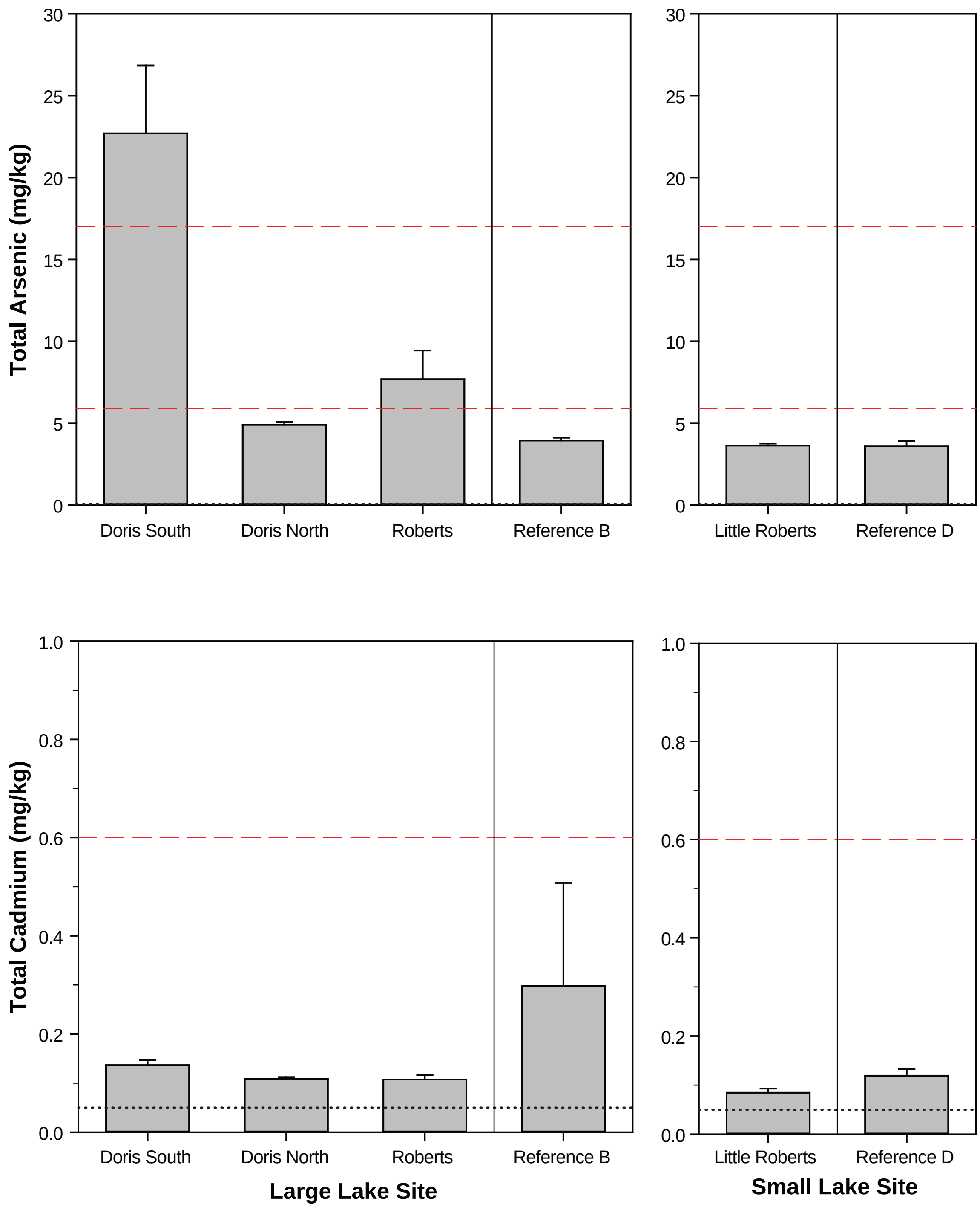
Notes: Error bars represent the standard error of the mean.
Stacked bars represent the mean of replicate samples.
Black dotted line represents the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Particle size distribution and total organic carbon content of sediments are required parameters as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.
Sediment samples from Roberts Lake were collected on September 24, 2011.

NEWMONT NORTH AMERICA

Particle Size Distribution and Total Organic Carbon Concentration in Lake Sediments, Doris North Project, August 2011

Figure A.4-6

Rescan Engineers & Scientists



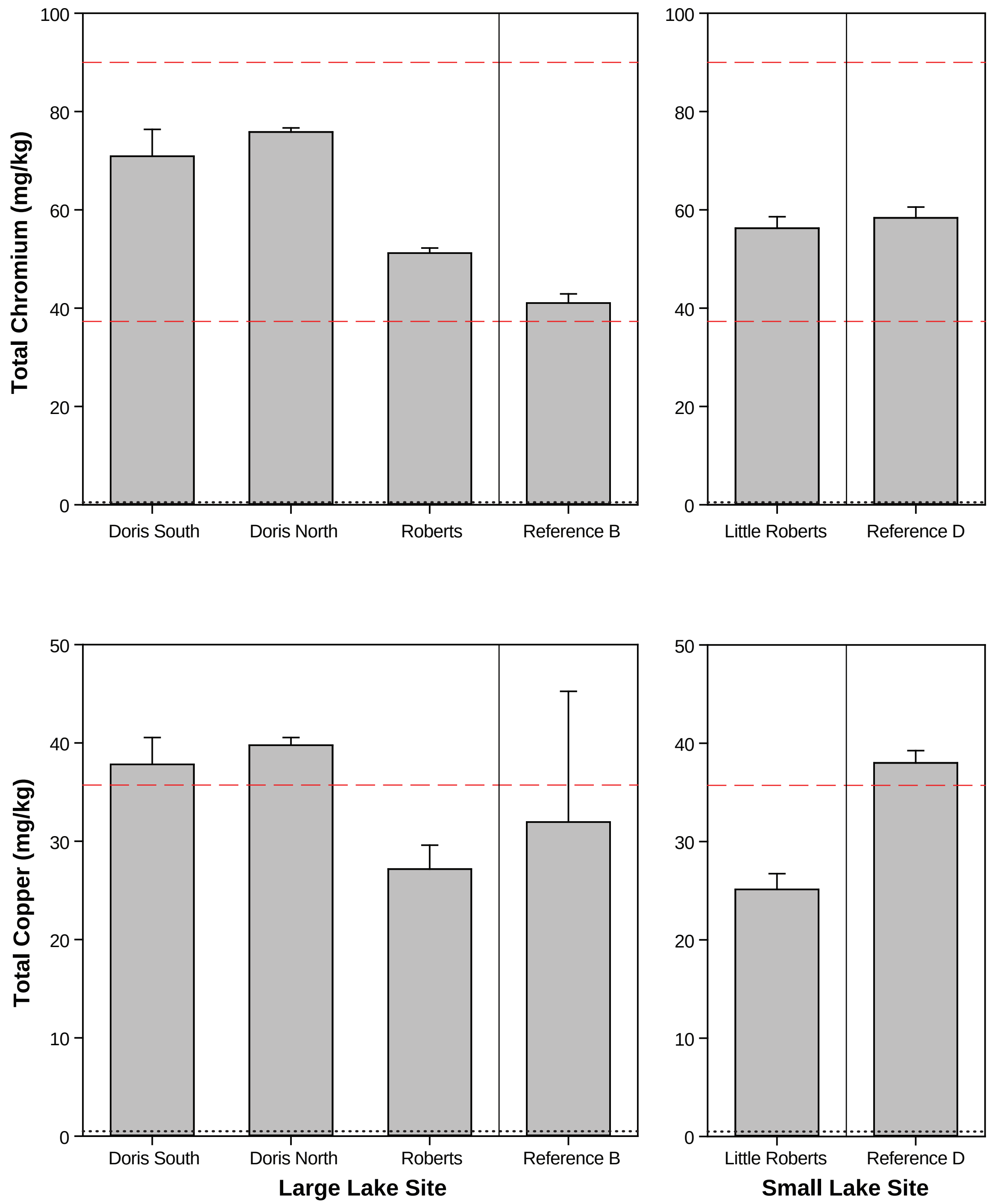
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for arsenic (5.9 mg/kg) and cadmium (0.6 mg/kg) and the probable effects level (PEL) for arsenic (17 mg/kg); the PEL for cadmium (3.5 mg/kg) is not shown.
Sediment samples from Roberts Lake were collected on September 24, 2011.

Newmont North America

Total Arsenic and Total Cadmium Concentrations in Lake Sediments, Doris North Project, August 2011

Figure A.4-7

Rescan Engineers & Scientists



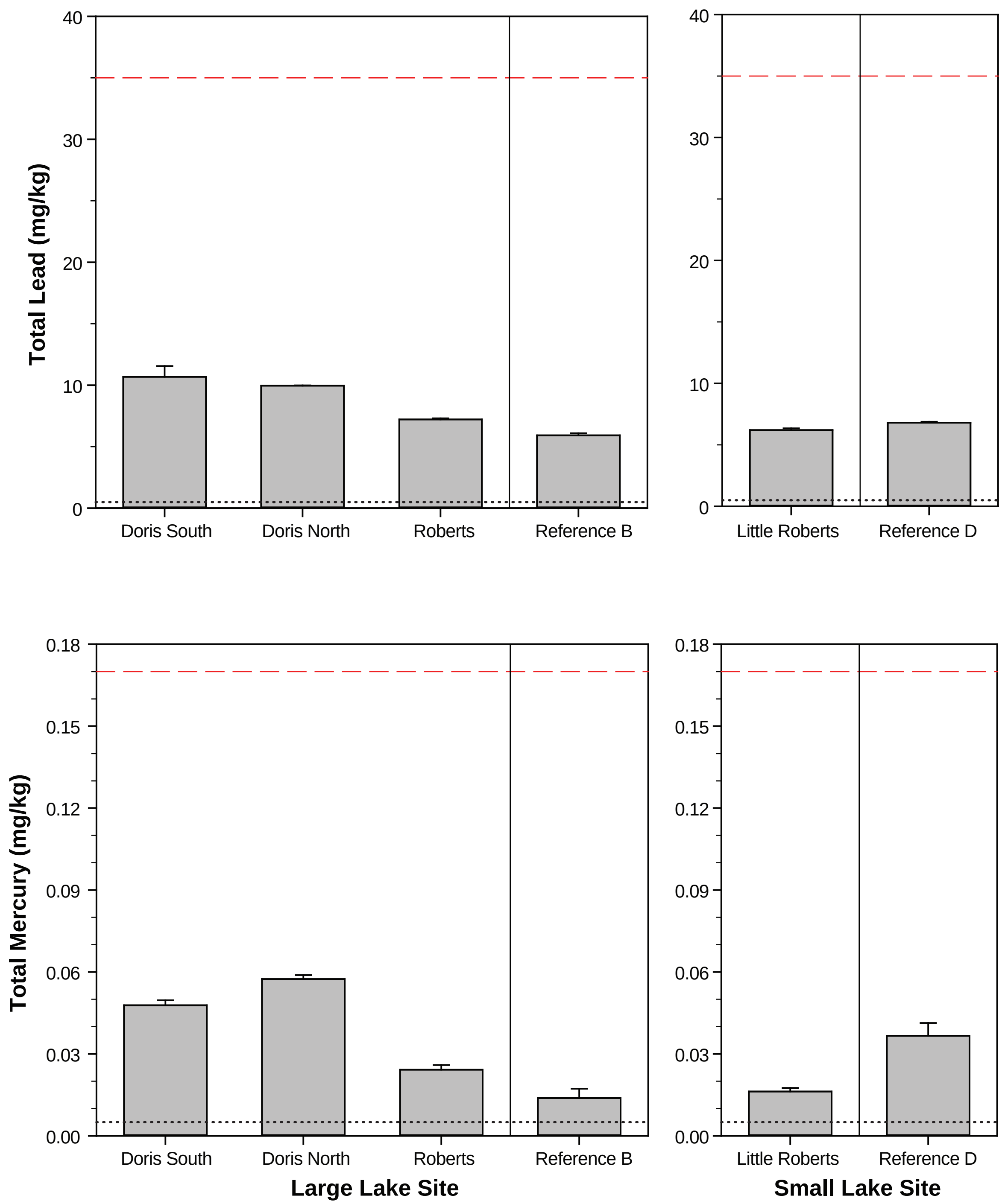
Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for chromium (37.3 mg/kg) and copper (35.7 mg/kg) and the probable effects level (PEL) for chromium (90 mg/kg); the PEL for copper (197 mg/kg) is not shown.
Sediment samples from Roberts Lake were collected on September 24, 2011.

NEWMONT NORTH AMERICA

Total Chromium and Total Copper Concentrations in Lake Sediments, Doris North Project, August 2011

Figure A.4-8

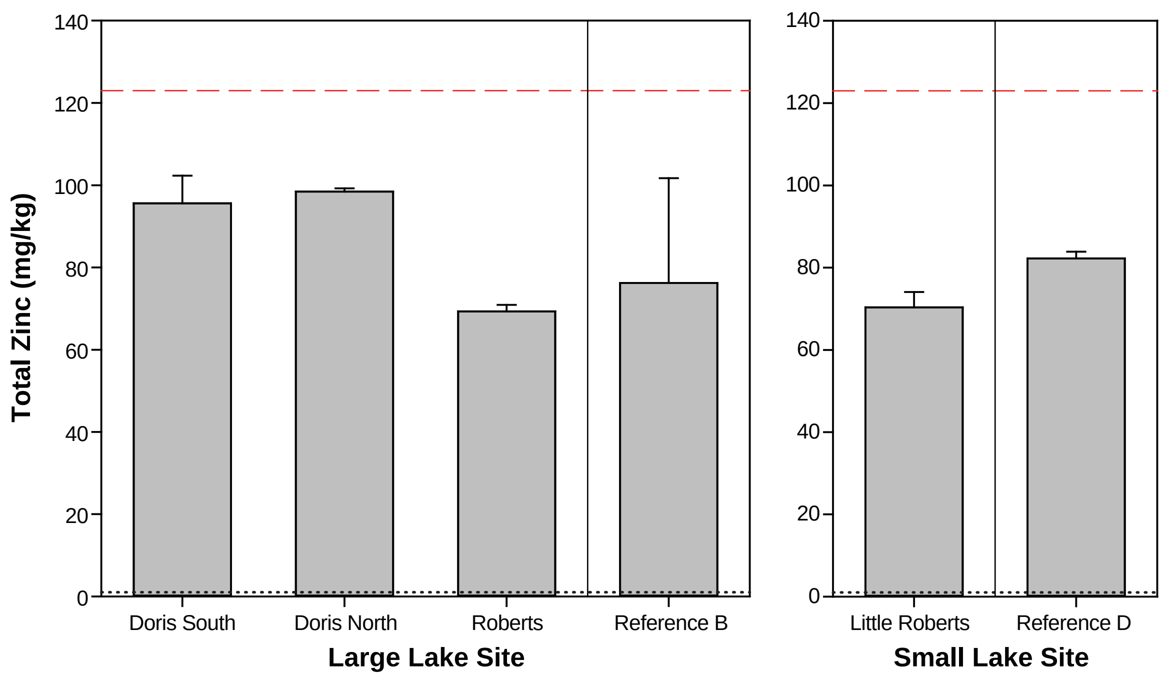
Rescan Engineers & Scientists



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME freshwater interim sediment quality guidelines (ISQGs) for lead (35 mg/kg) and mercury (0.17 mg/kg); probable effects levels (PELs) for lead (91.3 mg/kg) and mercury (0.486 mg/kg) are not shown.
Sediment samples from Roberts Lake were collected on September 24, 2011.

Figure A.4-9

Total Lead and Total Mercury Concentrations in Lake Sediments, Doris North Project, August 2011



Notes: Error bars represent the standard error of the mean.
Black dotted line represents the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Red dashed line represents the CCME freshwater interim sediment quality guideline (ISQG) for zinc (123 mg/kg); the probable effects level (PEL) for zinc (315 mg/kg) is not shown.
Sediment samples from Roberts Lake were collected on September 24, 2011.

NEWMONT NORTH AMERICA

Total Zinc Concentrations in Lake Sediments, Doris North Project, August 2011

Figure A.4-10

Rescan Engineers & Scientists

Table A.4-3. Sediment Quality in AEMP Lake Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2011

Lake Site	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Percent of Samples Higher Than ISQG[b] Guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			5.9	0.6	37.3	35.7	35	0.17	123
Large Lake Site									
Doris Lake South	3		100	0	100	33.3	0	0	0
Doris Lake North	3		0	0	100	100	0	0	0
Roberts Lake	3		66.7	0	100	0	0	0	0
Reference Lake B	3		0	33.3	100	33.3	0	0	33.3
Small Lake Site									
Little Roberts Lake	3		0	0	100	0	0	0	0
Reference Lake D	3		0	0	100	100	0	0	0

Lake Site	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Percent of Samples Higher Than PEL[c] Guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			17	3.5	90	197	91.3	0.486	315
Large Lake Site									
Doris Lake South	3		66.7	0	0	0	0	0	0
Doris Lake North	3		0	0	0	0	0	0	0
Roberts Lake	3		0	0	0	0	0	0	0
Reference Lake B	3		0	0	0	0	0	0	0
Small Lake Site									
Little Roberts Lake	3		0	0	0	0	0	0	0
Reference Lake D	3		0	0	0	0	0	0	0

Values represent the percentages of 2011 samples that are higher than CCME guidelines.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Council of Ministers of the Environment, Updated January 2011.

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Table A.4-4. Sediment Quality in AEMP Lake Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2011

Lake Site	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Factor by which Average Concentrations are Higher Than ISQG[b] Guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			5.9	0.6	37.3	35.7	35	0.17	123
Large Lake Site									
Doris Lake South	3		3.85	-	1.90	1.06	-	-	-
Doris Lake North	3		-	-	2.03	1.11	-	-	-
Roberts Lake	3		1.30	-	1.37	-	-	-	-
Reference Lake B	3		-	-	1.10	-	-	-	-
Small Lake Site									
Little Roberts Lake	3		-	-	1.51	-	-	-	-
Reference Lake D	3		-	-	1.56	1.06	-	-	-

Lake Site	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Factor by which Average Concentrations are Higher Than PEL[c] Guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			17	3.5	90	197	91.3	0.486	315
Large Lake Site									
Doris Lake South	3		1.34	-	-	-	-	-	-
Doris Lake North	3		-	-	-	-	-	-	-
Roberts Lake	3		-	-	-	-	-	-	-
Reference Lake B	3		-	-	-	-	-	-	-
Small Lake Site									
Little Roberts Lake	3		-	-	-	-	-	-	-
Reference Lake D	3		-	-	-	-	-	-	-

The average 2011 concentration of a particular parameter may be below the CCME guideline concentration even if a percentage of samples is higher than this guideline concentration.

Half the detection limit was substitued for values that were below the detection limit for the calculation of parameter averages.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Council of Ministers of the Environment, Updated January 2011.

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Annex A.4-2. Lake Sediment Quality Data, Doris North Project, 2011

		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit												
Site ID:					Doris Lake South	Doris Lake South	Doris Lake South	Doris Lake North	Doris Lake North	Doris Lake North	Reference Lake B	Reference Lake B	Reference Lake B	Little Roberts Lake	Little Roberts Lake	Little Roberts Lake
Depth Sampled (m):					11.5	11.5	11.5	13.7	13.7	13.7	10.5	10.5	10.5	3.6	3.6	3.6
Replicate:					1	2	3	1	2	3	1	2	3	1	2	3
Date Sampled:					16-Aug-11	16-Aug-11	16-Aug-11	16-Aug-11	16-Aug-11	16-Aug-11	20-Aug-11	20-Aug-11	20-Aug-11	28-Aug-11	28-Aug-11	28-Aug-11
ALS Sample ID:	Units	ISQG[b]	PEL[c]		L1047022-8	L1047022-9	L1047022-10	L1047022-5	L1047022-6	L1047022-7	L1049435-20	L1049435-21	L1049435-22	L1053787-4	L1053787-5	L1053787-6
Physical Tests																
Moisture	%			0.25	90.6	92.6	83.4	84.4	81.7	79.8	84.0	45.6	72.8	-	-	-
pH	pH			0.10	6.47	6.42	6.33	6.04	6.25	6.20	6.05	6.06	5.85	6.25	6.30	6.00
Particle Size																
% Gravel (>2 mm)	%			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
% Sand (2.0 mm - 0.063 mm)	%			0.10	0.70	0.62	0.54	0.95	0.59	1.14	23.8	15.3	14.6	7.14	7.65	6.50
% Silt (0.063 mm - 4 µm)	%			0.10	51.2	52.1	47.3	39.3	44.9	45.0	66.7	59.7	66.1	81.3	77.5	80.6
% Clay (<4 µm)	%			0.10	48.1	47.3	52.2	59.8	54.5	53.9	9.49	25.0	19.4	11.6	14.9	12.9
Anions & Nutrients																
Total Nitrogen	%			0.020	0.378	0.357	0.311	0.381	0.339	0.350	0.543	0.069	0.264	0.236	0.291	0.278
Organic / Inorganic Carbon																
Total Organic Carbon	%			0.10	3.02	2.93	2.56	2.93	2.78	2.85	5.29	0.59	2.43	1.74	2.16	2.06
Plant Available Nutrients																
Available Ammonium-N	mg/kg			1.6 to 8.8	28.8	30.5	28.2	74.5	48.5	52.6	4.1	<1.6	10.8	8.4	11.2	18.3
Available Nitrate-N	mg/kg			4.0 to 20	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0	<6.0	<4.0	<4.0	<6.0	<6.0	<6.0
Available Nitrite-N	mg/kg			0.80 to 4.0	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<1.2	<0.80	<0.80	<1.2	<1.2	<1.2
Available Phosphate-P	mg/kg			2.0 to 8.0	<2.0	2.7	2.3	2.9	<2.0	<2.0	124	<2.0	<4.0	2.6	3.4	3.7
Metals																
Aluminum (Al)	mg/kg			50	20300	26200	21300	24200	24300	24300	14900	12800	12900	16400	16100	17600
Antimony (Sb)	mg/kg			0.10	<0.10	0.12	<0.10	<0.10	<0.10	0.11	0.13	0.14	0.13	<0.10	<0.10	<0.10
Arsenic (As)	mg/kg	5.9	17	0.050	26.5	27.2	14.4	5.24	4.72	4.72	3.62	3.94	4.23	3.74	3.39	3.75
Barium (Ba)	mg/kg			0.50	176	220	171	145	154	155	83.0	75.8	73.7	100	97.7	113
Beryllium (Be)	mg/kg			0.20	0.73	0.97	0.83	0.86	0.84	0.86	0.50	0.47	0.43	0.50	0.50	0.49
Bismuth (Bi)	mg/kg			0.20	0.23	0.30	0.25	0.24	0.24	0.25	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.125	0.156	0.129	0.101	0.110	0.114	0.717	0.083	0.093	0.072	0.082	0.100
Calcium (Ca)	mg/kg			50	5380	6900	5180	5800	6000	5850	4020	3270	3110	5260	5180	5170
Chromium (Cr)	mg/kg	37.3	90	0.50	63.9	81.7	67.1	75.0	75.0	77.5	44.8	39.0	39.3	55.1	52.9	60.8
Cobalt (Co)	mg/kg			0.10	14.6	18.2	14.8	14.2	14.3	14.7	13.5	10.6	12.0	10.7	10.4	11.9
Copper (Cu)	mg/kg	35.7	197	0.50	34.7	43.3	35.4	40.4	38.2	40.7	58.5	16.8	20.5	23.2	23.9	28.3
Iron (Fe)	mg/kg			50	64100	74600	52600	41600	39200	39700	18700	34100	35600	27000	25300	29600
Lead (Pb)	mg/kg	35	91.3	0.50	9.46	12.4	10.2	9.99	9.90	10.0	6.25	5.62	5.89	6.16	5.98	6.48
Lithium (Li)	mg/kg			1.0	41.3	52.2	41.0	51.1	50.4	51.3	24.3	21.8	21.8	27.1	27.8	29.9
Magnesium (Mg)	mg/kg			20	13200	16500	13500	15400	15500	16000	7420	7100	7090	11500	11500	13400
Manganese (Mn)	mg/kg			1.0	3200	3730	1720	566	554	556	238	241	296	415	356	364
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0474	0.0512	0.0447	0.0602	0.0556	0.0564	0.0165	0.0071	0.0179	0.0143	0.0157	0.0187
Molybdenum (Mo)	mg/kg			0.50	2.94	3.72	1.70	1.13	1.21	1.26	2.04	1.83	1.92	1.21	1.13	1.25
Nickel (Ni)	mg/kg			0.50	41.9	53.2	43.8	46.3	45.4	47.5	31.7	19.0	20.8	28.3	27.9	32.3
Phosphorus (P)	mg/kg			50	1710	1870	1230	1300	967	1010	886	670	729	921	865	952
Potassium (K)	mg/kg			100	5180	6600	5300	6030	6080	6210	3000	3010	2970	4480	4370	4970
Selenium (Se)	mg/kg			0.20	0.39	0.49	0.37	0.33	0.29	0.30	0.80	0.30	0.39	<0.20	0.21	0.24
Silver (Ag)	mg/kg			0.10	0.13	0.14	0.10	0.31	0.33	0.27	0.11	<0.10	<0.10	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			100	1660	2080	1470	1440	1450	1420	490	430	400	830	800	980
Strontium (Sr)	mg/kg			0.50	37.3	48.8	36.3	37.2	38.4	37.3	29.0	23.6	23.3	29.4	28.7	29.4
Sulphur (S)	mg/kg			500	1500	1400	1400	3700	1800	1400	3500	900	1300	1200	1300	1500
Thallium (Tl)	mg/kg			0.050	0.256	0.336	0.279	0.300	0.292	0.297	0.324	0.159	0.159	0.185	0.184	0.212
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	1220	1710	1280	1460	1480	1520	849	885	827	1190	1110	1310
Uranium (U)	mg/kg			0.050	2.16	2.85	2.37	2.06	2.06	2.09	6.76	1.59	2.09	1.35	1.33	1.46
Vanadium (V)	mg/kg			0.20	74.7	94.4	77.3	76.6	78.1	79.6	53.8	44.0	42.4	59.2	56.2	65.6
Zinc (Zn)	mg/kg	123	315	1.0	87.9	109	89.9	97.4	98.0	100	127	46.7	55.0	67.5	65.9	77.7
Speciated Metals																
Methylmercury	mg/kg			0.000050	-	-	-	-	-	-	-	-	-	0.000157	0.000225	0.000200

Notes:

Shaded cells indicate values that exceed CCME guidelines.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Annex A.4-2. Lake Sediment Quality Data, Doris North Project, 2011

Site ID:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	Reference Lake D	Reference Lake D	Reference Lake D	Roberts Lake	Roberts Lake	Roberts Lake	Roberts Lake	Roberts Lake	Roberts Lake
Depth Sampled (m):					3.5	3.5	3.5	1.75	1.75	1.75	1.75	1.75	1.75
Replicate:					1	2	3	1	1	2	2	3	3
Date Sampled:					16-Aug-11	16-Aug-11	16-Aug-11	24-Sep-11	24-Sep-11	24-Sep-11	24-Sep-11	24-Sep-11	24-Sep-11
ALS Sample ID:	Units	ISQG[b]	PEL[c]		L1047022-11	L1047022-12	L1047022-13	L1064725-1	L1064725-2	L1064725-3	L1064725-4	L1064725-5	L1064725-6
Physical Tests													
Moisture	%			0.25	77.8	86.8	79.8	-	70.4	-	78.4	-	75.0
pH	pH			0.10	5.85	5.76	6.46	-	6.04	-	6.08	-	5.78
Particle Size													
% Gravel (>2 mm)	%			0.10	<0.10	<0.10	<0.10	<0.10	-	<0.10	-	<0.10	-
% Sand (2.0 mm - 0.063 mm)	%			0.10	1.50	0.44	0.30	8.39	-	2.68	-	3.88	-
% Silt (0.063 mm - 4 µm)	%			0.10	84.6	90.4	66.6	59.1	-	54.2	-	56.8	-
% Clay (<4 µm)	%			0.10	13.9	9.19	33.1	32.5	-	43.1	-	39.3	-
Anions & Nutrients													
Total Nitrogen	%			0.020	0.461	0.574	0.446	-	0.309	-	0.491	-	0.427
Organic / Inorganic Carbon													
Total Organic Carbon	%			0.10	4.06	4.93	4.06	-	3.13	-	6.03	-	4.56
Plant Available Nutrients													
Available Ammonium-N	mg/kg			1.6 to 8.8	40.6	46.7	27.6	-	33.3	-	80.2	-	41.5
Available Nitrate-N	mg/kg			4.0 to 20	<4.0	<4.0	<4.0	-	<6.0	-	<20	-	<6.0
Available Nitrite-N	mg/kg			0.80 to 4.0	<0.80	<0.80	<0.80	-	<1.2	-	<4.0	-	<1.2
Available Phosphate-P	mg/kg			2.0 to 8.0	<2.0	<2.0	8.7	-	2.1	-	17.2	-	<2.0
Metals													
Aluminum (Al)	mg/kg			50	19600	18300	18000	-	17000	-	17400	-	17600
Antimony (Sb)	mg/kg			0.10	<0.10	0.14	0.12	-	0.12	-	0.15	-	0.13
Arsenic (As)	mg/kg	5.9	17	0.050	3.89	3.89	3.01	-	4.55	-	10.6	-	7.90
Barium (Ba)	mg/kg			0.50	124	121	132	-	107	-	127	-	120
Beryllium (Be)	mg/kg			0.20	0.71	0.66	0.65	-	0.61	-	0.61	-	0.60
Bismuth (Bi)	mg/kg			0.20	<0.20	<0.20	<0.20	-	<0.20	-	<0.20	-	<0.20
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.107	0.105	0.146	-	0.089	-	0.114	-	0.119
Calcium (Ca)	mg/kg			50	4990	4980	5430	-	4920	-	5900	-	5480
Chromium (Cr)	mg/kg	37.3	90	0.50	62.4	57.9	54.8	-	49.6	-	53.2	-	50.8
Cobalt (Co)	mg/kg			0.10	17.6	14.3	11.6	-	11.8	-	12.4	-	12.1
Copper (Cu)	mg/kg	35.7	197	0.50	37.0	36.5	40.5	-	22.5	-	30.6	-	28.4
Iron (Fe)	mg/kg			50	49800	31700	24600	-	29400	-	38400	-	33500
Lead (Pb)	mg/kg	35	91.3	0.50	6.70	6.74	6.96	-	7.04	-	7.27	-	7.34
Lithium (Li)	mg/kg			1.0	35.3	33.4	32.8	-	31.5	-	31.7	-	32.1
Magnesium (Mg)	mg/kg			20	12100	11400	11500	-	11000	-	12100	-	11600
Manganese (Mn)	mg/kg			1.0	424	337	314	-	505	-	907	-	636
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0418	0.0408	0.0273	-	0.0209	-	0.0249	-	0.0268
Molybdenum (Mo)	mg/kg			0.50	1.34	1.42	1.68	-	1.01	-	1.29	-	1.31
Nickel (Ni)	mg/kg			0.50	37.9	35.2	33.6	-	27.8	-	32.0	-	30.5
Phosphorus (P)	mg/kg			50	1140	831	643	-	799	-	1410	-	1090
Potassium (K)	mg/kg			100	4660	4540	4410	-	4360	-	4850	-	4790
Selenium (Se)	mg/kg			0.20	0.42	0.38	0.30	-	0.25	-	0.43	-	0.34
Silver (Ag)	mg/kg			0.10	<0.10	<0.10	<0.10	-	<0.10	-	<0.10	-	<0.10
Sodium (Na)	mg/kg			100	900	920	890	-	920	-	1110	-	1050
Strontium (Sr)	mg/kg			0.50	31.4	30.7	33.2	-	30.8	-	39.4	-	35.0
Sulphur (S)	mg/kg			500	1700	2500	2100	-	2000	-	2600	-	3200
Thallium (Tl)	mg/kg			0.050	0.247	0.238	0.236	-	0.205	-	0.221	-	0.222
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0	-	<2.0	-	<2.0	-	<2.0
Titanium (Ti)	mg/kg			1.0	1340	1250	1250	-	1240	-	1280	-	1250
Uranium (U)	mg/kg			0.050	3.02	2.87	2.71	-	1.73	-	2.61	-	2.20
Vanadium (V)	mg/kg			0.20	66.8	61.8	61.6	-	58.0	-	63.2	-	61.1
Zinc (Zn)	mg/kg	123	315	1.0	85.5	80.1	81.1	-	66.4	-	71.9	-	69.7
Speciated Metals													
Methylmercury	mg/kg			0.000050	-	-	-	-	-	-	-	-	-

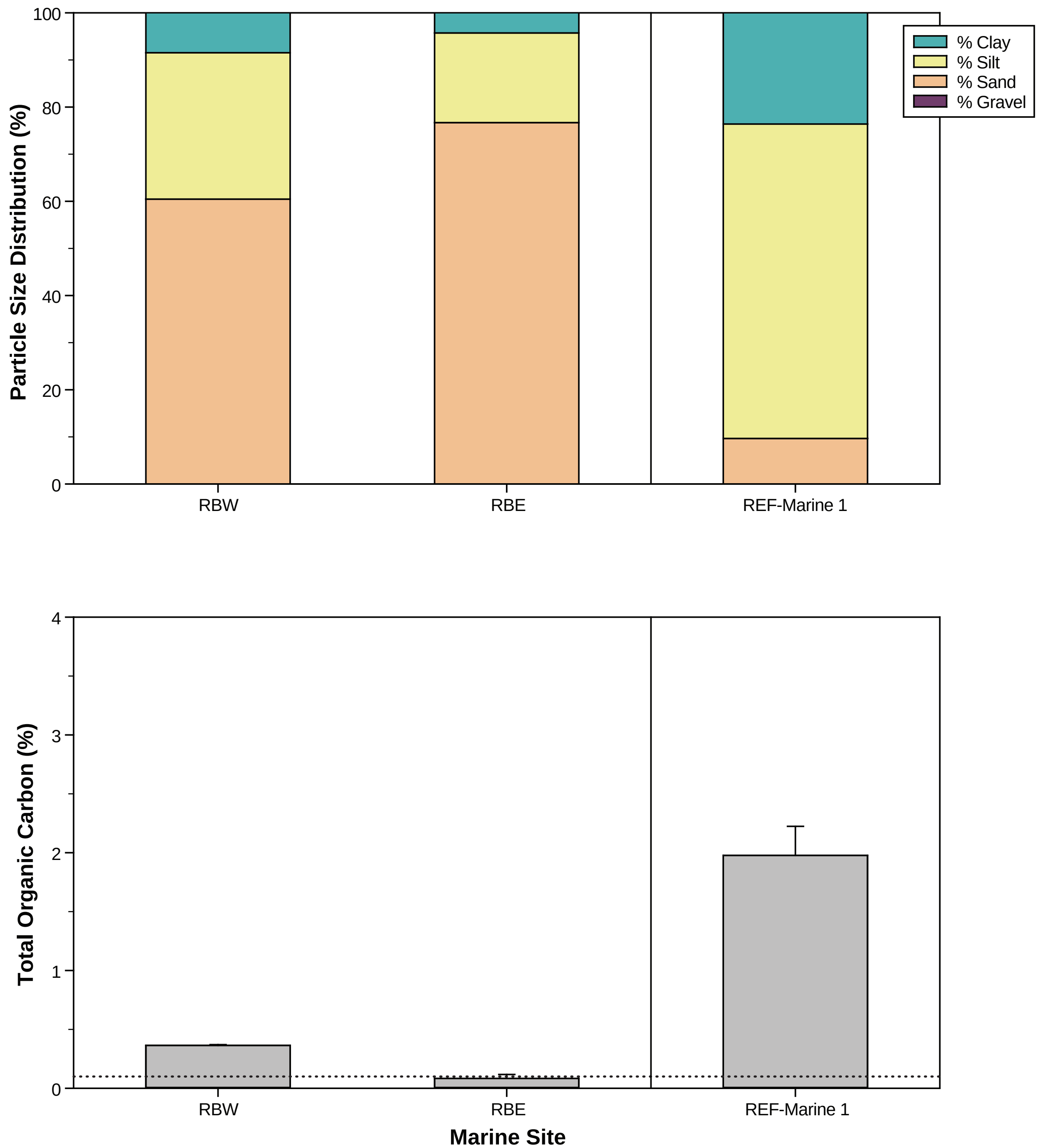
Notes:

Shaded cells indicate values that exceed CCME guidelines.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011.

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level



Notes: Error bars represent the standard error of the mean.
Stacked bars represent the mean of replicate samples.
Black dotted line represents the analytical detection limit; values below the detection limit are plotted at half the detection limit.
Particle size distribution and total organic carbon content of sediments are required parameters as part of benthic invertebrate surveys as per Schedule 5, s.16a (iii) of the MMER.

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Particle Size Distribution and Total Organic Carbon Concentration in Marine Sediments, Doris North Project, August 2011

Figure A.4-11

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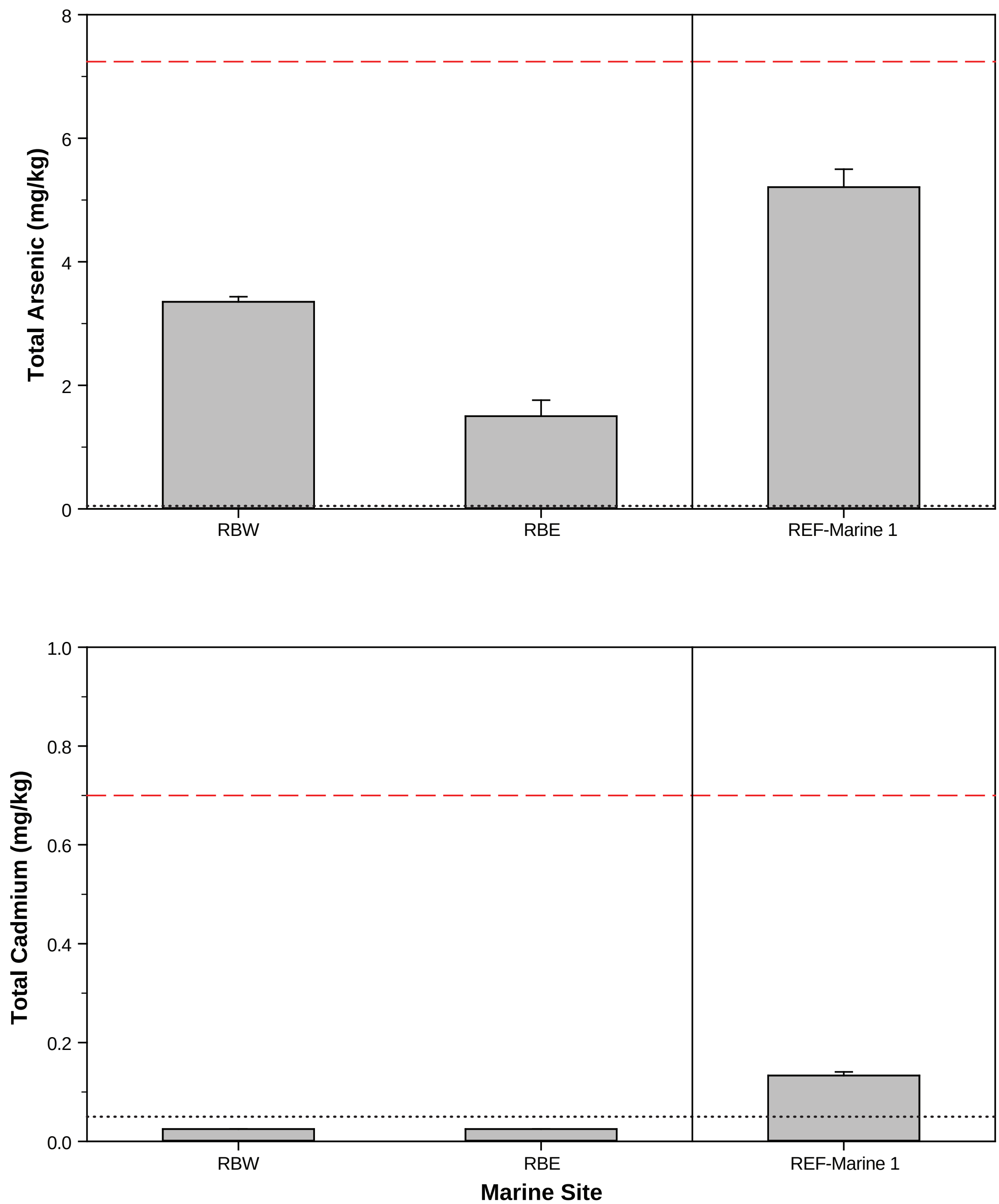

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guidelines (ISQGs) for arsenic (7.24 mg/kg) and cadmium (0.7 mg/kg); probable effects levels (PELs) for arsenic (41.6 mg/kg) and cadmium (4.2 mg/kg) are not shown.

Figure A.4-12

Total Arsenic and Total Cadmium Concentrations in Marine Sediments, Doris North Project, August 2011

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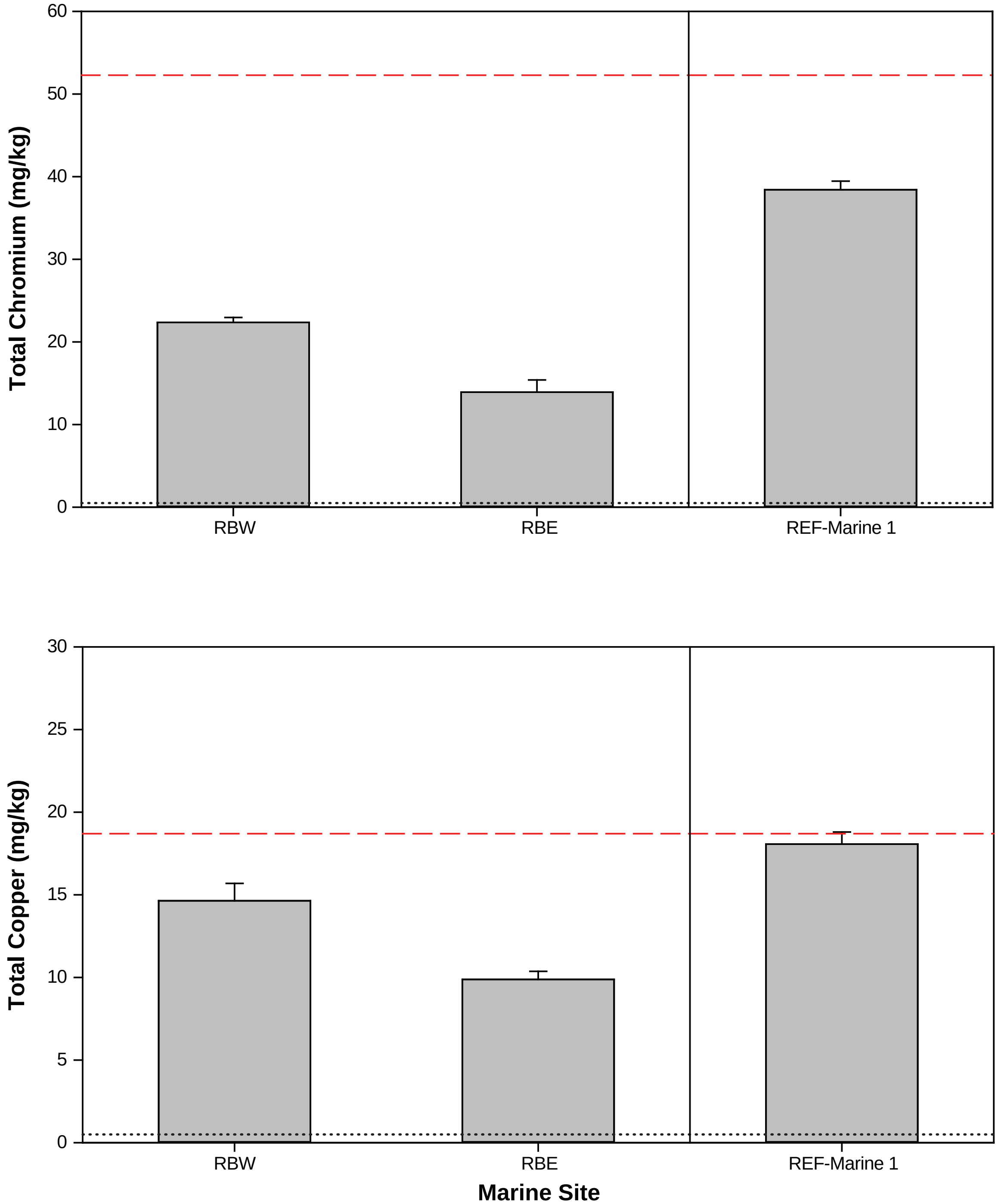

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guidelines (ISQGs) for chromium (52.3 mg/kg) and copper (18.7 mg/kg); probable effects levels (PELs) for chromium (160 mg/kg) and copper (108 mg/kg) are not shown.

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Total Chromium and Total Copper Concentrations in Marine Sediments, Doris North Project, August 2011

Figure A.4-13

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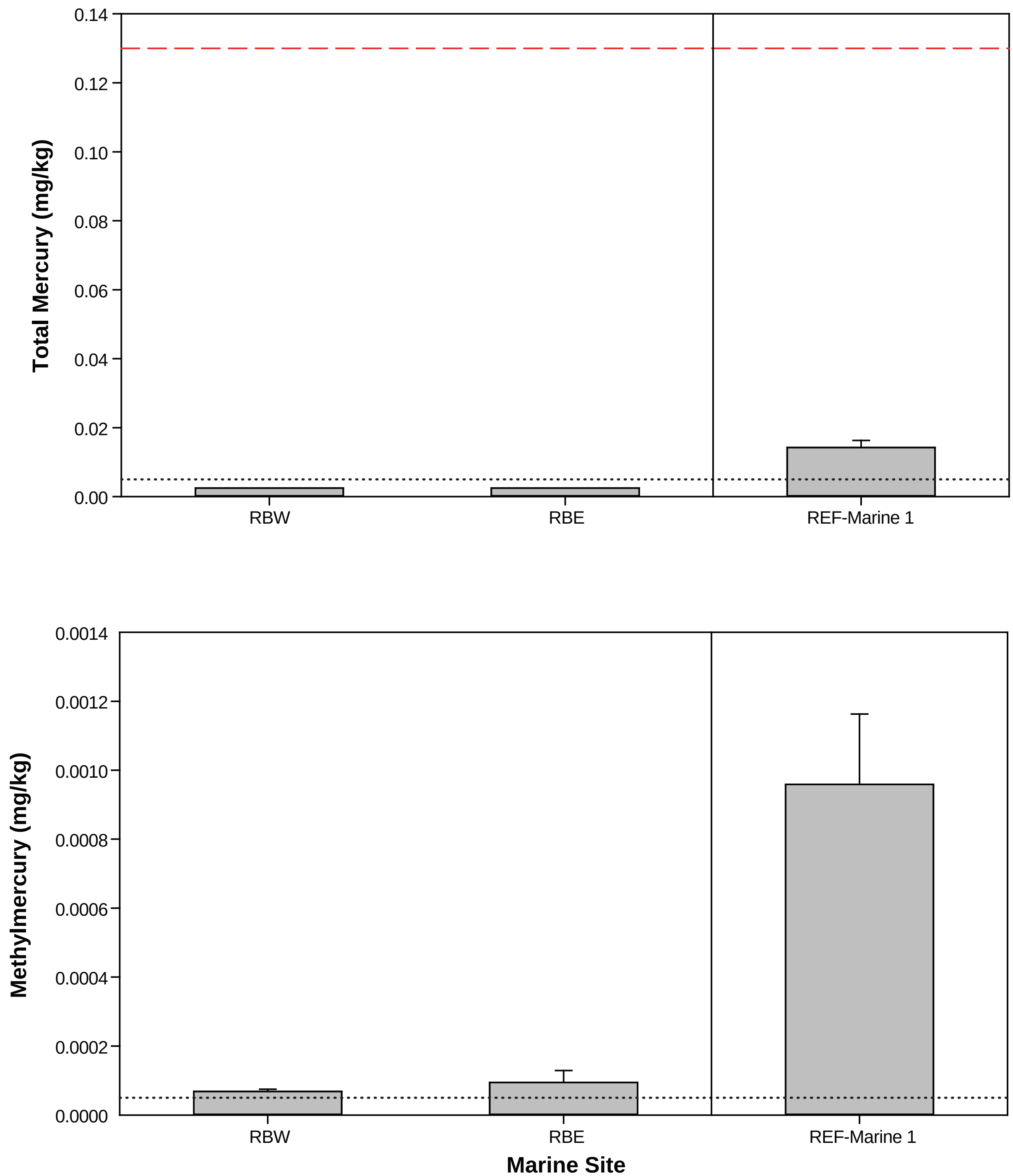

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guideline (ISQG) for total mercury (0.13 mg/kg); the probable effects level (PEL) for total mercury (0.7 mg/kg) is not shown.

Figure A.4-14

Total Mercury and Methylmercury Concentrations in Marine Sediments, Doris North Project, August 2011

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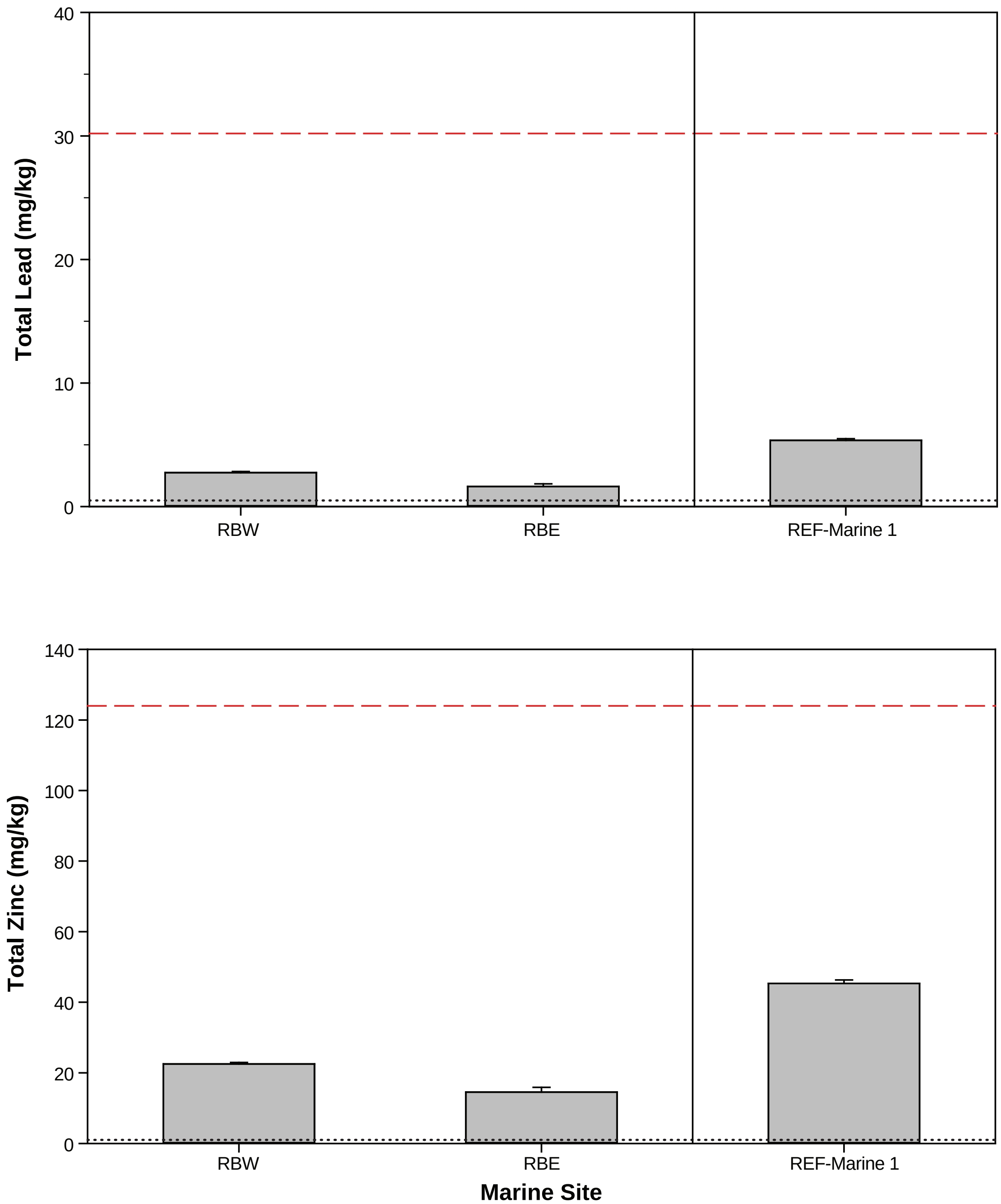

Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits; values below the detection limit are plotted at half the detection limit.
Red dashed lines represent the CCME marine and estuarine interim sediment quality guidelines (ISQGs) for lead (30.2 mg/kg) and zinc (124 mg/kg); probable effects levels (PELs) for lead (112 mg/kg) and zinc (271 mg/kg) are not shown.

Figure A.4-15

Total Lead and Total Zinc Concentrations in Marine Sediments, Doris North Project, August 2011

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Table A.4-5. Sediment Quality in AEMP Marine Sites, Percent of Samples in which Concentrations are Higher than CCME Guidelines, Doris North Project, 2011

Marine Site	Total Number of Samples Collected	CCME Guideline Value[a] (mg/kg):	Percent of Samples Higher than ISQG[b] Guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			7.24	0.7	52.3	18.7	30.2	0.13	124
RBW	3		0	0	0	0	0	0	0
RBE	3		0	0	0	0	0	0	0
REF-Marine 1	3		0	0	0	33.3	0	0	0

Marine Site	Total Number of Samples Collected	CCME Guideline Value[a] (mg/kg):	Percent of Samples Higher than PEL[c] Guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			41.6	4.2	160	108	112	0.7	271
RBW	3		0	0	0	0	0	0	0
RBE	3		0	0	0	0	0	0	0
REF-Marine 1	3		0	0	0	0	0	0	0

Values represent the percentages of 2011 samples that are higher than CCME guidelines.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Council of Ministers of the Environment, Updated January 2011.

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Table A.4-6. Sediment Quality in AEMP Marine Sites, Factor by which Average Concentrations are Higher than CCME Guidelines, Doris North Project, 2011

Marine Site	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Factor by which Average Concentrations are Higher than ISQG[b] Guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			7.24	0.7	52.3	18.7	30.2	0.13	124
RBW	3		-	-	-	-	-	-	-
RBE	3		-	-	-	-	-	-	-
REF-Marine 1	3		-	-	-	-	-	-	-

Marine Site	Total Number of Samples Collected	CCME Guideline value[a] (mg/kg):	Factor by which Average Concentrations are Higher than PEL[c] Guidelines						
			Arsenic (As)	Cadmium (Cd)	Chromium (Cr)	Copper (Cu)	Lead (Pb)	Mercury (Hg)	Zinc (Zn)
			41.6	4.2	160	108	112	0.7	271
RBW	3		-	-	-	-	-	-	-
RBE	3		-	-	-	-	-	-	-
REF-Marine 1	3		-	-	-	-	-	-	-

The average 2011 concentration of a particular parameter may be below the CCME guideline concentration even if a percentage of samples is higher than this guideline concentration.

Half the detection limit was substitued for values that were below the detection limit for the calculation of parameter averages.

a) Canadian sediment quality guidelines for the protection of freshwater aquatic life, Council of Ministers of the Environment, Updated January 2011.

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

Annex A.4-3. Marine Sediment Quality Data, Doris North Project, 2011

Site ID:		CCME Guidelines for the Protection of Aquatic Life[a]			RBW	RBW	RBW	RBE	RBE	RBE	REF-Marine 1	REF-Marine 1	REF-Marine 1
Depth (m):					3.7	3.7	3.7	1.2	1.2	1.2	4.5	4.5	4.5
Replicate:				Realized Detection Limit	1	2	3	1	2	3	1	2	3
Date Sampled:					19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11
ALS Sample ID:	Units	ISQG[b]	PEL[c]		L1049435-32	L1049435-33	L1049435-34	L1049435-29	L1049435-30	L1049435-31	L1049435-26	L1049435-27	L1049435-28
Physical Tests													
Moisture	%			0.25	23.5	26.5	30.1	26.5	27.0	15.9	60.2	69.5	62.1
pH	pH			0.10	8.24	7.89	8.04	7.74	7.35	7.29	7.50	7.50	7.66
Particle Size													
% Gravel (>2 mm)	%			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
% Sand (2.0 mm - 0.063 mm)	%			0.10	63.0	58.8	59.5	65.6	80.0	84.4	11.6	8.33	9.01
% Silt (0.063 mm - 4 µm)	%			0.10	27.7	34.4	31.1	28.0	16.3	12.8	64.6	66.2	69.4
% Clay (<4 µm)	%			0.10	9.31	6.75	9.44	6.43	3.75	2.83	23.8	25.5	21.6
Anions & Nutrients													
Total Nitrogen	%			0.020	0.050	0.052	0.040	<0.020	<0.020	<0.020	0.194	0.322	0.206
Organic / Inorganic Carbon													
Total Organic Carbon	%			0.10	0.35	0.37	0.37	0.15	<0.10	<0.10	1.73	2.47	1.73
Plant Available Nutrients													
Available Ammonium-N	mg/kg			1.0 to 2.4	12.8	17.0	10.2	<1.6	<1.0	<1.0	19.8	47.0	26.1
Available Nitrate-N	mg/kg			2.0 or 4.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<4.0	<4.0	<4.0
Available Nitrite-N	mg/kg			0.40 or 0.80	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.80	<0.80	<0.80
Available Phosphate-P	mg/kg			2.0	15.4	20.5	18.3	16.6	5.4	4.0	30.9	50.8	20.1
Metals													
Aluminum (Al)	mg/kg			50	6620	7200	6430	5170	3880	4170	13500	14900	13000
Antimony (Sb)	mg/kg			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.19	0.23	0.16
Arsenic (As)	mg/kg	7.24	41.6	0.050	3.38	3.48	3.20	2.02	1.24	1.25	5.41	5.58	4.64
Barium (Ba)	mg/kg			0.50	30.0	32.3	29.7	21.5	15.4	14.8	63.9	69.7	62.1
Beryllium (Be)	mg/kg			0.20	<0.20	0.20	<0.20	<0.20	<0.20	<0.20	0.45	0.46	0.37
Bismuth (Bi)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Cadmium (Cd)	mg/kg	0.7	4.2	0.050	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050	0.136	0.144	0.120
Calcium (Ca)	mg/kg			50	5170	3520	2910	2370	2050	2010	5210	6130	5580
Chromium (Cr)	mg/kg	52.3	160	0.50	22.4	23.4	21.3	16.9	12.3	12.6	37.4	40.5	37.4
Cobalt (Co)	mg/kg			0.10	5.10	5.38	5.05	4.33	3.57	3.67	7.40	7.89	7.26
Copper (Cu)	mg/kg	18.7	108	0.50	16.6	14.3	13.0	10.8	9.67	9.16	17.6	19.5	17.1
Iron (Fe)	mg/kg			50	13200	13800	12900	9680	7840	7960	19500	20800	19400
Lead (Pb)	mg/kg	30.2	112	0.50	2.62	2.94	2.70	2.05	1.37	1.49	5.58	5.40	5.11
Lithium (Li)	mg/kg			1.0	12.1	13.3	12.4	10.0	7.5	8.2	25.8	27.8	26.4
Magnesium (Mg)	mg/kg			20	5590	5980	5780	4340	3320	3400	11200	12700	11300
Manganese (Mn)	mg/kg			1.0	129	136	123	98.7	79.6	83.7	210	226	203
Mercury (Hg)	mg/kg	0.13	0.70	0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0127	0.0117	0.0183
Molybdenum (Mo)	mg/kg			0.50	<0.50	0.56	0.54	<0.50	<0.50	<0.50	2.20	2.64	2.22
Nickel (Ni)	mg/kg			0.50	11.9	12.5	11.6	9.32	7.32	7.35	19.5	20.8	19.0
Phosphorus (P)	mg/kg			50	532	579	494	427	316	256	791	935	784
Potassium (K)	mg/kg			100	1780	2000	1890	1320	860	910	4780	5480	4850
Selenium (Se)	mg/kg			0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	0.41	0.48	0.39
Silver (Ag)	mg/kg			0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			100	2990	3290	4580	2790	2830	1870	13200	18900	14000
Strontium (Sr)	mg/kg			0.50	27.3	19.0	16.4	12.3	10.1	9.91	48.7	65.3	52.2
Sulphur (S)	mg/kg			500	1500	1500	1500	1900	1300	1100	3200	4200	4500
Thallium (Tl)	mg/kg			0.050	0.075	0.084	0.078	0.062	<0.050	<0.050	0.168	0.178	0.166
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	553	582	472	437	341	357	1030	1050	909
Uranium (U)	mg/kg			0.050	0.511	0.586	0.536	0.505	0.445	0.355	1.73	1.71	1.62
Vanadium (V)	mg/kg			0.20	29.0	30.7	27.6	23.8	18.0	18.3	50.2	53.4	48.0
Zinc (Zn)	mg/kg	124	271	1.0	21.9	23.3	22.4	17.0	12.4	14.2	44.9	47.2	43.9
Speciated Metals													
Methylmercury	mg/kg			0.000050	0.000059	0.000081	0.000065	0.000162	0.000072	0.000050	0.00136	0.000692	0.000824

Notes:

Shaded cells indicate values that exceed CCME guidelines

a) Canadian sediment quality guidelines for the protection of marine aquatic life, Canadian Council of Ministers of the Environment, Updated January 2011

b) ISQG = Interim Sediment Quality Guideline

c) PEL = Probable Effects Level

A.5 2011 PRIMARY PRODUCERS

The following sections present the periphyton and phytoplankton biomass (as chlorophyll *a*) data collected between April and September 2011 from stream, lake, and marine sites.

A.5.1 Stream Data

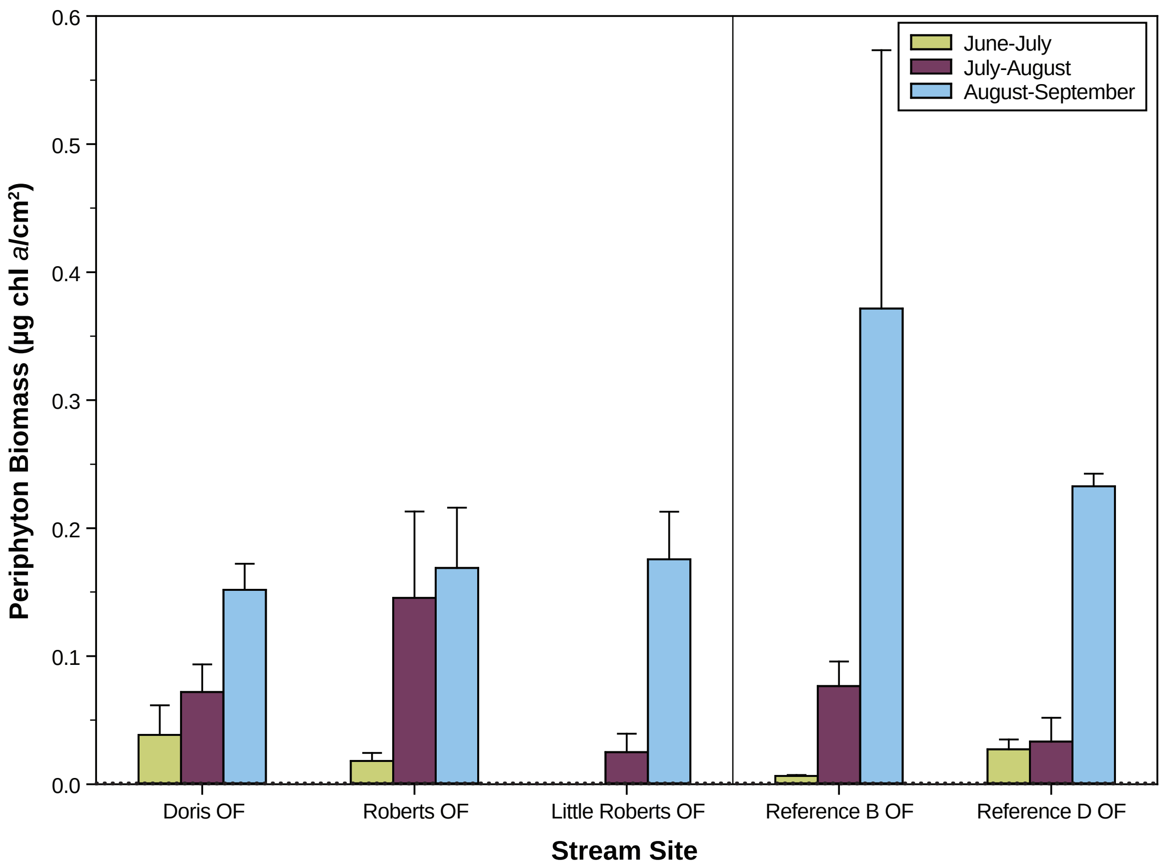
Stream periphyton sampling plates were installed three times in AEMP streams (in June, July, and August), and were retrieved after approximately one month (in July, August, and September, respectively). Figure A.5-1 shows the periphyton biomass levels measured in streams. Annex A.5-1 presents the raw periphyton biomass data.

A.5.2 Lake Data

Lake phytoplankton samples were collected in April (under-ice sampling) and monthly from July to September 2011. Figure A.5-2 shows the phytoplankton biomass levels measured in lakes. Annex A.5-2 presents the raw phytoplankton biomass data.

A.5.3 Marine Data

Marine phytoplankton samples were collected in April (under-ice sampling) and monthly from July to September 2011. Figure A.5-3 shows the phytoplankton biomass levels measured at marine sites. Annex A.5-3 presents the raw phytoplankton biomass data.



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.
No periphyton data was available for Litttle Roberts Outflow in June-July because all periphyton plates installed over this period were either exposed or could not be located at the time of retrieval.

Figure A.5-1

Periphyton Biomass (as Chlorophyll *a*) in Stream Sites, Doris North Project, 2011

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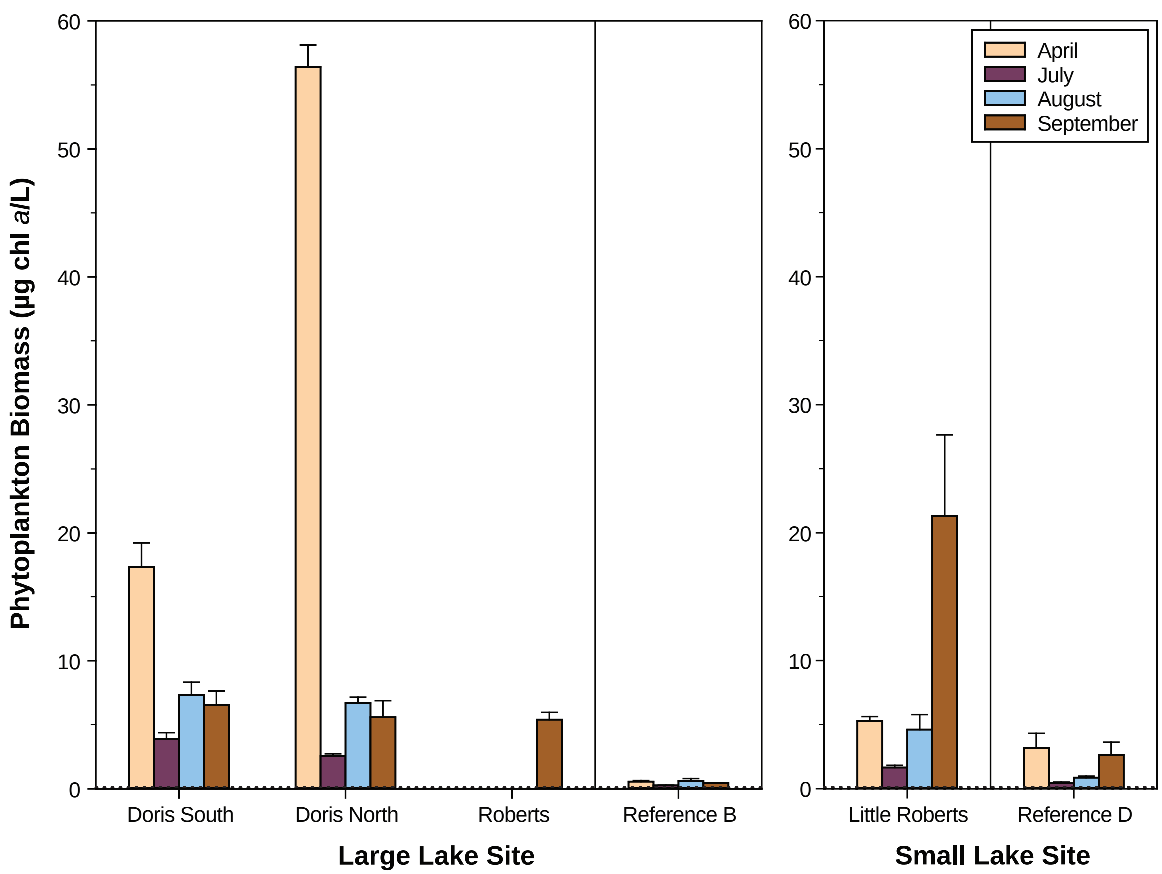
Annex A.5-1. Stream Periphyton Biomass Data, Doris North Project, 2011

Stream Site	Date Sampler Installed	Date Sampler Retrieved	Number of Days Immersed	Area sampled (cm^2)	ALS Sample ID	Replicate #	Periphyton Biomass (µg chl *a* /cm^2)	Mean	SE
Doris OF	26-Jun-11	23-Jul-11	27	100	L1047581-21	1	0.0842	0.0384	0.0232
Doris OF	26-Jun-11	23-Jul-11	27	100	L1047581-22	2	0.0094		
Doris OF	26-Jun-11	23-Jul-11	27	100	L1047581-23	3	0.0217		
Doris OF	23-Jul-11	27-Aug-11	35	100	L1052615-34	1	0.0539	0.0719	0.0217
Doris OF	23-Jul-11	27-Aug-11	35	100	L1052615-35	2	0.115		
Doris OF	23-Jul-11	27-Aug-11	35	100	L1052615-36	3	0.0467		
Doris OF	27-Aug-11	23-Sep-11	27	100	L1066513-13	1	0.112	0.152	0.021
Doris OF	27-Aug-11	23-Sep-11	27	100	L1066513-14	2	0.181		
Doris OF	27-Aug-11	23-Sep-11	27	100	L1066513-15	3	0.162		
Roberts OF	26-Jun-11	23-Jul-11	27	100	L1047581-16	1	0.0119	0.018	0.006
Roberts OF	26-Jun-11	23-Jul-11	27	100	L1047581-17	2	0.0244		
Roberts OF	23-Jul-11	27-Aug-11	35	100	L1052615-37	1	0.0778	0.145	0.068
Roberts OF	23-Jul-11	27-Aug-11	35	100	L1052615-38	2	0.213		
Roberts OF	27-Aug-11	23-Sep-11	27	100	L1066513-10	1	0.187	0.169	0.047
Roberts OF	27-Aug-11	23-Sep-11	27	100	L1066513-11	2	0.240		
Roberts OF	27-Aug-11	23-Sep-11	27	100	L1066513-12	3	0.0801		
Little Roberts OF	26-Jun-11	23-Jul-11	27	no plates retrieved — plates were either exposed or could not be located					
Little Roberts OF	23-Jul-11	28-Aug-11	36	100	L1052615-39	1	0.0107	0.0251	0.0144
Little Roberts OF	23-Jul-11	28-Aug-11	36	100	L1052615-40	2	0.0394		
Little Roberts OF	28-Aug-11	23-Sep-11	26	100	L1066513-7	1	0.110	0.176	0.037
Little Roberts OF	28-Aug-11	23-Sep-11	26	100	L1066513-8	2	0.239		
Little Roberts OF	28-Aug-11	23-Sep-11	26	100	L1066513-9	3	0.178		
Reference B OF	26-Jun-11	23-Jul-11	27	100	L1047581-24	1	0.00500	0.00632	0.00087
Reference B OF	26-Jun-11	23-Jul-11	27	100	L1047581-25	2	0.00599		
Reference B OF	26-Jun-11	23-Jul-11	27	100	L1047581-26	3	0.00797		
Reference B OF	23-Jul-11	20-Aug-11	28	100	L1052615-44	1	0.0382	0.0766	0.0192
Reference B OF	23-Jul-11	20-Aug-11	28	100	L1052615-45	2	0.0947		
Reference B OF	23-Jul-11	20-Aug-11	28	100	L1052615-46	3	0.0969		
Reference B OF	20-Aug-11	18-Sep-11	29	100	L1066513-1	1	0.773	0.372	0.202
Reference B OF	20-Aug-11	18-Sep-11	29	100	L1066513-2	2	0.206		
Reference B OF	20-Aug-11	18-Sep-11	29	100	L1066513-3	3	0.136		
Reference D OF	26-Jun-11	23-Jul-11	27	100	L1047581-18	1	0.0236	0.0272	0.0077
Reference D OF	26-Jun-11	23-Jul-11	27	100	L1047581-19	2	0.0160		
Reference D OF	26-Jun-11	23-Jul-11	27	100	L1047581-20	3	0.0419		
Reference D OF	23-Jul-11	21-Aug-11	29	100	L1052615-41	1	0.00186	0.0333	0.0185
Reference D OF	23-Jul-11	21-Aug-11	29	100	L1052615-42	2	0.0660		
Reference D OF	23-Jul-11	21-Aug-11	29	100	L1052615-43	3	0.0319		
Reference D OF	21-Aug-11	23-Sep-11	33	100	L1066513-4	1	0.227	0.233	0.010
Reference D OF	21-Aug-11	23-Sep-11	33	100	L1066513-5	2	0.219		
Reference D OF	21-Aug-11	23-Sep-11	33	100	L1066513-6	3	0.252		

SE = standard error of the mean



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.

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Phytoplankton Biomass (as Chlorophyll *a*) in Lake Sites, Doris North Project, 2011

Figure A.5-2

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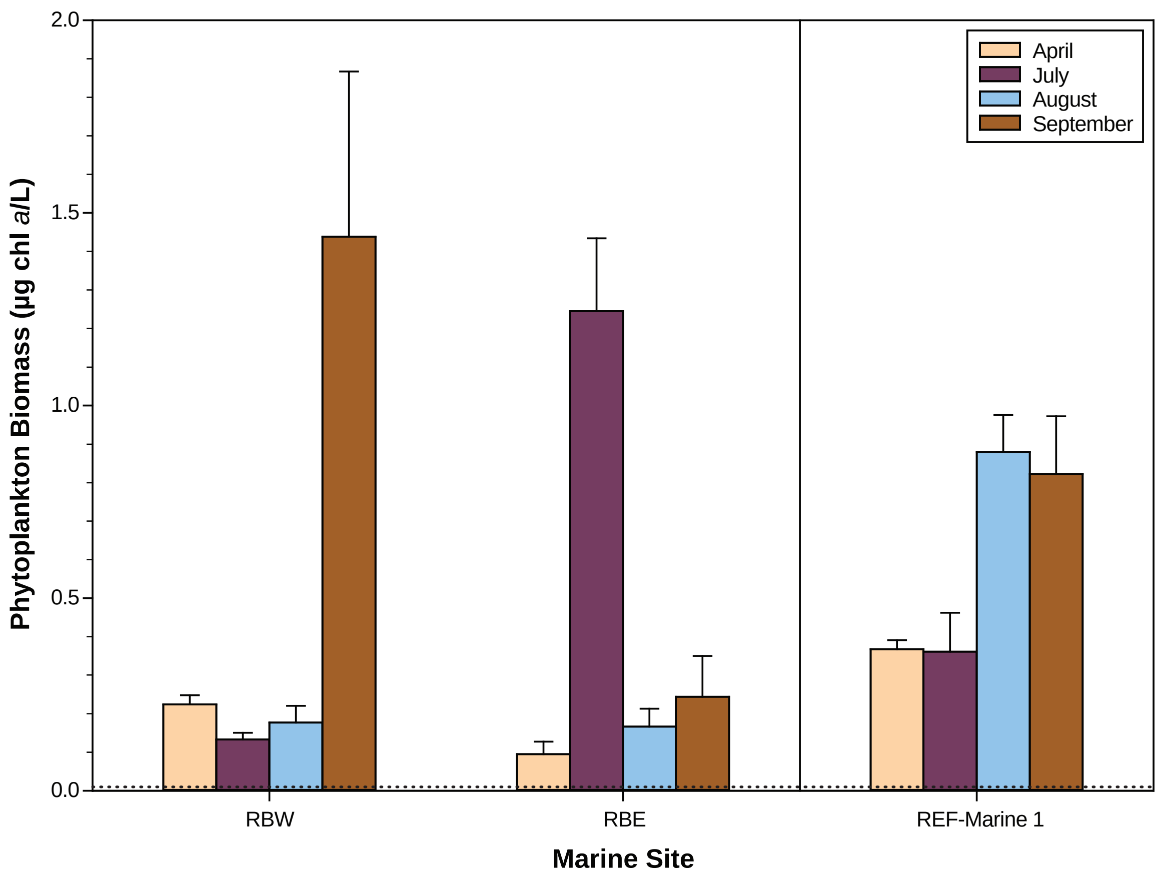
Annex A.5-2. Lake Phytoplankton Biomass Data, Doris North Project, 2011

Lake Site	Date Sampled	Depth Sampled	ALS Sample ID	Replicate #	Phytoplankton Biomass (µg chl *a* /L)	Mean	SE
Doris Lake South	24-Apr-11	2.7 m	L1012910-10	1	18.8	17.3	1.9
Doris Lake South	24-Apr-11	2.7 m	L1012910-11	2	13.6		
Doris Lake South	24-Apr-11	2.7 m	L1012910-12	3	19.6		
Doris Lake South	19-Jul-11	1 m	L1047581-4	1	3.78	3.91	0.48
Doris Lake South	19-Jul-11	1 m	L1047581-5	2	4.80		
Doris Lake South	19-Jul-11	1 m	L1047581-6	3	3.14		
Doris Lake South	15-Aug-11	1 m	L1052615-16	1	5.58	7.33	0.99
Doris Lake South	15-Aug-11	1 m	L1052615-17	2	7.38		
Doris Lake South	15-Aug-11	1 m	L1052615-18	3	9.02		
Doris Lake South	19-Sep-11	1 m	L1066512-7	1	6.32	6.55	1.07
Doris Lake South	19-Sep-11	1 m	L1066512-8	2	4.82		
Doris Lake South	19-Sep-11	1 m	L1066512-9	3	8.52		
Doris Lake North	24-Apr-11	2.4 m	L1012910-7	1	54.3	56.4	1.7
Doris Lake North	24-Apr-11	2.4 m	L1012910-8	2	59.8		
Doris Lake North	24-Apr-11	2.4 m	L1012910-9	3	55.1		
Doris Lake North	19-Jul-11	1 m	L1047581-1	1	2.22	2.55	0.19
Doris Lake North	19-Jul-11	1 m	L1047581-2	2	2.87		
Doris Lake North	19-Jul-11	1 m	L1047581-3	3	2.55		
Doris Lake North	15-Aug-11	1 m	L1052615-13	1	7.46	6.68	0.47
Doris Lake North	15-Aug-11	1 m	L1052615-14	2	5.85		
Doris Lake North	15-Aug-11	1 m	L1052615-15	3	6.74		
Doris Lake North	19-Sep-11	1 m	L1066512-4	1	7.97	5.59	1.30
Doris Lake North	19-Sep-11	1 m	L1066512-5	2	5.30		
Doris Lake North	19-Sep-11	1 m	L1066512-6	3	3.50		
Roberts Lake	24-Sep-11	1 m	L1066512-10	1	5.90	5.40	0.57
Roberts Lake	24-Sep-11	1 m	L1066512-11	2	4.27		
Roberts Lake	24-Sep-11	1 m	L1066512-12	3	6.03		
Reference Lake B	22-Apr-11	2.5 m	L1012910-16	1	0.556	0.564	0.081
Reference Lake B	22-Apr-11	2.5 m	L1012910-17	2	0.428		
Reference Lake B	22-Apr-11	2.5 m	L1012910-18	3	0.707		
Reference Lake B	18-Jul-11	1 m	L1047581-51	1	0.285	0.256	0.018
Reference Lake B	18-Jul-11	1 m	L1047581-52	2	0.261		
Reference Lake B	18-Jul-11	1 m	L1047581-53	3	0.223		

Annex A.5-2. Lake Phytoplankton Biomass Data, Doris North Project, 2011

Lake Site	Date Sampled	Depth Sampled	ALS Sample ID	Replicate #	Phytoplankton Biomass (µg chl *a* /L)	Mean	SE
Reference Lake B	20-Aug-11	1 m	L1052615-28	1	0.931	0.594	0.198
Reference Lake B	20-Aug-11	1 m	L1052615-29	2	0.605		
Reference Lake B	20-Aug-11	1 m	L1052615-30	3	0.247		
Reference Lake B	18-Sep-11	1 m	L1066512-1	1	0.401	0.432	0.032
Reference Lake B	18-Sep-11	1 m	L1066512-2	2	0.399		
Reference Lake B	18-Sep-11	1 m	L1066512-3	3	0.495		
Little Roberts Lake	21-Apr-11	2 m	L1012910-13	1	4.72	5.29	0.33
Little Roberts Lake	21-Apr-11	2 m	L1012910-14	2	5.85		
Little Roberts Lake	21-Apr-11	2 m	L1012910-15	3	5.31		
Little Roberts Lake	19-Jul-11	1 m	L1047581-7	1	1.41	1.65	0.17
Little Roberts Lake	19-Jul-11	1 m	L1047581-8	2	1.56		
Little Roberts Lake	19-Jul-11	1 m	L1047581-9	3	1.97		
Little Roberts Lake	28-Aug-11	1 m	L1052615-31	1	2.94	4.61	1.16
Little Roberts Lake	28-Aug-11	1 m	L1052615-32	2	4.04		
Little Roberts Lake	28-Aug-11	1 m	L1052615-33	3	6.85		
Little Roberts Lake	24-Sep-11	1 m	L1066512-13	1	8.64	21.3	6.3
Little Roberts Lake	24-Sep-11	1 m	L1066512-14	2	27.6		
Little Roberts Lake	24-Sep-11	1 m	L1066512-15	3	27.7		
Reference Lake D	22-Apr-11	2 m	L1012910-1	1	1.98	3.18	1.13
Reference Lake D	22-Apr-11	2 m	L1012910-2	2	2.12		
Reference Lake D	22-Apr-11	2 m	L1012910-3	3	5.44		
Reference Lake D	20-Jul-11	1 m	L1047581-10	1	0.555	0.421	0.078
Reference Lake D	20-Jul-11	1 m	L1047581-11	2	0.422		
Reference Lake D	20-Jul-11	1 m	L1047581-12	3	0.285		
Reference Lake D	16-Aug-11	1 m	L1052615-19	1	1.03	0.853	0.113
Reference Lake D	16-Aug-11	1 m	L1052615-20	2	0.643		
Reference Lake D	16-Aug-11	1 m	L1052615-21	3	0.886		
Reference Lake D	26-Sep-11	1 m	L1066512-16	1	4.60	2.63	0.98
Reference Lake D	26-Sep-11	1 m	L1066512-17	2	1.57		
Reference Lake D	26-Sep-11	1 m	L1066512-18	3	1.73		

SE = standard error of the mean



Notes: Error bars represent the standard error of the mean.
Black dotted lines represent analytical detection limits.

Phytoplankton Biomass (as Chlorophyll *a*) in Marine Sites, Doris North Project, 2011

Figure A.5-3

Annex A.5-3. Marine Phytoplankton Biomass Data, Doris North Project, 2011

Marine Site	Date Sampled	Depth Sampled	ALS Sample ID	Replicate #	Phytoplankton Biomass (µg chl *a* /L)	Mean	SE
RBW	24-Apr-11	2.8 m	L1012910-28	1	0.272	0.224	0.024
RBW	24-Apr-11	2.8 m	L1012910-29	2	0.197		
RBW	24-Apr-11	2.8 m	L1012910-30	3	0.202		
RBW	23-Jul-11	1 m	L1047581-30	1	0.110	0.133	0.017
RBW	23-Jul-11	1 m	L1047581-31	2	0.167		
RBW	23-Jul-11	1 m	L1047581-32	3	0.121		
RBW	14-Aug-11	1 m	L1052615-4	1	0.110	0.177	0.043
RBW	14-Aug-11	1 m	L1052615-5	2	0.258		
RBW	14-Aug-11	1 m	L1052615-6	3	0.162		
RBW	20-Sep-11	1 m	L1066522-4	1	0.634	1.44	0.43
RBW	20-Sep-11	1 m	L1066522-5	2	1.58		
RBW	20-Sep-11	1 m	L1066522-6	3	2.10		
RBE	23-Apr-11	2.5 m	L1012910-25	1	0.111	0.095	0.032
RBE	23-Apr-11	2.5 m	L1012910-26	2	0.141		
RBE	23-Apr-11	2.5 m	L1012910-27	3	0.033		
RBE	23-Jul-11	0.5 m	L1047581-33	1	1.58	1.25	0.19
RBE	23-Jul-11	0.5 m	L1047581-34	2	0.926		
RBE	23-Jul-11	0.5 m	L1047581-35	3	1.23		
RBE	14-Aug-11	0.5 m	L1052615-1	1	0.131	0.166	0.046
RBE	14-Aug-11	0.5 m	L1052615-2	2	0.110		
RBE	14-Aug-11	0.5 m	L1052615-3	3	0.258		
RBE	20-Sep-11	0.5 m	L1066522-1	1	0.122	0.244	0.106
RBE	20-Sep-11	0.5 m	L1066522-2	2	0.154		
RBE	20-Sep-11	0.5 m	L1066522-3	3	0.455		
REF-Marine 1	23-Apr-11	2.6 m	L1012910-31	1	0.411	0.367	0.024
REF-Marine 1	23-Apr-11	2.6 m	L1012910-32	2	0.361		
REF-Marine 1	23-Apr-11	2.6 m	L1012910-33	3	0.330		
REF-Marine 1	23-Jul-11	1 m	L1047581-42	1	0.564	0.361	0.102
REF-Marine 1	23-Jul-11	1 m	L1047581-43	2	0.265		
REF-Marine 1	23-Jul-11	1 m	L1047581-44	3	0.253		
REF-Marine 1	19-Aug-11	1 m	L1052615-22	1	0.962	0.880	0.096
REF-Marine 1	19-Aug-11	1 m	L1052615-23	2	0.689		
REF-Marine 1	19-Aug-11	1 m	L1052615-24	3	0.989		
REF-Marine 1	25-Sep-11	1 m	L1066522-7	1	0.572	0.822	0.150
REF-Marine 1	25-Sep-11	1 m	L1066522-8	2	0.805		
REF-Marine 1	25-Sep-11	1 m	L1066522-9	3	1.09		

SE = standard error of the mean

A.6 2011 BENTHIC INVERTEBRATES

The following sections present the benthic invertebrate taxonomy data collected in August 2011 from stream, lake, and marine sites. Benthos data were used to calculate several community descriptors including: total density, taxa richness, evenness, diversity, and the Bray-Curtis Index. Details of these calculations are provided in the main body of the AEMP report.

A.6.1 Stream Data

Figure A.6-1 presents the density and taxonomic composition of stream benthos communities. Figure A.6-2 presents the family richness, Simpson's Evenness Index, and the Simpson's Diversity Index, and Figure A.6-3 presents the Bray-Curtis Index calculated for stream benthos communities. Annex A.6-1 provides the raw stream benthos taxonomy data, and Annex A.6-2 presents the summary statistics calculated for the community descriptors.

A.6.2 Lake Data

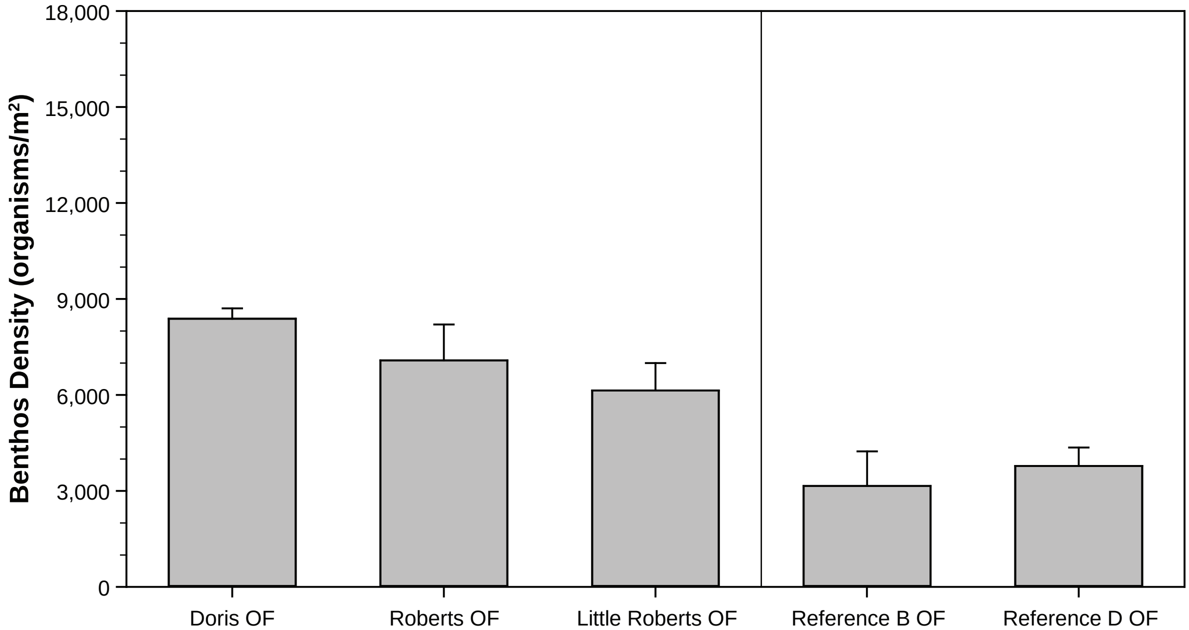
Figure A.6-4 presents the density and taxonomic composition of lake benthos communities. Figure A.6-5 presents the family richness, Simpson's Evenness Index, and the Simpson's Diversity Index, and Figure A.6-6 presents the Bray-Curtis Index calculated for lake benthos communities. Annex A.6-3 provides the raw lake benthos taxonomy data, and Annex A.6-4 presents the summary statistics calculated for the community descriptors.

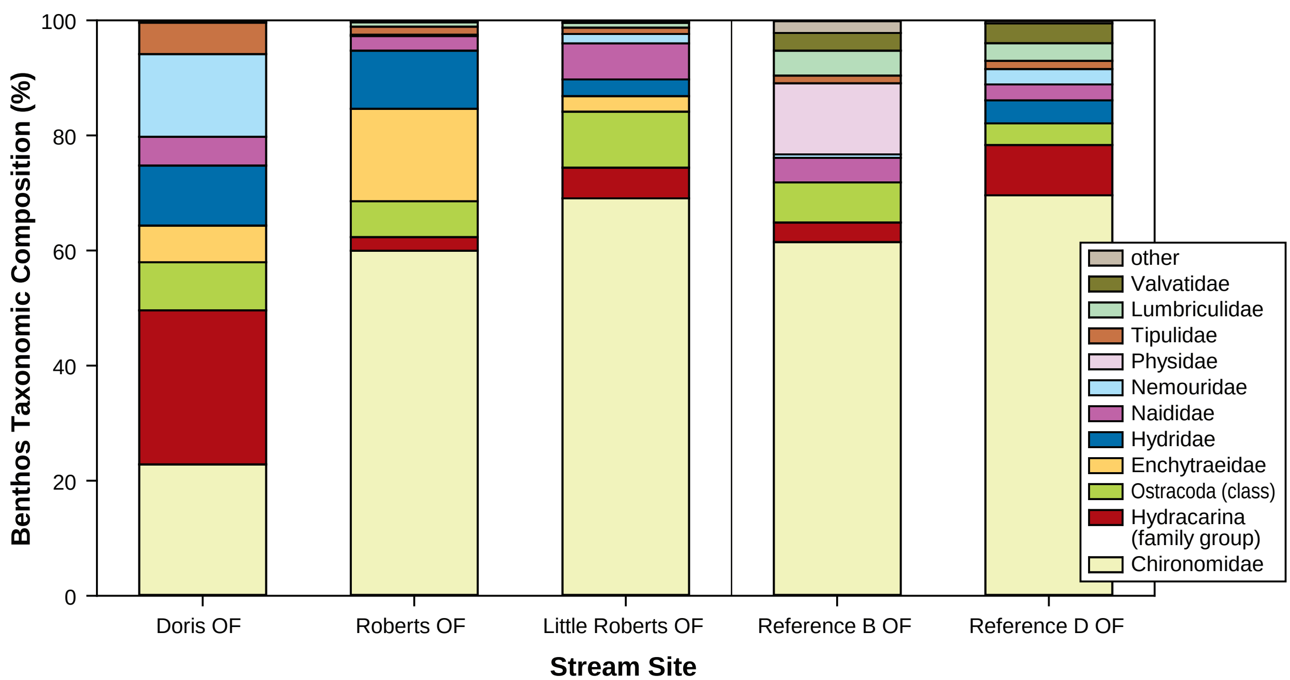
A.6.3 Marine Data

Figure A.6-7 presents the density and taxonomic composition of marine benthos communities. Figure A.6-8 presents the family richness, Simpson's Evenness Index, and the Simpson's Diversity Index, and Figure A.6-9 presents the Bray-Curtis Index calculated for marine benthos communities. Annex A.6-5 provides the raw marine benthos taxonomy data, and Annex A.6-6 presents the summary statistics calculated for the community descriptors.

A.6.4 Quality Assurance/Quality Control (QA/QC) Data

A re-sorting of randomly selected sample residues was conducted by taxonomists on a minimum of 10% of the benthos samples to determine the level of sorting efficiency. Results of this QA/QC procedure are provided in Annex A.6-7.





Notes: Error bars represent the standard error of the mean.
Stacked bars represent the mean of replicate samples.

Figure A.6-1

Benthos Density and Taxonomic Composition in Stream Sites, Doris North Project, August 2011

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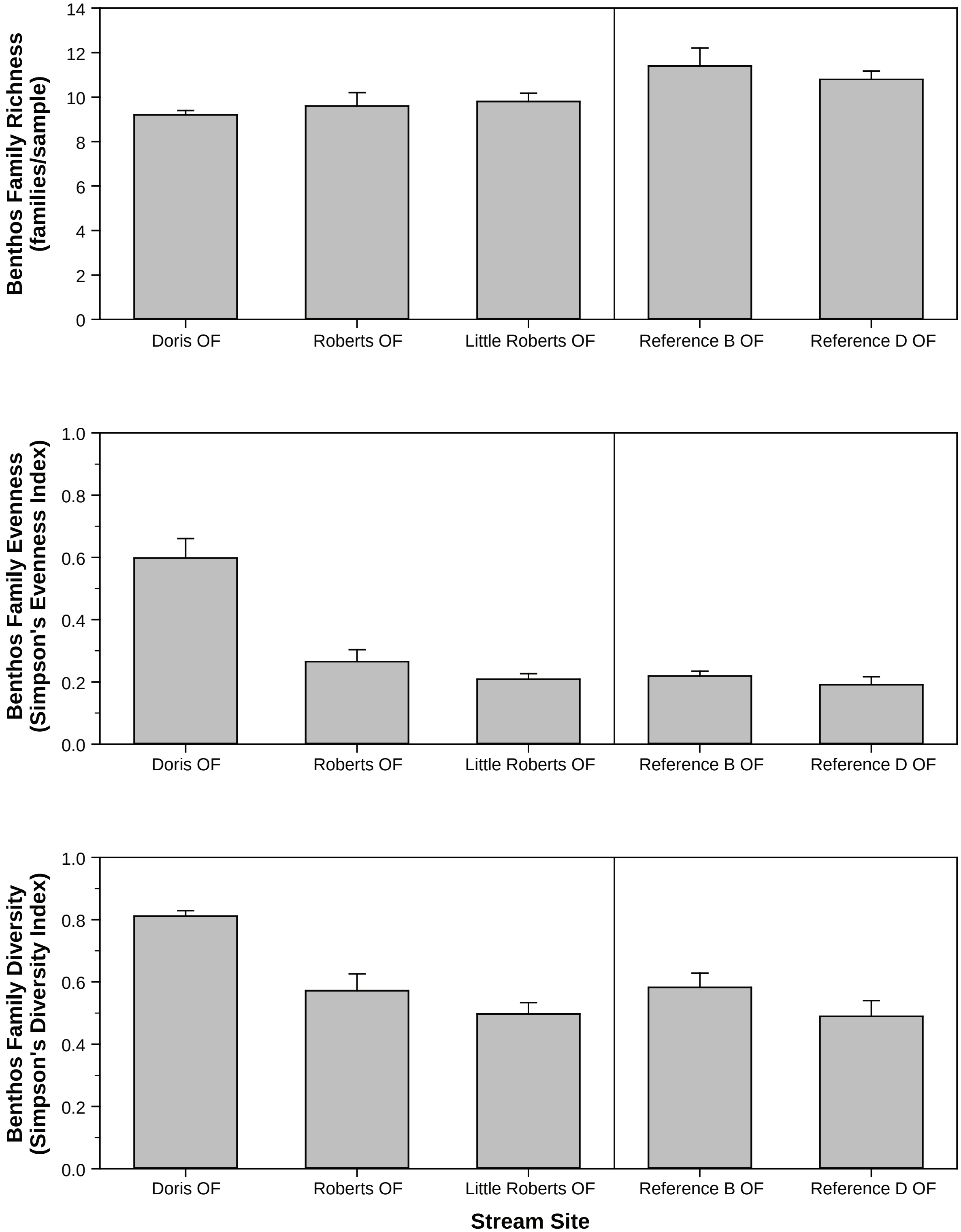

Notes: Error bars represent the standard error of the mean.

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Benthos Richness, Evenness, and Diversity in Stream Sites, Doris North Project, August 2011

Figure A.6-2

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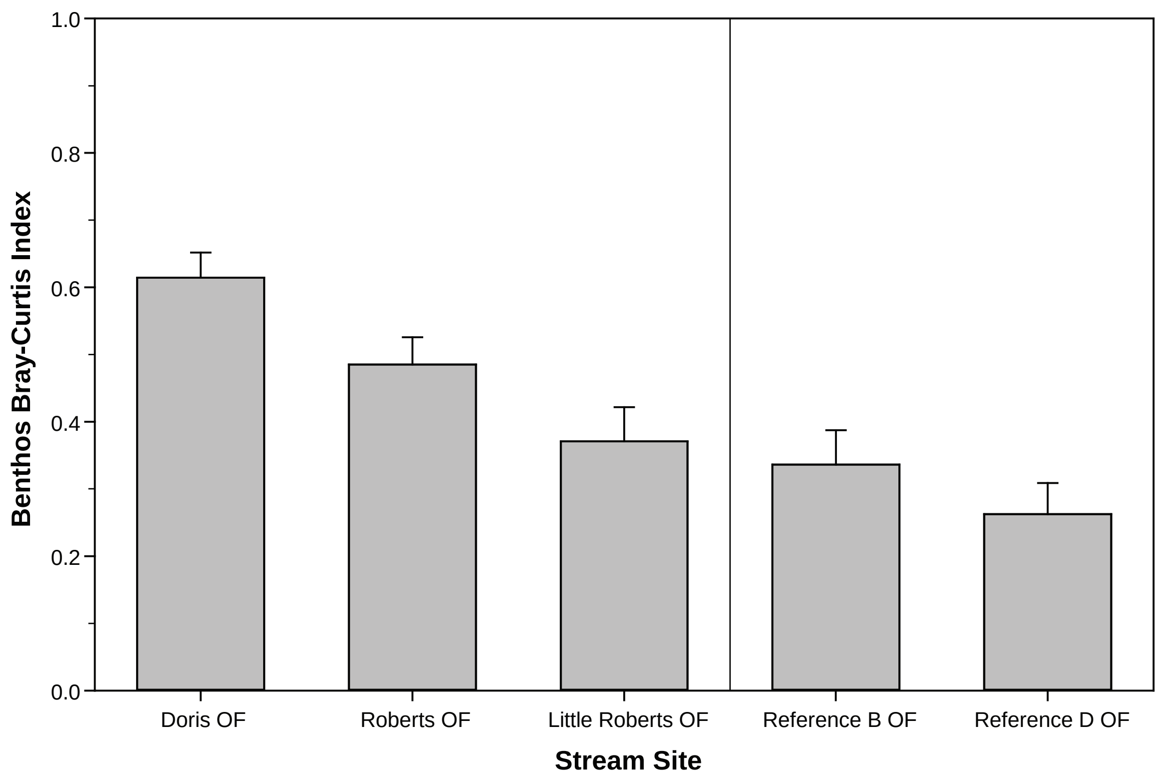

Notes: Error bars represent the standard error of the mean.

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Benthos Bray-Curtis Index for Stream Sites, Doris North Project, August 2011

Figure A.6-3

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Annex A.6-1. Stream Benthos Taxonomy Data, Doris North Project, 2011

Taxonomic Identification					Doris OF					Roberts OF					Little Roberts OF					Reference B OF					Reference D OF				
					27-Aug-11					27-Aug-11					28-Aug-11					20-Aug-11									
Major Group	Family	Subfamily	Tribe	Genus	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5
Coelenterata	Hydridae	-	-	*Hydra*	260	260	144	308	300	180	544	112	136	104	24	8	80	180							10	16		24	152
Nematoda*	-	-	-	-	693	368	60	105	111	200	68	56	196	276	298	306	215	513	147	99	7	12	8	9	18	113	141	19	50
Hirudinea	Piscicolidae	-	-	*Piscicola punctata*								4	4	4															
Oligochaeta	Enchytraeidae	-	-	-	240	251	64	145	60	320	180	324	288	336	24	128	10	14	22										
	Lumbriculidae	-	-	-	17	6		10	3	4	8		40	4	15	19	14	8	8	104	1	17	43	37	38	45	67	15	
	Naididae	Naidinae	-	-							24			8	1		10	110	80		24		16		40	40	20	8	1
	Naididae	Tubificinae	-	-	217	181	29	157	10	8	24	4	100	40	89	42	113	52	68	75	1	5	65	10	10	16	19	2	
Gastropoda	Physidae	-	-	*Physa*																191	54	76	70	97					
	Valvatidae	-	-	*Valvata sincera*																131	40	5	3	3	50	36	52	19	25
Pelecypoda	Sphaeriidae	-	-	(i/d)															20			1	1						
		-	-	*Pisidium*															7			1							
Hydracarina	-	-	-	-	460	635	712	852	570	40	72	40	16	72	51	73	96	179	86	166	31	4	5	10	75	90	71	48	168
Copepoda - Cyclopoida*	Cyclopidae*	Cyclopinae*	-	*Acanthocyclops**							20		8		8	8		10	20			16	12				10		
Copepoda - Cyclopoida*	Ergasilidae*	-	-	*Ergasilus**																		4	8	5					
Copepoda - Harpacticoida*	-	-	-	-										48															
Ostracoda	-	-	-	-	304	105	128	240	230	260	100	32	196	8	144	72	250	220	160	120	32	52	56	35	10	48	90	24	16
Cladocera*	Chydoridae*	-	-	*Eurycercus**													1							2					
Amphipoda	Epimeriidae	-	-	*Epimeria loricata*		1										1													
Malacostraca	Mysidae	-	-	*Mysis relicta*											2	6	1												
Isopoda	Chaetiliidae	-	-	*Saduria entomon*									4	4															
Ephemeroptera	Baetidae	-	-	*Baetis*			8													22								1	1
	Ephemerellidae	-	-	*Ephemerella*																	1								
	Heptageniidae	-	-	(i/d) (*Heptagenia* ???)																									1
Plecoptera	Nemouridae	-	-	*Nemoura*	244	272	478	415	316		4		8	8	21	12	2	130	13	64					22	14	4	29	44
	Perlodidae	-	-	*Skwala*																									1
Trichoptera	Brachycentridae	-	-	*Brachycentrus*																22	11			1	1				
	Hydroptilidae	-	-	*Agraylea*																				2					
	-	-	-	*Oxyethira*																	1								
	Limnephilidae	-	-	(i/d)																				1					
	-	-	-	*Grensia praeterica*																	1			2		1	3		
Coleoptera	Dytiscidae	-	-	*Agabus*																				1					
	-	-	-	*Oreodytes*																2		1							1
Diptera	Chironomidae	-	-	(pupa)	4	5	4	4	20	20				72	8	8	10			20	8			5	21	25	23		34
		Tanypodinae	Pentaneurini	*Thienemannimyia* group	72	191	130	123	282	208	152	160	96	344	510	454	514	768	357	66	22	14	10	65	20	66	46	45	173
			Procladiini	*Procladius*										8	3	2		10					5						
		Diamesinae	Diamesini	*Diamesa*	83	272	213	115	411	1244	1396	452	144	224	1	23	131	298	266	281	53				354	58	26	34	68
				Potthastia longimana group													10								10	24	10		
		Orthocladiinae	-	(i/d)													1			1					15	9	10	2	
			Orthocladiini	*Cardiocladius*						72		16																	
				Cricotopus/Orthocladius	40	40	32	20	160	452	152	224	100	524	213	241	83	265	343	454	86			5	535	379	680	42	223
				Eukiefferiella		5	16													20	48				5	32	40		34
				Euryhapsis		6		16	22						13	30	32	94	92	130	11		2	2	43	94	11	77	177
				Heterotrissocladius		5																							
				Nanocladius																20				5					
				Paracladius																	8					3			
				Parakiefferiella	60										48	24	30	50	20										
				Psectrocladius											51				1	22	23	177	289	63				1	
				Pseudosmittia																	32	4	4				1		
				Synorthocladius				16					8																
				Tvetenia	48	59	20	2	40	4	12				1	1	16	3	1	42					11	35	1	15	6
				Zalutschia														10											
		Chironominae	Chironomini	(i/d)		1													1										
				Chironomus									8						1	1		3	3						
				Cryptochironomus																		8							
				Demicryptochironomus																2								2	
				Dicrotendipes											1			10	1	28	28	17	55	19		17	28		25
				Polypedilum																					5				
				Sergenta	5	5	116	22	71			20	56	12					2			1	3	1			23		
				Stictochironomus		17									1	10		2	22			11	14	7					
			Tanytarsini	*Cladotanytarsus*				16					8	8	40	24			20										
				Corynocera																		4							
				Micropsectra						20	12																		
				Paratanytarsus								16	8	8	22	24	3	5	1	40	10	193	110	38	86	116	23	32	29
				Rheotanytarsus							4			16	40	88	30	180	280	61									
				Stempellina							8		8	8	16	16	20	50	40										
				Tanytarsus							4		8	88	72	16		10		20		36	40	5					8
	Simulidae	-	-	*Metacnephia*																2									
		-	-	*Prosimulium*																1									
				Prosimulium - pupa																8					1	4	3		
				Simulium																	8				10				
		-	-	*Simulium* - pupa								4									11					2			
	Tipulidae	-	-	*Tipula*	178	116	91	114	158	16	12	20	24	52	8	11	42	23	9	19	2	5	1	20	8	1	7	23	10
Terrestrial*	-	-	-	-											2	1				6	1	2		2				1	
Fish*	Gasterosteidae*	-	-	*Pungitius pungitius**						16		4	4	4		2		1	2			3	1				1		
TOTAL number of individuals					2232	2433	2185	2575	2653	2848	2708	1428	1260	1952	1419	1333	1498	2671	1921	2135	547	635	795	434	1380	1171	1258	443	1197

Notes:

** Taxa marked with an asterisk were excluded from total counts and from all benthos analyses.*

i/d = immature or damaged

Cladocerans and cyclopoid copepods were excluded because they are generally planktonic.

Nematodes and harpacticoid copepods were excluded because they are meiofauna and are not adequately sampled using a 500 um sieve bucket.

Terrestrial organisms and fish were excluded because they are not aquatic invertebrates.

The total number of individuals was divided by 3 times the surface area of the Hess sampler (i.e., 3 x 0.096 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of 3 pooled Hess samples).

Annex A.6-2. Stream Benthos Summary Statistics, Doris North Project, 2011

	Doris OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	7,587	9,212	8,448	8,388	714	319
Family Richness	9.0	10.0	9.0	9.2	0.4	0.2
Simpson's Diversity Index	0.77	0.87	0.82	0.81	0.04	0.02
Simpson's Evenness Index	0.49	0.83	0.57	0.60	0.14	0.06
Bray-Curtis Index	0.54	0.72	0.56	0.61	0.08	0.04

	Little Roberts OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	4,629	9,274	5,201	6,140	1,920	859
Family Richness	9.0	11.0	10.0	9.8	0.8	0.4
Simpson's Diversity Index	0.42	0.61	0.46	0.50	0.08	0.04
Simpson's Evenness Index	0.17	0.26	0.19	0.21	0.04	0.02
Bray-Curtis Index	0.26	0.54	0.32	0.37	0.11	0.05

	Roberts OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	4,375	9,889	6,778	7,081	2,510	1,122
Family Richness	8.0	11.0	9.0	9.6	1.3	0.6
Simpson's Diversity Index	0.47	0.78	0.54	0.57	0.12	0.05
Simpson's Evenness Index	0.19	0.41	0.24	0.27	0.09	0.04
Bray-Curtis Index	0.36	0.60	0.46	0.49	0.09	0.04

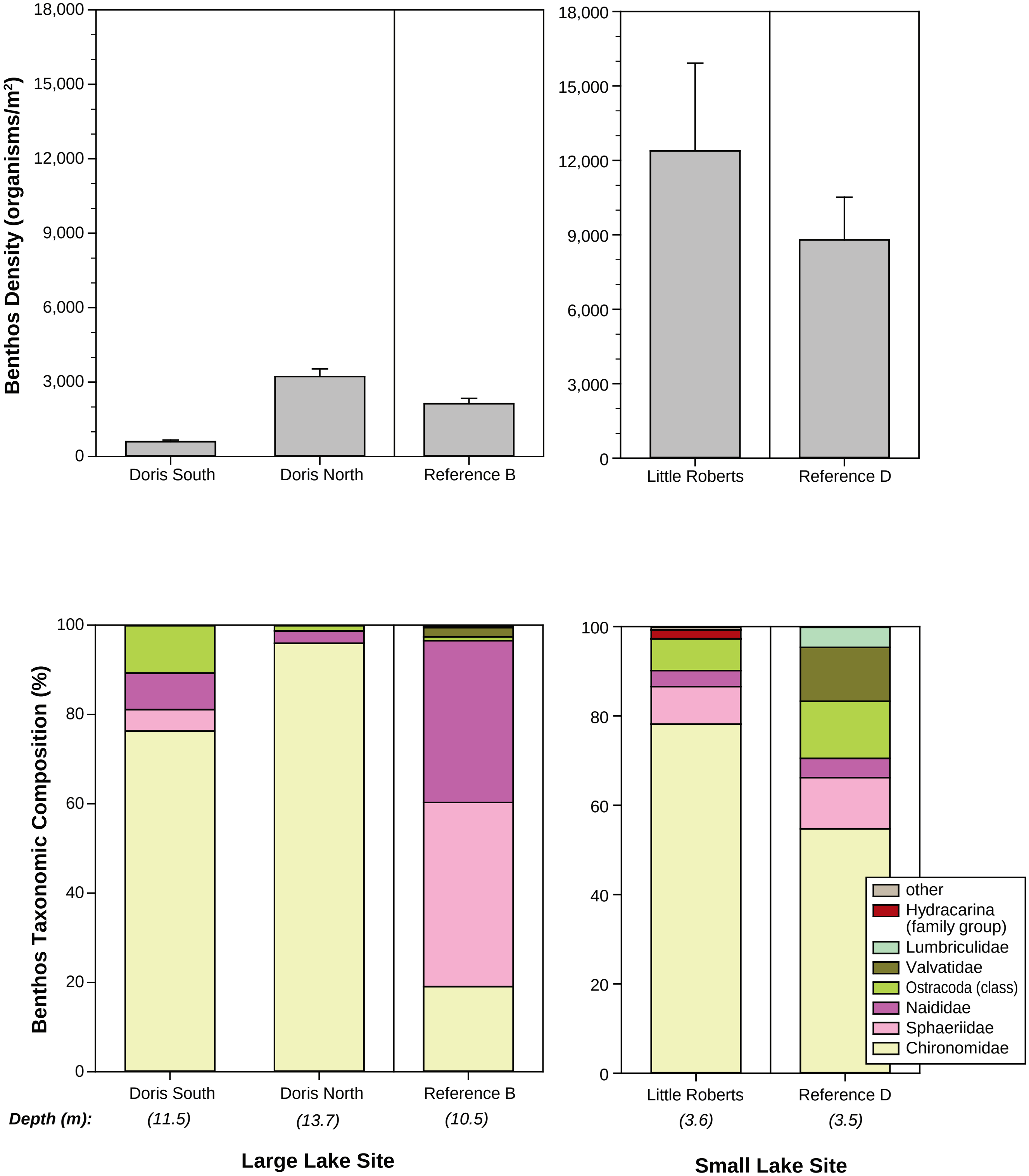
	Reference B OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	1,507	7,413	2,205	3,157	2,423	1,084
Family Richness	9.0	13.0	12.0	11.4	1.8	0.8
Simpson's Diversity Index	0.43	0.69	0.61	0.58	0.10	0.05
Simpson's Evenness Index	0.18	0.27	0.22	0.22	0.03	0.02
Bray-Curtis Index	0.20	0.48	0.34	0.34	0.12	0.05

	Reference D OF					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	1,538	4,792	4,156	3,784	1,286	575
Family Richness	10.0	12.0	11.0	10.8	0.8	0.4
Simpson's Diversity Index	0.35	0.65	0.45	0.49	0.11	0.05
Simpson's Evenness Index	0.14	0.29	0.18	0.19	0.06	0.03
Bray-Curtis Index	0.16	0.43	0.26	0.26	0.10	0.05

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean



Notes: Error bars represent the standard error of the mean.
Stacked bars represent the mean of replicate samples.

Figure A.6-4

Benthos Density and Taxonomic Composition in Lake Sites, Doris North Project, August 2011

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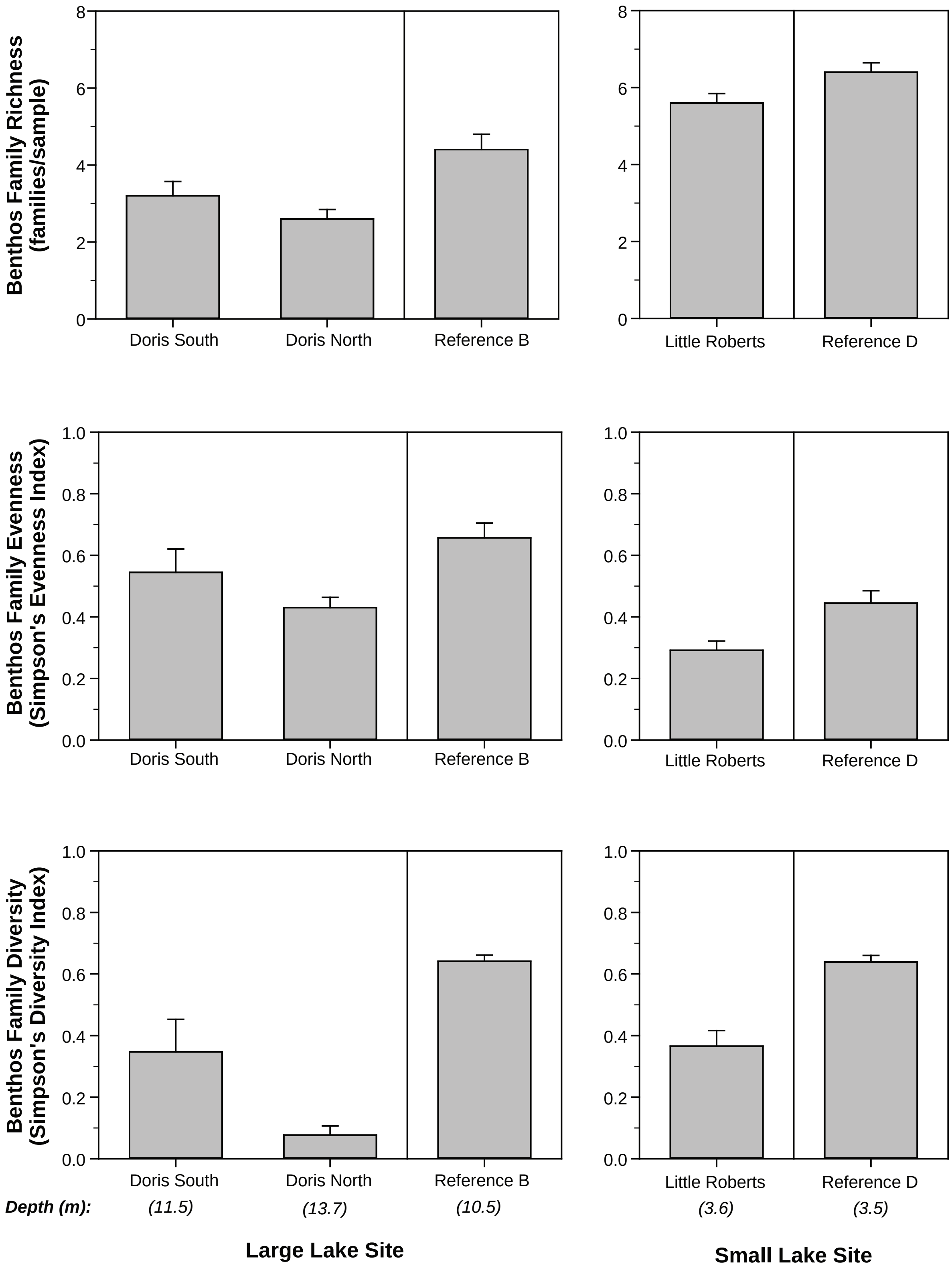

Notes: Error bars represent the standard error of the mean.

Figure A.6-5

Benthos Richness, Evenness, and Diversity in Lake Sites, Doris North Project, August 2011

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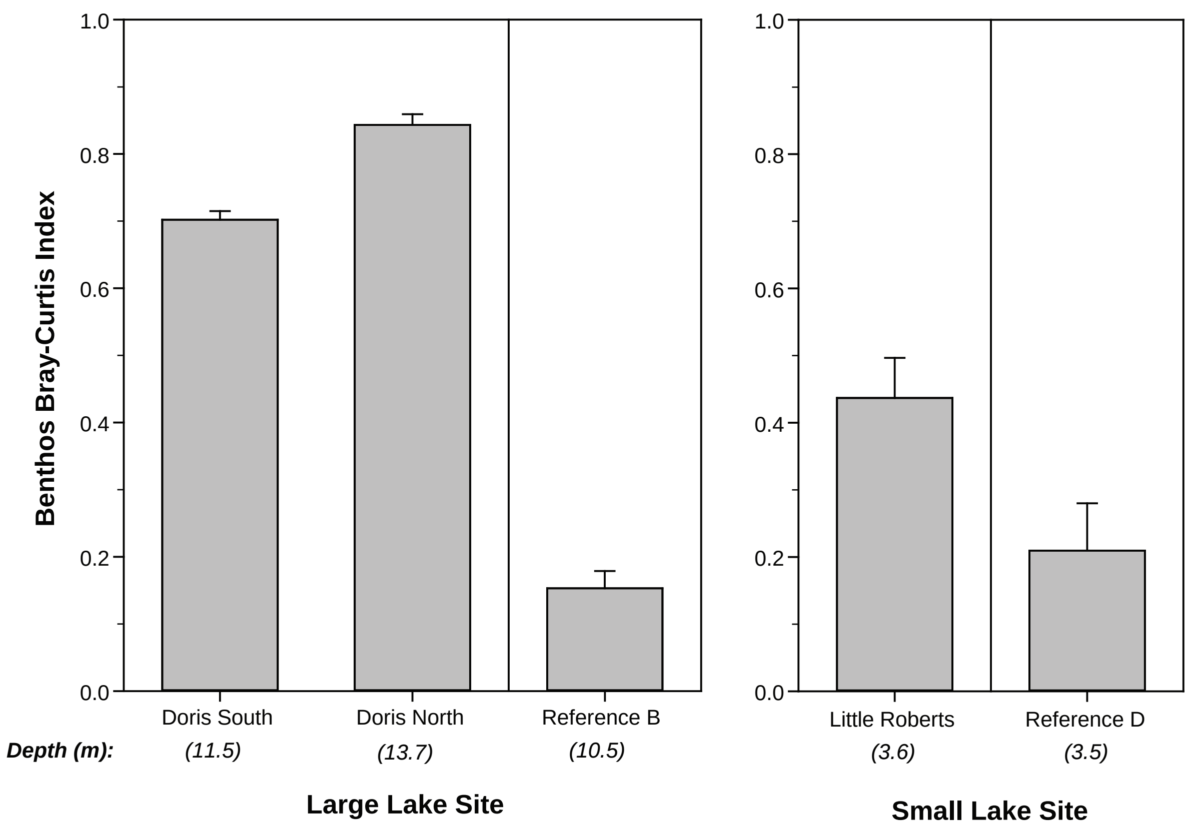

Notes: Error bars represent the standard error of the mean.

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Benthos Bray-Curtis Index for Lake Sites, Doris North Project, August 2011

Figure A.6-6

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Annex A.6-3. Lake Benthos Taxonomy Data, Doris North Project, 2011

Taxonomic Identification					Doris Lake South 16-Aug-11					Doris Lake North 16-Aug-11					Reference Lake B 20-Aug-11					Little Roberts Lake 28-Aug-11					Reference Lake D 16-Aug-11				
Major Group	Family	Subfamily	Tribe	Genus	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5	Rep-1	Rep-2	Rep-3	Rep-4	Rep-5
Nematoda*	-	-	-	-								1			56	147	144	170	84	4	44				436	220	1036	308	332
Oligochaeta	Lumbriculidae	-	-	-												1			1					4	20	20	28	16	20
	Naididae	Naidinae	-	-																					8		8		
	Naididae	Tubificinae	-	-	3		3	9		1	4	4	10	9	30	39	85	62	43	4	16	20	48	16	8	40	28	8	12
Gastropoda	Valvatidae	-	-	*Valvata sincera*											14										20	88	68	68	128
Pelecypoda	Sphaeriidae	-	-	(i/d)		1		3							21	54	63	45	24	4	20	4	52	16	4	80	8	44	16
		-	-	*Sphaerium*											2	3										20	8	4	20
		-	-	*Pisidium*		5	1	1							30	20	12	24	5	24	36	24	60	68		84	36	32	40
Hydracarina	-	-	-	-									1							8	8	12	12			4			4
Copepoda - Calanoida*	-	-	-	-	12	2	7	4	10		5	4	6																
Copepoda - Cyclopoida*	Cyclopidae*	Cyclopinae*	-	*Acanthocyclops**																4	24		8		8		16	16	32
Copepoda - Harpacticoida*	-	-	-	-								3	1																
Ostracoda	-	-	-	-	3	4	5	8	1		2			9	1	4	2			40	32		152	136	56	8	64	80	92
Amphipoda	Epimeriidae	-	-	*Epimeria loricata*																			4						
Malacostraca	Mysidae	-	-	*Mysis relicta*															1										
Isopoda	Chaetiliidae	-	-	*Saduria entomon*																4		4		4					
Diptera	Chironomidae	-	-	(pupa)	4	1	1		2	2	3	3	1	1	1														
		Tanypodinae	Pentaneurini	*Ablabesmyia*																	8			28	4	32			12
				Thienemannimyia group													2												
			Procladiini	*Procladius*	13	25	3		1				2		2	6			2	52	108	28	76	76	16	36	12	8	36
		Diamesinae	Protanypini	*Protanypus*													2	2	6										
		Prodiamesinae	-	*Monodiamesa*	4	5	4	2	6						1	2		1				16		4					
		Orthocladiinae	-	(i/d)																						8			
			Orthocladiini	*Cricotopus/Orthocladius*																	56			8		28	20	12	24
				Mesocricotopus			1		2																				
				Paracladius															2										
				Psectrocladius				2	1						2	8	2	5	1										
				Zalutschia											7	13	7	6		4				8		8			
		Chironominae	Chironomini	*Chironomus*	3		6	4	1	238	154	277	198	170	2					32	56	12	152	48	8	4	4	2	24
				Parachironomus																					16		8	24	8
				Sergenta																48	136		204	152	8	8	64	28	44
				Stictochironomus	9	17	12	7	19											4						4			
			Tanytarsini	*Cladotanytarsus*																						8			
				Corynocera											1			2		4						8	12	16	8
				Micropsectra													2												
				Micropsectra / Tanytarsus															2										
				Paratanytarsus											20	9	6	2	4	112	320	4	340	604	44	172	140	200	332
				Stempellina																		4	8						
				Tanytarsus	1										1				2	60	112	72	88	304	12	200		12	4
Terrestrial*	-	-	-	-	1							1																	
Fish*	Gasterosteidae*	-	-	*Pungitius pungitius**																									4
TOTAL number of individuals					40	58	36	36	33	241	163	284	212	189	135	159	183	149	93	400	908	200	1196	1476	224	860	508	554	824

Notes:

** Taxa marked with an asterisk were excluded from total counts and from all benthos analyses.*

i/d = immature or damaged

Cyclopoid and calanoid copepods were excluded because they are generally planktonic.

Nematodes and harpacticoid copepods were excluded because they are meiofauna and are not adequately sampled using a 500 um sieve bucket.

Terrestrial organisms and fish were excluded because they are not aquatic invertebrates.

The total number of individuals was divided by 3 times the surface area of the Ekman sampler (i.e., 3 x 0.0225 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of 3 pooled Ekman grabs).

Annex A.6-4. Lake Benthos Summary Statistics, Doris North Project, 2011

	Doris Lake South					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	489	859	533	601	149	67
Family Richness	2.0	4.0	3.0	3.2	0.8	0.4
Simpson's Diversity Index	0.06	0.70	0.30	0.35	0.24	0.11
Simpson's Evenness Index	0.42	0.84	0.48	0.54	0.17	0.08
Bray-Curtis Index	0.66	0.74	0.71	0.70	0.03	0.01

	Doris Lake North					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	2,415	4,207	3,141	3,227	694	311
Family Richness	2.0	3.0	3.0	2.6	0.5	0.2
Simpson's Diversity Index	0.01	0.18	0.07	0.08	0.07	0.03
Simpson's Evenness Index	0.36	0.51	0.41	0.43	0.07	0.03
Bray-Curtis Index	0.81	0.88	0.82	0.84	0.04	0.02

	Little Roberts Lake					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	2,963	21,867	13,452	12,385	7,905	3,535
Family Richness	5.0	6.0	6.0	5.6	0.5	0.2
Simpson's Diversity Index	0.23	0.50	0.36	0.37	0.11	0.05
Simpson's Evenness Index	0.24	0.40	0.26	0.29	0.07	0.03
Bray-Curtis Index	0.21	0.54	0.47	0.44	0.13	0.06

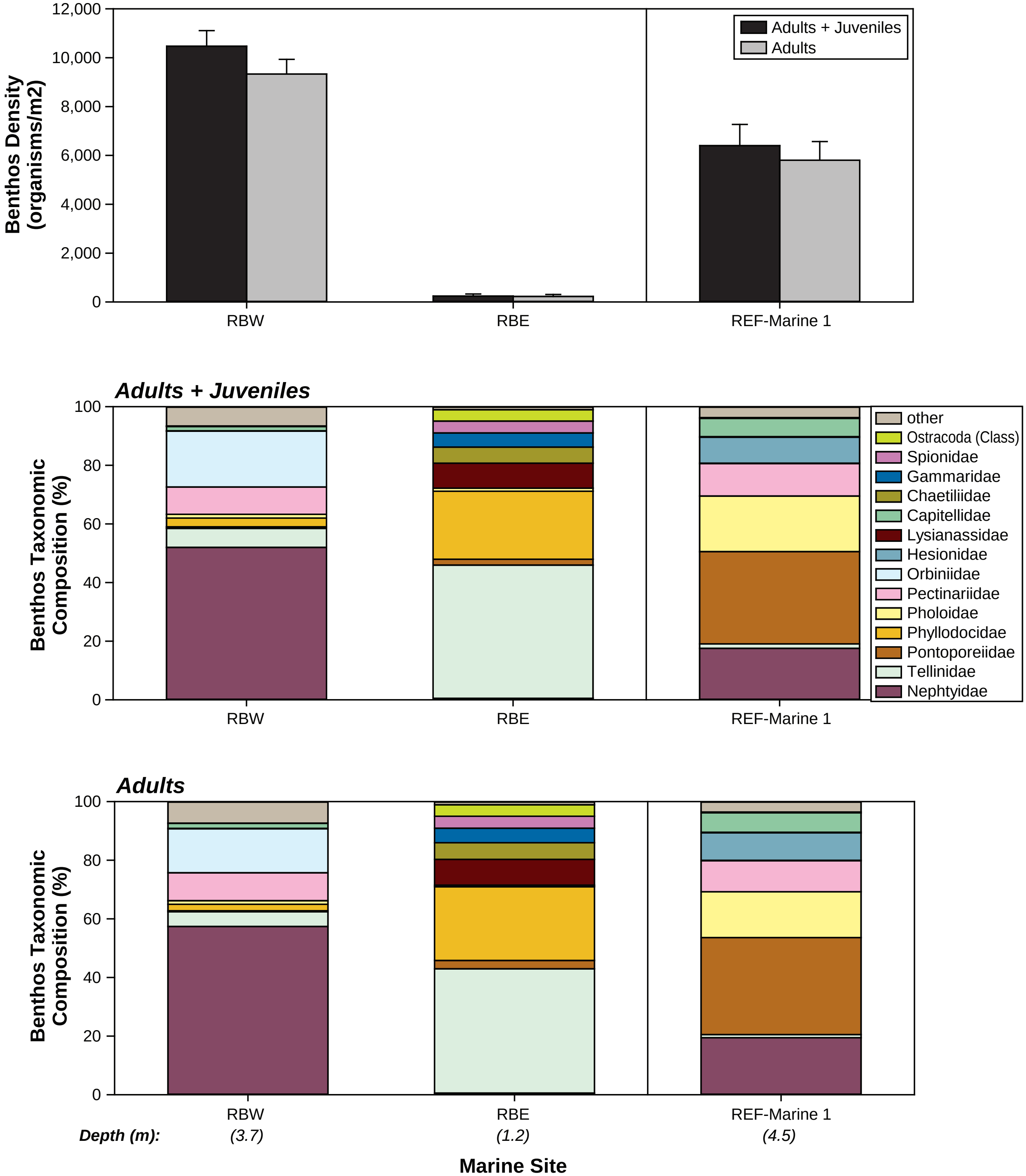
	Reference Lake B					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	1,378	2,711	2,207	2,130	494	221
Family Richness	3.0	5.0	5.0	4.4	0.9	0.4
Simpson's Diversity Index	0.60	0.71	0.65	0.64	0.05	0.02
Simpson's Evenness Index	0.57	0.83	0.63	0.66	0.11	0.05
Bray-Curtis Index	0.08	0.22	0.15	0.15	0.06	0.03

	Reference Lake D					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	3,319	12,741	8,207	8,800	3,846	1,720
Family Richness	6.0	7.0	6.0	6.4	0.6	0.2
Simpson's Diversity Index	0.58	0.69	0.65	0.64	0.05	0.02
Simpson's Evenness Index	0.34	0.53	0.47	0.44	0.09	0.04
Bray-Curtis Index	0.03	0.42	0.21	0.21	0.16	0.07

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean



Notes: Error bars represent the standard error of the mean.
Stacked bars represent the mean of replicate samples.

Figure A.6-7

NEWMONT NORTH AMERICA

Benthos Density and Taxonomic Composition in Marine Sites, Doris North Project, August 2011

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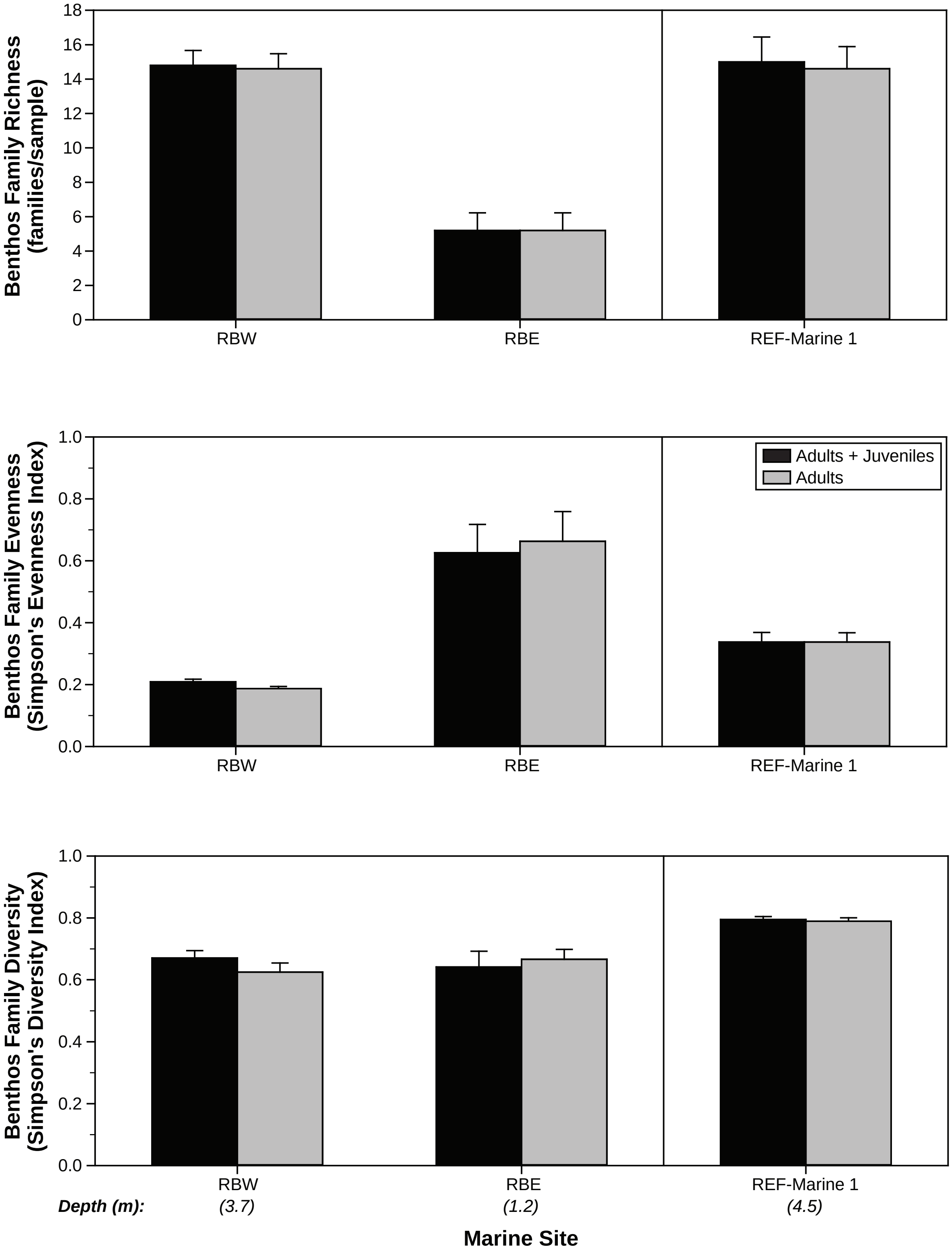

Notes: Error bars represent the standard error of the mean.

Figure A.6-8

NEWMONT NORTH AMERICA

Benthos Richness, Evenness, and Diversity in Marine Sites, Doris North Project, August 2011

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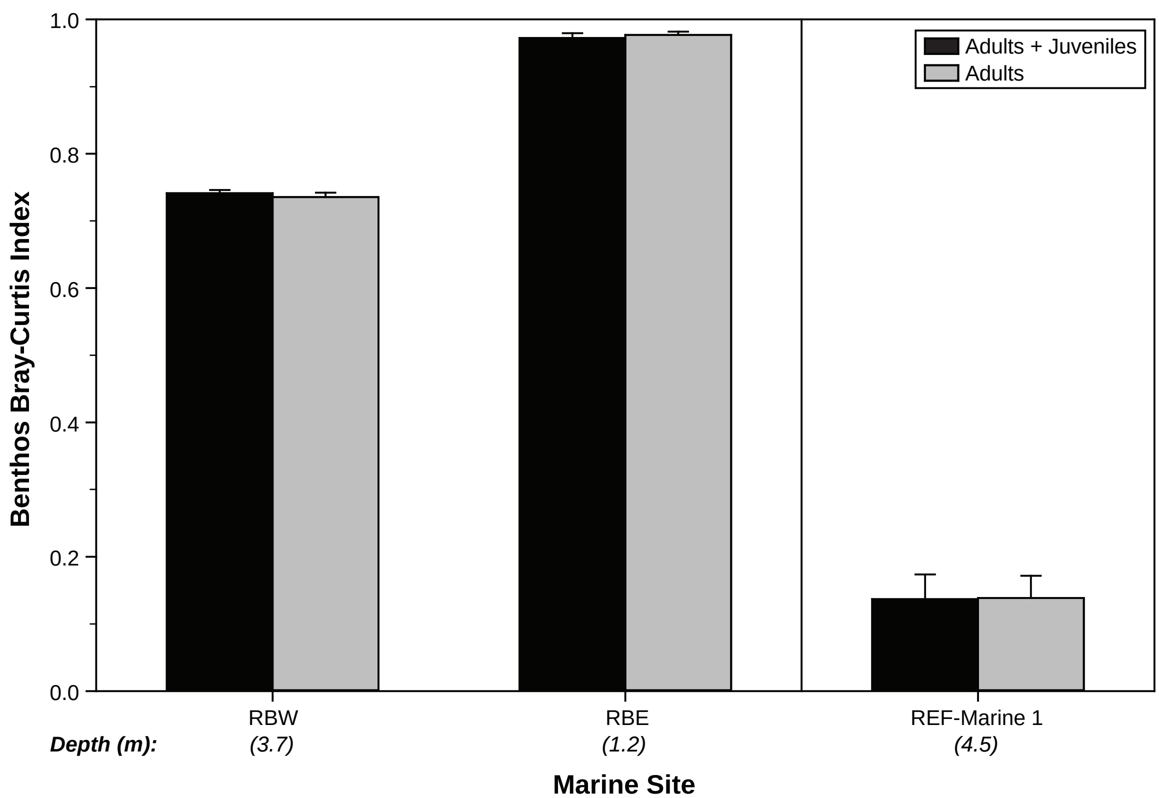

Notes: Error bars represent the standard error of the mean.

NEWMONT NORTH AMERICA

Benthos Bray-Curtis Index for Marine Sites, Doris North Project, August 2011

Figure A.6-9

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Annex A.6-5. Marine Benthos Taxonomy Data, Doris North Project, 2011

Taxonomic Identification			RBW										RBE										REF-Marine 1									
			18-Aug-11										18-Aug-11										19-Aug-11									
Major Group	Family	Genus/Species	Rep-1		Rep-2		Rep-3		Rep-4		Rep-5		Rep-1		Rep-2		Rep-3		Rep-4		Rep-5		Rep-1		Rep-2		Rep-3		Rep-4		Rep-5	
			A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J	A	J
NEMERTEA																																
	Hoplonemertea (Order)*	Hoplonemertea Indet.*																														
	Nemertea (Phylum)*	Nemertea Indet.*	2	1	1						1																					
	Tubulanidae	*Tubulanus* sp.							1														1				1		1			
ANNELIDA																																
Polychaeta Errantia	Phyllodocidae	*Eteone longa*			2				3		3		1		2		2		3		4		1									
		Eteone nr. *pacifica*									1																					
		Phyllodoce groenlandica	18	6	7	3	9	4	18	21	9	6																				
	Polynoidae	*Harmothoe imbricata* Cmplx.																					3		3		4		2	1		
	Hesionidae	Hesionidae Indet.			1						1																					
	Nephtyidae	*Nephtys ciliata*									1																					
		Nephtys sp.	347	5	378	4	366	7	371	9	360	9	1										97		64		74		127		34	
	Hesionidae	*Nereimyra* sp.																					46	1	41	2	39	1	32	1	25	1
	Pholoidae	*Pholoe* nr. *minuta*	6		5		4		4	1	4	2											7	1	4		4	1	3		1	
		Pholoe sp.	5		1		2		5		4	2	1	1									79	36	80	17	69	25	61	30	12	3
Polychaeta Sedentaria	Cirratulidae	*Aphelochaeta* sp.	1																													
	Paraonidae	*Aricidea* sp.	4		13	1	13		6		1																					
	Capitellidae	*Capitella capitata* Cmplx.			1		1																21		8		5	2	5	1	10	
		Mediomastus sp.	5		9		14		11		12												26		9		17		12		17	
	Maldanidae	Euclymeninae Indet.	1		1		1		1		2																					
	Orbiniidae	*Leitoscoloplos* sp.	118	37	91	38	91	42	114	37	67	46																	1		1	
	Spionidae	*Marenzelleria arctia*																	1		1				1							
		Scolelepis sp.											1																			
		Spio sp.																					2				1		1			
	Pectinariidae	*Pectinaria granulata*	32	7	110	3	26	7	100	5	33	3											38		44	10	27	2	47	7	41	3
		Pectinaria sp.			14	2			5		5	2											5	11								
	Trichobranchidae	*Terebellides* sp.					1																5	1	5	1	3	1	5	2	10	1
ARTHROPODA																																
Amphipoda	Lysianassidae	*Boeckosimus affinis*	1		1								11		1								2	1							1	
	Gammaracanthidae	*Gammaracanthus loricatus*																					1				2	1	2	1		
	Hyperiidae	Hyperiidae Indet.																					1									
	Gammaridae	*Lagunogammarus setosus*		1					1						1				2													
	Oedicerotidae	*Monoculodes* sp.																											1			
	Pontoporeiidae	*Pontoporeia femorata*	2	2	3	2	1	2	3	2	2	1					1						224	7	129	1	67	3	140	9	110	7
Ostracoda	Ostracoda (Class)	Ostracoda Indet.											2		1																	
Cumacea	Diastylidae	*Diastylis rathkei*							1																1		1		3		1	
	Leuconidae	*Leucon* sp.											1																			
Isopoda	Chaetiliidae	*Saduria entomon*			2						1								3		1							1	1			
Decapoda	Majidae	Majidae Indet.																						1								
MOLLUSCA																																
Gastropoda	Cylichnidae	*Acteocina* sp.	3		2				2																							
		Cylichna alba	18		21		12		40		19																					
		Cylichna sp.			24		8		20		14																					
	Haminoeidae	*Haminoea* sp.							1		2																					
Bivalvia	Astartidae	*Astarte borealis*	3		4																											
	Hiatellidae	*Hiatella arctica*							1														1		1		1		2			
	Tellinidae	*Macoma balthica*	26	8	41	22	24	8	47	20	26	15	18		2		4	3	10	1	2		6	2	5	5	2	2	4	1	2	1
		Macoma calcarea																									1					
		Macoma elimata									1																					
		Macoma sp.												1															2			
	Mytilidae	*Musculus niger*			1																											
		Mytilus trossulus																					3				3					
	Myidae	*Mya truncata*																									1					
UROCHORDATA																																
Ascidiacea	Molgulidae	*Rhizomogula globularis*			2								1																			
TOTAL number of individuals			590	66	734	75	573	70	755	95	568	86	37	2	7	0	7	3	19	1	8	0	569	61	395	36	322	39	452	53	265	16

Notes:

** Taxa marked with an asterisk were excluded from total counts and from all benthos analyses because these taxa were not identifiable to the family level and made up a minor proportion (<2%) of the benthos assemblage in each replicate.*

The total number of individuals was divided by 3 times the surface area of the Petite Ponar (i.e., 3 x 0.023 m^2) to determine the benthos density in units of organisms/m^2 (because each replicate consisted of 3 pooled Petite Ponar grabs).

A = adult

J = juvenile

Annex A.6-6. Marine Benthos Summary Statistics, Doris North Project, 2011

	Roberts Bay West (RBW) - Adults and Juveniles					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	9,319	12,319	9,507	10,470	1,434	641
Family Richness	12.0	17.0	15.0	14.8	1.9	0.9
Simpson's Diversity Index	0.61	0.74	0.65	0.67	0.05	0.02
Simpson's Evenness Index	0.19	0.24	0.21	0.21	0.02	0.01
Bray-Curtis Index	0.72	0.75	0.74	0.74	0.01	0.005

	Roberts Bay West (RBW) - Adults					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	8,232	10,942	8,551	9,333	1,339	599
Family Richness	12.0	17.0	14.0	14.6	1.9	0.9
Simpson's Diversity Index	0.56	0.70	0.61	0.63	0.07	0.03
Simpson's Evenness Index	0.17	0.21	0.19	0.19	0.02	0.01
Bray-Curtis Index	0.71	0.75	0.74	0.74	0.02	0.01

	Roberts Bay East (RBE) - Adults and Juveniles					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	101	565	145	243	195	87
Family Richness	3.0	9.0	5.0	5.2	2.3	1.0
Simpson's Diversity Index	0.46	0.78	0.66	0.64	0.11	0.05
Simpson's Evenness Index	0.34	0.89	0.62	0.63	0.20	0.09
Bray-Curtis Index	0.95	0.99	0.97	0.97	0.02	0.01

	Roberts Bay East (RBE) - Adults					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	101	536	116	226	188	84
Family Richness	3.0	9.0	5.0	5.2	2.3	1.0
Simpson's Diversity Index	0.57	0.78	0.66	0.67	0.07	0.03
Simpson's Evenness Index	0.33	0.89	0.73	0.66	0.21	0.10
Bray-Curtis Index	0.96	0.99	0.98	0.98	0.01	0.005

	Ida Bay (REF-Marine 1) - Adults and Juveniles					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	4,073	9,130	6,246	6,400	1,943	869
Family Richness	11.0	18.0	17.0	15.0	3.2	1.4
Simpson's Diversity Index	0.76	0.82	0.80	0.79	0.02	0.01
Simpson's Evenness Index	0.26	0.43	0.33	0.34	0.07	0.03
Bray-Curtis Index	0.03	0.25	0.12	0.14	0.08	0.04

	Ida Bay (REF-Marine 1) - Adults					
	Min	Max	Median	Mean	SD	SE
Density (#/m^2)	3,841	8,246	5,725	5,806	1,709	764
Family Richness	11.0	17.0	16.0	14.6	2.9	1.3
Simpson's Diversity Index	0.76	0.83	0.79	0.79	0.02	0.01
Simpson's Evenness Index	0.26	0.41	0.36	0.34	0.07	0.03
Bray-Curtis Index	0.04	0.24	0.12	0.14	0.07	0.03

Notes:

SD - Standard deviation of the mean

SE - Standard error of the mean

Annex A.6-7. Results of Benthos QA/QC Sorting Efficiencies, Doris North Project, 2011

Sample ID	# from First Sort	1st QAQC Re-sort # Found	Initial Sort Efficiency (%)	Re-sort Required?	2nd QAQC Re-sort # Found	Final Efficiency (%)
Freshwater						
Reference Lake B, rep 2	306	5	98.4	N	-	98.4
Reference B OF, rep 3	672	13	98.1	N	-	98.1
Doris Lake South, rep 1	53	0	100	N	-	100
Doris Lake North, rep 5	189	3	98.4	N	-	98.4
Roberts OF, rep 4	1468	32	97.9	N	-	97.9
Marine						
REF-Marine 1, rep 1	630	1	99.2	N	-	99.2
REF-Marine 1, rep 2	431	1	98.9	N	-	98.9
REF-Marine 1, rep 3	361	0	100	N	-	100
REF-Marine 1, rep 4	505	0	100	N	-	100
REF-Marine 1, rep 5	281	1	98.3	N	-	98.3
RBE, rep 1	39	0	100	N	-	100
RBE, rep 2	7	0	100	N	-	100
RBE, rep 3	9	1	64.3	Y	0	100
RBE, rep 4	20	0	100	N	-	100
RBE, rep 5	8	0	100	N	-	100
RBW, rep 1	659	0	100	N	-	100
RBW, rep 2	810	0	100	N	-	100
RBW, rep 3	643	2	98.5	N	-	98.5
RBW, rep 4	850	0	100	N	-	100
RBW, rep 5	655	1	99.2	N	-	99.2

Notes:

If the efficiency is 90% or better nothing further is done and the QA/QC invertebrates are not added to the data.

If the efficiency is less than 90%, the QA/QC invertebrates are added to the sample, it is re-sorted,
and a second 20% QA/QC is performed.

*Freshwater data: % Sorting Efficiency = [1- {# in QA/QC re-sort/(# sorted originally + # in QA/QC re-sort)}]*100*

*Marine data (20% of sample is re-sorted): % Sorting Efficiency = [1- {(5 x # in QA/QC re-sort)/(# sorted originally + (5 x # in QA/QC re-sort))}]*100*

Appendix B
2011 Evaluation of Effects Supporting Information

Engineers and Scientists

Appendix B. 2011 Evaluation of Effects Supporting Information

Appendix B. 2011 Evaluation of Effects Supporting Information

B.1 BASELINE DATA SELECTION RATIONALE FOR EVALUATION OF EFFECTS

The tables presented in this section present a summary of the baseline water quality, sediment quality, and primary producer biomass data collected at the AEMP sites, as well as the rationale for the inclusion or exclusion of certain baseline data from the 2011 evaluation of effects.

B.1.1 Water Quality Data

Table B.1-1 presents a summary of the baseline water quality data collected at AEMP stream, lake, and marine sites, and the rationale for the inclusion or exclusion of certain baseline data from the 2011 evaluation of effects. The selection of historical data to include in the water quality evaluation of effects was mainly based on similarity of baseline sampling locations to 2011 sampling locations, methodology, and sampling depth.

B.1.2 Sediment Quality Data

Table B.1-2 presents a summary of the baseline sediment quality data collected at AEMP stream, lake, and marine sites, and the rationale for the inclusion or exclusion of certain baseline data from the 2011 evaluation of effects. The selection of historical data to include in the sediment quality evaluation of effects was mainly based on the comparability of the depth strata sampled between baseline and 2011 samples, the proximity of baseline sampling sites to the 2011 sites, and the similarity of sampling techniques.

B.1.3 Phytoplankton and Periphyton Biomass Data

Table B.1-3 presents a summary of the baseline phytoplankton and periphyton biomass data collected at AEMP stream, lake, and marine sites, and the rationale for the inclusion or exclusion of certain baseline data from the 2011 evaluation of effects. The main criteria for the selection of historical phytoplankton and periphyton biomass data for inclusion in the evaluation of effect were the proximity of baseline sampling sites to 2011 AEMP sampling sites, and the comparability of sampling methodologies.

Table B.1-1. Baseline Data Selection Rationale for Water Quality, Doris North Project, 2011

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Streams					
Doris OF	1996	June, August	All	None	
	1997	June July, August	All	None	
	2000	June, September	All	None	
	2003	July, August, September	All	None	
	2004	June, July, August, September	All	None	
	2005	June, July, August, September	All	None	
	2006	June, July, August, September	All	None	
	2007	June, July, August, September	All	None	
	2008	June, July, August, September	All	None	
	2009	June, August, September	All	None	
Roberts OF	2004	June, July, August, September	All	None	
	2005	June, July, August, September	All	None	
	2006	June, July, August, September	All	None	
	2007	June, July, August, September	All	None	
	2008	June, July, August, September	All	None	
Little Roberts OF	1996	June, August	None	All	• 1996-1997 sampling site was further downstream than the 2003-2011 sampling site.
	1997	June, July, August	None	All	• 1996-1997 sampling site was further downstream than the 2003-2011 sampling site.
	2003	July, August, September	All	None	
	2004	June, July, August, September	All	None	
	2005	June, July, August, September	All	None	
	2006	June, July, August, September	All	None	
	2007	June, July, August, September	All	None	
	2008	June, July, August, September	All	None	
	2009	June, August, September	All	None	
Reference B OF	2009	June, August, September	All	None	
Reference D OF	no pre-2010 baseline data available				

(continued)

Table B.1-1. Baseline Data Selection Rationale for Water Quality, Doris North Project, 2011 (continued)

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Lakes					
Doris South	1995	May, June, July, August	Included May and June under-ice samples and August samples collected from boat at site SW4	Excluded shoreline grabs from July and August	• Shoreline grabs from July and August were from a near-shore site that is not comparable to the 2011 Doris South site.
	1996	April, August	All	None	
	1997	April, July, August	All	None	
	1998	April	All	None	
	2000	July, August	All	None	
	2009	April, August	All	None	
Doris North	1995	May, June, July, August	Included May and June under-ice samples and August samples collected from boat a site SW3	Excluded shoreline grabs from July and August	• Shoreline grabs from July and August are from a shallow, near-shore site that is not comparable to the 2011 Doris North site.
	2003	July, August, September	All	None	
	2004	June, July, August, September	All	None	
	2005	July, August, September	All	None	
	2006	May, July, August, September	All	None	
	2007	May, July, August, September	All	None	
	2008	May, July, August, September	All	None	
	2009	April, August	All	None	
Little Roberts	1995	May, June, July, August	Included May and June under-ice samples	Excluded shoreline grabs from July and August	• Shoreline grabs from July and August are from a near-shore site that is not comparable to the 2011 Little Roberts Lake site.
	1996	August	All	None	
	1997	July	All	None	
	2003	July, August, September	All	None	
	2004	July, August, September	All	None	
	2005	July, August, September	All	None	
	2006	May, July, August, September	All	None	
	2007	May, July, August, September	All	None	
	2008	May, July, August, September	All	None	
	2009	April, August	All	None	
Reference B	2009	April, August	All	None	
Reference D	no pre-2010 baseline data available				

(continued)

Table B.1-1. Baseline Data Selection Rationale for Water Quality, Doris North Project, 2011 (completed)

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Marine Sites					
RBW	1996	August	None	All	• 1996-1998 sampling sites were >1 km away from 2011 RBW site.
	1997	August	None	All	• 1996-1998 sampling sites were >1 km away from 2011 RBW site.
	1998	July	None	All	• 1996-1998 sampling sites were >1 km away from 2011 RBW site.
	2009	April, August	Included surface samples from sites WT1 and ST2	Exluded samples from sites: WT2, WT4, WT6, ST1, ST3, ST4, ST5, ST6, and deep sample from site ST2	• Excluded sites that were >1 km away from 2011 RBW site, and excluded deep samples because only surface samples were collected in 2011.
RBE	1996	August	Included single site that was in the eastern basin	None	
	1997	August	None	All	• 1997-1998 sampling site in eastern basin was closer to the mouth of Little Roberts Outflow than the 2011 RBE site (greater freshwater influence).
	1998	July	None	All	• 1997-1998 sampling site in eastern basin was closer to the mouth of Little Roberts Outflow than the 2011 RBE site (greater freshwater influence).
	2004	July, August, September	All	None	
	2005	July, August, September	All	None	
	2006	May, July, August, September	All	None	
	2007	May, July, August, September	All	None	
	2008	July, August, September	All	None	
	2009	April, August	All	None	
REF-Marine 1	2009	April, August	Included surface samples from site RP3	Excluded samples from sites: REF-W and REF-4, and deep samples from site RP3	• Excluded sites that were >1 km away from 2011 REF-Marine 1 site, and excluded deep samples because only surface samples were collected in 2011.

Table B.1-2. Baseline Data Selection Rationale for Sediment Quality, Doris North Project, 2011

Sampling sites	Years Sampled	Month Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Streams					
Doris OF	2009	August	All	None	
Roberts OF	no pre-2010 baseline data available				
Little Roberts OF	2009	August	All	None	
Reference B OF	2009	August	All	None	
Reference D OF	no pre-2010 baseline data available				
Lakes					
Doris South (deep)	1996	August	None	All	• Sediment sample was separated into layers (0-1 cm and 1-3 cm).
	1997	July	All	None	
	2009	August	Included deep site	Excluded shallow site	• Shallow site was sampled.
Doris North (deep)	2009	August	Included deep site	Excluded shallow site	• Shallow site was sampled.
Little Roberts (shallow)	1996	August	None	All	• Sediment sample was separated into layers (0-1 cm and 1-3 cm).
	1997	July	All	None	
	2009	August	All	None	
Reference B (deep)	2009	August	None	All	• Shallow/mid depth sites and located at opposite end of lake relative to 2011 site.
Reference D (shallow)	no pre-2010 baseline data available				
Marine Sites					
RBW (shallow)	1997	August	None	All	• Mid-depth/deep sites and located >1 km from 2011 RBW site.
	2002	August	Included shallow site RB4	Excluded sites RB1, RB2, RB3	• RB1 and RB2 were >1 km from 2011 RBW site; RB3 was a mid-depth site.
	2009	August	None	All	• Sites were all ~0.4 km or more away from 2011 RBW site.
RBE (shallow)	1997	August	None	All	• sampling site in eastern basin was closer to the mouth of Little Roberts Outflow than the 2011 RBE site (greater freshwater influence, and depositional zone).
REF-Marine 1 (shallow)	2009	August	Included shallow site RP1	Excluded sites RP2, RP3	• RP2 was a mid-depth site and RP3 was a deep site.

Table B.1-3. Baseline Data Selection Rationale for Primary Producer Biomass (as Chlorophyll *a*), Doris North Project, 2011

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
Streams (Periphyton)					
Doris OF	1996	August	None	All	• An instantaneous sample was collected, and chlorophyll *a* concentrations were not measured (only abundance and taxonomy data).
	1997	June-July, July-August	All	None	
	2000	July-August	All	None	
	2009	July-August	All	None	
Roberts OF	no pre-2010 baseline data available				
Little Roberts OF	1996	August	None	All	• 1996 sampling site was further downstream than 2009-2011 sampling site, an instantaneous sample was collected, and chlorophyll *a* concentrations were not measured (only abundance and taxonomy data).
	1997	June-July, July-August	None	All	• 1997 sampling site was further downstream than 2009-2011 sampling site.
	2009	July-August	All	None	
Reference B OF	2009	July-August	All	None	
Reference D OF	no pre-2010 baseline data available				
Lakes (Phytoplankton)					
Doris South	1996	August	None	All	• Chlorophyll *a* concentrations were not measured (only abundance and taxonomy data).
	1997	July	All	None	
	2000	July	All	None	
	2009	April, August	All	None	
Doris North	2003	July, August, September	None	All	• Each sample consisted of a composite of 5 subsamples collected throughout the euphotic zone (not comparable to discrete surface samples collected in 2011).
	2006	September	None	All	• Phytoplankton biomass sampling method not descibed in report.
	2007	July, August, September	None	All	• Phytoplankton biomass samplles were collected using an integrated tube sampler deployed throughout the euphotic zone (not comparable to discrete surface samples collected in 2011).
	2008	July, August, September	None	All	• Phytoplankton biomass samplles were collected using an integrated tube sampler deployed throughout the euphotic zone (not comparable to discrete surface samples collected in 2011).
	2009	April, August	All	None	

(continued)

Table B.1-3. Baseline Data Selection Rationale for Primary Producer Biomass (as Chlorophyll *a*), Doris North Project, 2011 (completed)

Sampling Sites	Years Sampled	Months Sampled	Data Included in Historical Graphs and Statistical Analyses	Data Excluded from Historical Graphs and Statistical Analyses	Rationale for Exclusion
	1997	July	All	None	
	2003	July, August, September	None	All	• Each sample consisted of a composite of 5 subsamples collected throughout the euphotic zone (not comparable to discrete surface samples collected in 2011).
	2006	September	None	All	• Phytoplankton biomass sampling method not descibed in report.
	2007	July, August, September	None	All	• Phytoplankton biomass samplles were collected using an integrated tube sampler deployed throughout the euphotic zone (not comparable to discrete surface samples collected in 2011).
	2008	July, August, September	None	All	• Phytoplankton biomass samplles were collected using an integrated tube sampler deployed throughout the euphotic zone (not comparable to discrete surface samples collected in 2011).
	2009	April, August	All	None	
Reference B	2009	August	All	None	
Reference D	no pre-2010 baseline data available				
Marine Sites (Phytoplankton)					
RBW	2009	August	Included surface samples from site ST2	Exluded samples from sites: ST1, ST3, ST4, ST5, ST6, and deep samples from site ST2	• Excluded sites that were >1 km away from 2011 RBW site, and excluded deep samples because only surface samples were collected in 2011.
RBE	2006	September	None	All	• Phytoplankton biomass sampling method not descibed in report.
	2007	July, August, September	None	All	• Phytoplankton biomass samples were collected using an integrated tube sampler deployed throughout the euphotic zone (not comparable to discrete surface samples collected in 2011).
	2008	July, August, September	None	All	• Phytoplankton biomass samples were collected using an integrated tube sampler deployed throughout the euphotic zone (not comparable to discrete surface samples collected in 2011).
	2009	August	All	None	
REF-Marine 1	2009	August	Included surface samples from site RP3	Excluded samples from site REF-4, and deep samples from site RP3	• Excluded sites that were >1 km away from 2011 REF-Marine 1 site, and excluded deep samples because only surface samples were collected in 2011.

B.2 STATISTICAL METHODOLOGY AND RESULTS FOR EVALUATION OF EFFECTS

The following reports present the statistical methodology and results, including lists of outliers and statistical outputs, for the evaluation of effects on Secchi depth, water quality, sediment quality, phytoplankton and periphyton biomass, and benthic invertebrates.

Appendix B.2.1. Statistical Methodology and Results for Secchi Depth Evaluation of Effects, Doris North Project, 2011

Table of Contents

1. Analysis Methods

1.1 ASSUMPTIONS

The key assumption is that the Secchi depth measurements included in this analysis are representative of each lake site's Secchi depth for that monitoring period.

1.2 TRANSFORMATIONS

No transformation was needed.

1.3 OUTLINE OF ANALYSIS PLAN

There are several classes of statistical tests that can be done to assess evidence of change in the Secchi depth over time and to assess if changes may reflect an impact of the Project.

1.3.1 Before vs. After Analysis

The first analysis conducted compares the mean Secchi depth for all years prior to 2010 (before initiation of construction) to the mean for 2011 (year 2 of construction). Each lake site is treated independently.

The final statistical model (in standard shorthand notation) is:

*Y = Period Season Period*Season Year(period)-R*

where *Y* is the mean Secchi depth for a year; *Period* is the effect of before vs. after Project initiation (which is the effect of interest); *Season* is the effect of season (3 seasons in the sampling year: 1) July, 2) August, 3) September); *Period*Season* is an interaction effect between period and season; and *Year(Period)* is a random year effect (applicable if more than one year was sampled during each period). If the data are too sparse (e.g., not all seasons measured in all periods), then the Period*Season interaction effect cannot be estimated and is dropped.

This model is preferable to simply treating all measurement within a period (e.g., over two years pre-construction) as having the same mean and assuming that they are completely independent of each other. This model also "averages" the Secchi depth data in way that weights each baseline year equally rather than weighting by the sample size. For example, suppose that the Secchi depth measured in 2008 was 22 m, while the two Secchi depths measured in 2009 were 25 m and 27 m. The simple mean (22+25+27)/3=24.7 m would be more heavily weighted toward the mean in the second year. In order to give each year's data equal weight, the reading over both years is computed as an average of averages:

$$\frac{\frac{22}{1}+\frac{25+27}{2}}{2}=24.0$$

This can be extended to multiple years in a similar fashion.

This model was fit using Proc Mixed in SAS 9.2. In order to reduce the number of "false positives" because a large number of statistical tests are done, a reduced significance level (e.g., 0.01) should be used when reviewing the results.

The key disadvantage of this model is that changes in Secchi depth over time may be unrelated to the effects of the Project, e.g., the average Secchi depth in 2011 could be worse than expected because of long term climate change that is unrelated to the Project. Consequently, if a statistically significant effect is detected, it will require further investigation.

1.3.2 BACI Analysis

The standard method to assess an environmental impact is through a Before-After-Control-Impact (BACI) analysis (Smith 2002). The analysis of these designs looks for non-parallelism in response over time between the Project and reference waterbodies. A BACI analysis was performed for each large Project lake (Doris Lake North and Doris Lake South) versus the corresponding reference lake (Reference Lake B). A BACI analysis was not performed for Little Roberts Lake (small lake) because there is no pre-construction data for Reference Lake D.

The formal statistical model (in standard shorthand notation) is:

*Y = Period Class Period*Class Season Period*Season Year(Period)-R*

where *Y* is the parameter of interest; *Period* is the effect of period (before or after construction); *Class* is the effect of the site classification (Project or reference); *Period*Class* is the BACI effect of interest (i.e., is the effect of *Period* the same (parallel) for both classes of sites); *Season* is the seasonal (sampling month) effect; *Period*Season* is an interaction effect between period and season; and *Year(Period)* is the random year effect within each period (applicable if more than one year was sampled during each period). If the data are too sparse (e.g., not all seasons measured in all periods), then the Period*Season interaction effect cannot be estimated and is dropped. If there were multiple reference waterbodies (as is the case for streams), a term *Body(Class)-R* (the random site effect within each class) would also be added to the model so that the change in the mean for the Project site is compared to the average change in the mean for the reference bodies. Sites that were measured only in one period (e.g., Reference D OF measured only post-construction) contribute some information on the year-effect which improves precision of the BACI estimate.

Not all sites were measured in all years and only those Project-Reference pairs of sites that were measured both in the before and after period can be used to estimate this BACI contrast. The results from this comparison are specific to the particular Project-reference sites.

The key parameter of interest is the *Period*Class* effect as this measures the amount of non-parallelism between the changes in the mean (Before-After) over the two classes of sites (Project or reference). The BACI estimate is computed as the "difference in the differences":

$$BACI = (\mu_{PA} - \mu_{PB}) - (\mu_{RA} - \mu_{RB})$$

where μ_{PA} is the mean parameter reading in the *Project* class of sites *after* Project initiation, μ_{PB} is the mean parameter reading in the *Project* class of sites *before* Project initiation, μ_{RA} is the mean parameter reading in the *reference* class of sites *after* Project initiation, and μ_{RB} is the mean parameter reading in the *reference* class of sites *before* Project initiation. The BACI contrast is estimated by replacing the population means above by the model-based estimates. Estimated differences close to 0 would indicate no evidence of non-parallelism.

Note that the hypothesis that the BACI contrast has the value of zero is identical to the hypothesis that the Period*Class interaction is zero with identical p-values. Consequently, only the results for the BACI contrast are reported here.

The BACI model was fit using Proc Mixed in SAS 9.2.

2. Results

There was no censoring of the Secchi depth data, and preliminary plots of the data showed no obvious outliers.

The lakes were divided into small lakes (Little Roberts Lake and Reference Lake D) and large lakes (Doris Lake North, Doris Lake South, and Reference Lake B) and separate results are presented for each size class of lake. The results from the analysis that compared the means before and after Project construction are presented in Tables Large Lake-1 and Small Lake-1. There was no evidence of a change in the mean Secchi depth for any lake between the before and after periods. No measurements were taken prior to construction for Reference Lake D, so no before-after analysis could be performed for this lake.

There was no evidence of a differential before-after response in the mean Secchi depth in large Project lakes compared to Reference Lake B (Table Large Lake-2). Because no Secchi depth measurements were made in Reference Lake D prior to construction, no BACI comparison can be made for Little Roberts Lake (small lake).

References

Helsel, D.R. (2005). Nondetects and data analysis. Wiley:New York.

McBride, G.B. (2005). Using statistical methods for water quality management. Wiley: New York.

Smith, E. P. (2002). BACI Design. Encyclopedia of Environmetrics, Wiley: New York.

Table Large Lake-1. Summary of Test for No Difference in Mean between Before and After Periods for Large Lake Secchi Depth

Parameter	Period			Period*Season			Season		
	Large Lake Site			Large Lake Site			Large Lake Site		
	Doris North	Doris South	Reference B	Doris North	Doris South	Reference B	Doris North	Doris South	Reference B
	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F
Secchi Depth	0.989	0.896	.	0.343	.	.	0.157	0.771	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.

Table Lake-Large-2. Summary of BACI Comparison of Large Lake Secchi Depth for Individual Project Sites

Parameter	Large Lake Site					
	Doris North			Doris South		
	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
Secchi Depth	1.6179	0.8914	0.088	-0.0833	2.4384	0.974

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.

Table Small Lake-1. Summary of Test for No Difference in Mean between Before and After Periods for Small Lake Secchi Depth

Parameter	Period		Period*Season		Season	
	Small Lake Site		Small Lake Site		Small Lake Site	
	Little Roberts Lake	Reference D	Little Roberts Lake	Reference D	Little Roberts Lake	Reference D
	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F
Secchi Depth	0.683	.	0.822	.	0.904	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
No pre-construction Secchi depth readings were collected at Reference Lake D, so no before-after comparison is possible.

Appendix B.2.2. Statistical Methodology and Results for Water Quality Evaluation of Effects, Doris North Project, 2011

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1. Analysis Methods

1.1 ASSUMPTIONS

There are several assumptions made for the analyses of water quality. The key assumption is that the samples taken are a random sample of the site's water for that monitoring period (e.g., for that month in that year when measured).

Another necessary assumption is that missing data (e.g., a stream was not measured in a month in a particular year) is missing completely at random (MCAR), so that there is no information about the water quality from the "missingness". This assumption could be violated if, for example, samples were not taken because it was known that water quality was compromised on the selected sampling date. There is no way to assess this assumption except by carefully considering why data was not collected on a particular date. If, for example, data were not collected because the sampling vial broke in transit, this is likely a case of MCAR.

It is further assumed that the water columns of all sampled waterbodies are completely mixed so that depth effects can be ignored. This assumption was verified by examining the raw sample means at various depths and fitting statistical models to examine the effects of depth, and few depth effects were seen.

1.2 REPLICATE SAMPLES

Replicate samples collected within the same day and at the same depth were treated as pseudo-replicates (Hurlbert 1984) and values were averaged before further analyses. This will be an approximate analysis (compared to actually modelling replicated values as nested within a particular day), but given the high variability seen for most of the readings, the reported results should be insensitive to this averaging.

1.3 DEALING WITH CENSORING (VALUES BELOW DETECTION LIMITS)

The proportion of data with readings below the detection limit varies by waterbody and by water quality parameter. The analyses below follow the advice of McBride (2005; Section 11.4.3).

- When the dataset includes a small number of below detection values, these values will be replaced by ½ of the detection limit for the analysis.
- When the majority of the dataset consists of values below the detection limit (e.g., more than about 70% below detection limit), there is very little that can be done as there is essentially no information (other than the values are below the detection limit). The analyses will be performed as above, but interpreting the results should be done carefully. Helsel (2005) has other suggestions for analysis (e.g., comparing the proportions below the detection limits) but these tests will require much larger sample sizes than available here.
- When there is an intermediate amount of censoring, a more complex analysis can be conducted that fully integrates the information from the censored values with the known values. This is most easily done using Bayesian methods using MCMC methods as likelihood methods would require integration of the likelihood for each censored value over and above dealing with the other random effects in the model. There is currently, no readily available software available for the latter.

Fortunately, most water quality parameters fall into one of the two first categories.

It should be noted that for data collected in the late 1990's, the detection limits were often considerably higher than the detection limits available for more recent sampling (often 5x or 6x higher). Consequently, there is little to be gained from using this very early data and it was often removed prior to analysis and treated as outliers as noted in the sections below.

1.4 TRANSFORMATIONS

For all water quality parameters, the values were fairly homogeneous and no obvious transformation was suggested, i.e., metals analyzed on the ppm scale and pH measured on the log-scale.

1.5 DEALING WITH SPARSE DATA IN SOME CLASSIFICATIONS SUCH AS SEASON

In models with season effects, samples were not always collected during all seasons of all years or periods. In these cases, interaction effects involving season cannot be fit but additive models can still be fit.

1.6 OUTLINE OF ANALYSIS PLAN

There are several classes of statistical tests that can be done to assess evidence of change in the mean of the water quality parameter over time and to assess if changes in the means may reflect an impact of the Project.

1.6.1 Before vs. After Analysis

The first analysis conducted compares the mean readings for all years prior to 2010 (before initiation of construction) to the mean for 2011 (year 2 of construction). Each waterbody is treated independently, and each water quality parameter is treated separately.

The final statistical model (in standard shorthand notation) is:

*Y = Period Season Period*Season Year(Period)-R*

where *Y* is the (mean) parameter reading for a date within a year; *Period* is the effect of before vs. after Project initiation (which is the effect of interest); *Season* is the effect of early or late in the year; *Period*Season* represent the interaction between Project and season effects (i.e., is the effect of the period consistent in both seasons); and *Year(Period)* is a random year effect (applicable if more than one year was sampled during each period). This separates the variation in water quality into components representing variation within a season in a year and year-to-year variation. If the data are too sparse (e.g., not all seasons measured in all periods), then the Period*Season interaction effect cannot be estimated and is dropped.

This model is preferable to simply treating all measurement within a period (e.g., over several years pre-construction) as having the same mean and assuming that they are completely independent of each other. This model also "averages" the water quality values collected over the baseline years in way that weights each year equally rather than weighting by the sample size. For example, suppose that the water quality parameter measured in 2008 was 22 ppm, while the two readings measured in year 2009 were 25 and 27 ppm. The simple mean (22+25+27)/3=24.7 ppm would be more heavily weighted toward the mean in 2009. In order to give each year's data equal weight, the reading over both years is computed as an average of averages:

$$\frac{\frac{22}{1}+\frac{25+27}{2}}{2}=24.0\text{ ppm}$$

This can be extended to multiple years in a similar fashion.

This model was fit using a mixed-model ANOVA using Proc Mixed in SAS 9.2. In order to reduce the number of “false positives” because a large number of statistical tests are done, a reduced significance level (e.g., 0.01) should be used when reviewing the results.

The key disadvantage of this model is that changes over time may be unrelated to the effects of the Project, e.g., the mean water quality readings in 2011 could be worse than expected because of long term climate change that is unrelated to the Project. Consequently, if a statistically significant effect is detected, it will require further investigation.

1.6.2 BACI Analysis

The standard method to assess an environmental impact is through a Before-After-Control-Impact (BACI) analysis (Smith 2002). The analysis of these designs looks for non-parallelism in response over time between the Project and reference waterbodies. A BACI analysis was performed for each Project waterbody versus the corresponding reference waterbody.

The formal statistical model (in standard shorthand notation) is:

*Y = Period Season Period*Season Class Period*Class Year(Period)-R*

where *Y* is the parameter of interest; *Period* is the effect of period (before or after construction); *Season* is the effect of season (early (June or earlier) or late (July or later)); *Period*Season* represents the interaction between Project and season effects (i.e., is the effect of the period consistent in both seasons); *Class* is the effect of the site classification (Project or reference); *Period*Class* is the BACI effect of interest (i.e., is the effect of Period the same (parallel) for both classes of sites); and *Year(Period)* is the random year effect within each period (applicable if more than one year was sampled during each period). If the data are too sparse (e.g., not all seasons measured in all periods), then the Period*Season interaction effect cannot be estimated and is dropped. If there were multiple reference waterbodies (as is the case for streams), a term *Body(Class)-R* (the random site effect within each class) would also be added to the model so that the change in the mean for the Project site is compared to the average change in the mean for the reference bodies. Sites that were measured only in one period (e.g., Reference D OF measured only post-construction) contribute some information on the year-effect which improves precision of the BACI estimate.

Not all sites were measured in all years and only those Project-reference pairs of sites that were measured both in the before and after period can be used to estimate this BACI contrast. The results from this comparison are specific to the particular Project-reference sites.

The key parameter of interest is the *Period*Class* effect as this measures the amount of non-parallelism between the changes in the mean (Before-After) over the two classes of sites (Project or reference). The BACI estimate is computed as the “difference in the differences”:

$$BACI=\left(\mu_{PA}-\mu_{PB}\right)-\left(\mu_{RA}-\mu_{RB}\right)$$

where μ_{PA} is the mean parameter reading in the *Project* class of sites *after* Project initiation, μ_{PB} is the mean parameter reading in the *Project* class of sites *before* Project initiation, μ_{RA} is the mean parameter reading in the *reference* class of sites *after* Project initiation, and μ_{RB} is the mean parameter reading in the *reference* class of sites *before* Project initiation. The BACI contrast is estimated by replacing the population means above by the model-based estimates. Estimated differences close to 0 would indicate no evidence of non-parallelism.

Note that the hypothesis that the BACI contrast has the value of zero is identical to the hypothesis that the *Period*Class* interaction is zero with identical p-values. Consequently, only the results for the BACI contrast are reported here.

The model was fit using Proc Mixed in SAS 9.2.

1.6.3 Multivariate Approaches

All of the approaches above analyze each water quality parameter independently of any other. However, the chemical constituents do not occur independently of each other, and presumably higher power would result if a multivariate approach were used. However, because of the censoring and missing data, no simple multivariate approach is possible and such an analysis would likely require the use of a full Bayesian MCMC approach. This has not been attempted in this report.

2. Results

2.1 STREAM DATA

A summary of the amount of censoring (values below the detection limit) for the stream data is found in Table Stream-1. High levels of censoring in all streams were found for the Cd, nitrate, and Ra parameters and the results of the analyses for these parameters will be non-informative and should be discarded.

High levels of censoring for TSS, Ammonia, Mo, Pb, and Zn were found in one or all of the reference streams but a lower proportion of censored values was found in Project streams. In these cases, the results will require further investigation to ensure that the censoring is not causing an artifact in the results.

Preliminary plots of the data showed some outliers, primarily from readings in the late 1990's where the detection limit was much higher than in recent times (Table Stream-2). These were discarded as such a large detection limit compared to more recent data provides little information on the actual value. Some other outliers that were not related to high detection limits were also discarded.

The results from the analysis that compared the means before and after Project construction are presented in Table Stream-3. There was evidence of a change in the mean between the before and after periods for CN (intermediate amounts of censoring) in Little Roberts OF and Roberts OF, Mo in Doris OF, and TSS in Little Roberts OF.

The results of the BACI comparison of each Project stream against the reference streams (Table Stream-4) failed to find evidence of a differential response in the mean between Project and reference streams over the before and after periods, with the exception of Hg in Roberts OF (which was likely an artifact of the high detection limit at Reference B OF in 2009). Unfortunately, CN was not measured in reference streams prior to Project impact, and so a BACI comparison cannot be performed for this parameter.

2.2 MARINE DATA

A summary of the amount of censoring (values below the detection limit) for the site data is found in Table Marine-1.

Preliminary plots of the data showed some outliers which were removed prior to analysis (Table Marine-2). Of particular concern are the As readings at the RBE site, which were substantially elevated between 2004 and 2006, but then fell to near or below detection limits from 2007 to 2011. The elevated readings prior to 2007 were treated as outliers and removed from the analysis to ensure that these observations did not artificially inflate the variance estimates, leading to a reduced power to detect effects.

The results from the analysis that compared the means before and after Project construction are presented in Table Marine-3. There was no evidence of a change in the mean between the before and after periods for any marine exposure site except for TSS at RBW. However, the results of the BACI comparison (Table Marine-4) failed to find evidence of a differential response in the mean between any marine Project site and the reference site over the before and after periods.

2.3 SMALL LAKE DATA

A summary of the amount of censoring (values below the detection limit) for the small lake data is found in Table Small Lake-1. High levels of censoring in all streams were found for Cd, Nitrate, and Ra parameters and the results of the analyses for these parameters will be non-informative and should be discarded.

Preliminary plots of the data showed some outliers that were primarily censored data from the early 1990s. The observations listed in Table Small Lake-2 were discarded prior to analysis to ensure that these observations did not artificially inflate the variance estimates leading to a reduced power to detect effects.

There was evidence of a change in the mean of the CN parameter between the before and after period in the Little Roberts Lake (Table Small Lake-3). In this case, all of the readings prior to Project construction were near or below detection limits and none of the readings in 2011 were below the detection limit. A period effect was also detected for Cd, but this parameter was highly censored.

Because water quality samples were not collected at Reference Lake D before construction started, no BACI analysis is possible.

2.4 LARGE LAKE DATA

A summary of the amount of censoring (values below the detection limit) for the large lake data is found in Table Large Lake-1. High levels of censoring in all streams were found for Cd and Ra parameters and the results of the analyses for these parameters will be non-informative and should be discarded. High levels of censoring were also found for the reference lake only for Mo, TSS, and Zn. This will make the BACI comparison difficult to interpret.

Preliminary plots of the data showed some potential outliers that were excluded from the analysis (Table Large Lake-2).

There was evidence of a difference in the means between the before and after periods for As in Doris Lake North and Hg in Doris Lake South (Table Large Lake-3). However, the BACI comparison failed to find evidence of a differential response in the mean between any Project site and the reference site over the before and after periods (Table Large Lake-4).

References

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Hurlbert S.H. (1984) Pseudoreplication and the design of ecological field experiments. Ecological Monographs, 54, 187-211.

McBride, G.B. (2005). Using statistical methods for water quality management. Wiley: New York.

Smith, E. P. (2002). BACI Design. Encyclopedia of Environmetrics, Wiley: New York.

Table Stream-1. Summary of the Proportion of Measurements that were Below Detection Limit (Before Outliers Removed) for Stream Sampling

	Stream Site				
	Doris OF	Little Roberts OF	Ref. B OF	Ref. D OF	Roberts OF
Parameter	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored
Al	0.00	0.00	0.14	0.00	0.00
Alk	0.00	0.00	0.00	0.00	0.00
Ammonia	0.31	0.31	0.36	0.88	0.26
As	0.05	0.03	0.00	0.00	0.00
CN	0.75	0.55	0.00	0.00	0.61
Cd	0.76	0.67	1.00	1.00	0.71
Cu	0.00	0.00	0.00	0.00	0.00
Fe	0.00	0.00	0.00	0.00	0.00
Hardness	0.00	0.00	0.00	0.00	0.00
Hg	0.72	0.68	0.43	0.00	0.52
Mo	0.00	0.00	0.86	0.00	0.00
Ni	0.05	0.00	0.21	0.00	0.00
Nitrate	0.86	0.95	0.29	1.00	0.77
Pb	0.14	0.15	0.93	0.50	0.03
Ra	0.91	0.82	0.75	0.88	0.94
TSS	0.14	0.05	0.86	0.25	0.03
Zn	0.26	0.33	1.00	1.00	0.29
pH	0.00	0.00	0.00	0.00	0.00

Table Stream-2. Summary of Potential Outliers from the Stream Data

Stream	Parameter	Year	Date	Rep	Value	Censored (1=yes 0=no)
Doris OF	Ammonia	1997	19JUL97	1	1.359800	0
Doris OF	Ammonia	1997	19JUL97	2	1.402400	0
Doris OF	Ammonia	1997	20AUG97	1	1.353300	0
Doris OF	As	1996	23JUN96	1	0.002000	1
Doris OF	As	1996	22AUG96	1	0.003000	0
Doris OF	Cd	1996	23JUN96	1	0.000190	0
Doris OF	Cd	1996	22AUG96	1	0.000025	1
Doris OF	Cd	1997	19JUN97	1	0.000100	1
Doris OF	Cd	1997	19JUL97	1	0.000100	1
Doris OF	Cd	1997	19JUL97	2	0.000100	1
Doris OF	Cd	1997	20AUG97	1	0.000100	1
Doris OF	Cd	2000	20JUN00	1	0.000025	1
Doris OF	Cd	2000	20JUN00	2	0.000025	1
Doris OF	Cd	2000	14SEP00	1	0.000025	1
Doris OF	Cd	2000	14SEP00	2	0.000025	1
Doris OF	Cd	2004	24JUN04	1	0.000025	1
Doris OF	Hg	1997	20AUG97	1	0.000025	1
Doris OF	Hg	2000	20JUN00	1	0.000025	1
Doris OF	Hg	2000	20JUN00	2	0.000025	1
Doris OF	Hg	2000	14SEP00	1	0.000025	1
Doris OF	Hg	2000	14SEP00	2	0.000025	1
Doris OF	Hg	2003	28JUL03	1	0.000025	1
Doris OF	Mo	1997	19JUN97	1	0.000500	1
Doris OF	Mo	1997	19JUL97	1	0.000500	1
Doris OF	Mo	1997	19JUL97	2	0.000500	1
Doris OF	Mo	1997	20AUG97	1	0.000500	1
Doris OF	Pb	1997	19JUN97	1	0.000500	1
Doris OF	Pb	1997	19JUL97	1	0.000500	1
Doris OF	Pb	1997	19JUL97	2	0.000500	1
Doris OF	Pb	1997	20AUG97	1	0.000500	1
Little Roberts OF	Hg	2003	28JUL03	1	0.000025	1

Notes: Censored values were replaced by ½ of the detection limit.

Table Steam-3. Summary of Test for No Difference in Mean between Before and After Periods for Stream Water Quality Parameters

	Effect														
	Period Stream Site					Period*Season Stream Site					Season Stream Site				
	Doris OF	Little Roberts OF	Ref. B OF	Ref. D OF	Roberts OF	Doris OF	Little Roberts OF	Ref. B OF	Ref. D OF	Roberts OF	Doris OF	Little Roberts OF	Ref. B OF	Ref. D OF	Rob O
meter	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr
	0.607	0.104	0.549	.	0.471	0.647	0.389	0.787	.	0.658	0.937	**0.003**	0.054	0.235	**0.0**
	0.193	0.995	0.471	.	0.674	0.238	0.657	0.162	.	0.426	0.645	0.016	0.106	0.038	**<.0**
onia	0.846	0.956	0.665	.	0.730	0.874	0.735	0.539	.	0.902	0.860	0.975	0.893	**<.001**	0.8
	0.558	0.358	**<.001**	.	0.043	0.827	0.674	**<.001**	.	0.670	0.418	0.644	**<.001**	0.109	0.9
	0.236	**<.001**	.	.	**<.001**	0.038	**<.001**	.	.	**<.001**	0.030	**<.001**	0.491	0.074	**<.0**
	0.700	0.775	**<.001**	.	0.734	0.616	0.995	.	.	0.891	0.616	0.901	.	.	0.8
	0.922	0.285	0.891	.	0.402	0.579	0.667	0.971	.	0.784	0.789	0.398	0.858	0.660	0.9
	0.219	0.014	0.380	.	0.155	0.836	0.683	0.725	.	0.610	0.606	**0.003**	0.078	0.761	**<.0**
ness	0.019	0.403	0.680	.	0.378	0.472	0.473	0.403	.	0.844	0.789	0.010	0.424	0.191	**<.0**
	0.956	0.902	**<.001**	.	0.090	0.058	0.981	0.215	.	0.019	0.948	0.797	0.215	0.250	0.1
	0.006	0.378	0.703	.	0.319	0.970	0.417	0.703	.	0.979	0.730	0.488	0.703	0.861	0.3
	0.367	0.102	0.761	.	0.170	0.577	0.228	0.552	.	0.267	0.704	**0.006**	0.171	0.389	**0.0**
te	0.415	0.612	0.484	.	0.752	0.622	0.423	0.121	.	0.855	0.622	0.423	0.963	.	0.0
	0.709	0.406	0.703	.	0.775	0.855	0.986	0.703	.	0.761	0.867	0.078	0.703	0.111	0.0
	0.752	0.046	.	.	.	0.673	0.054	.	.	.	0.673	0.143	0.449	**<.001**	.
	0.293	**0.007**	**<.001**	.	0.042	0.929	0.904	**<.001**	.	0.600	0.696	0.057	**<.001**	0.034	0.6
	0.858	0.339	**<.001**	.	0.346	0.527	0.094	.	.	0.321	0.846	0.094	.	.	0.3
	0.311	0.252	0.435	.	0.436	0.810	0.229	0.744	.	0.495	0.477	0.018	0.917	0.807	0.0

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.Seasonal effects are not of interest.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Stream-4. Summary of BACI Comparison of Water Quality Parameters for Individual Project Stream Sites

	Stream Site								
	Doris OF			Little Robert OF			Roberts OF		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
Al	0.0254	0.1098	0.818	0.1001	0.1176	0.401	0.0188	0.1508	0.902
Alk	0.8408	2.4584	0.733	0.1204	1.5965	0.940	0.3825	1.7601	0.832
Ammonia	-0.0060	0.0069	0.393	-0.0072	0.0066	0.280	-0.0065	0.0059	0.274
As	-0.0000	0.0001	0.824	-0.0000	0.0001	0.666	-0.0002	0.0001	0.041
CN	.	.	.	.	.	.	.	.	.
Cd	0.0000	0.0000	0.441	0.0000	0.0000	0.876	0.0000	0.0000	0.870
Cu	-0.0001	0.0003	0.874	0.0001	0.0002	0.714	0.0001	0.0002	0.656
Fe	0.0800	0.1361	0.559	0.1754	0.1307	0.188	0.0680	0.1070	0.530
Hardness	6.3177	5.9911	0.297	2.6132	3.6946	0.484	2.0312	2.5541	0.436
Hg	0.0000	0.0000	0.252	0.0000	0.0000	0.431	0.0000	0.0000	**<.001**
Mo	0.0000	0.0000	0.110	0.0000	0.0000	0.719	-0.0000	0.0000	0.951
Ni	0.0001	0.0002	0.454	0.0001	0.0001	0.317	0.0001	0.0001	0.279
Nitrate	-0.0012	0.0028	0.668	-0.0006	0.0019	0.766	-0.0001	0.0105	0.992
Pb	-0.0000	0.0000	0.908	0.0000	0.0001	0.727	0.0000	0.0001	0.985
Ra	.	.	.	.	.	.	.	.	.
TSS	2.2603	2.9782	0.451	5.1158	2.9609	0.093	3.4172	2.2268	0.143
Zn	-0.0004	0.0021	0.863	-0.0010	0.0013	0.445	-0.0022	0.0017	0.242
pH	0.1246	0.2627	0.637	0.1045	0.1805	0.566	0.1391	0.3652	0.715

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Marine-1. Summary of the Proportion of Measurements that were Below Detection Limit (Before Outliers Removed) for Marine Sampling

	Site		
	RBE	RBW	REF-Marine 1
Parameter	Proportion Censored	Proportion Censored	Proportion Censored
Al	0.03	0.27	0.33
Alk	0.00	0.00	0.00
Ammonia	0.44	0.73	0.56
As	0.00	0.00	0.00
CN	0.40	0.00	0.13
Cd	0.31	0.00	0.00
Cu	0.00	0.00	0.00
Fe	0.03	0.09	0.22
Hardness	0.00	0.00	0.00
Hg	0.56	0.45	0.44
Mo	0.10	0.09	0.00
Ni	0.10	0.00	0.00
Nitrate	0.81	0.27	0.78
Pb	0.43	0.27	0.33
Ra	0.64	0.38	0.50
TSS	0.24	0.73	0.78
Zn	0.20	0.18	0.67
pH	0.00	0.00	0.00

Table Marine-2. Summary of Potential Outliers from the Marine Data

Site	Parameter	Year	Date	Rep	Value	Censored (1=yes 0=no)
RBE	Ammonia	1996	28AUG96	1	2.500000	1
RBE	Ammonia	2007	23JUL07	1	0.214000	0
RBE	As	1996	28AUG96	1	0.002500	1
RBE	As	2004	19JUL04	1	0.008020	0
RBE	As	2004	14AUG04	1	0.015200	0
RBE	As	2004	16AUG04	1	0.013100	0
RBE	As	2004	09SEP04	1	0.022300	0
RBE	As	2005	21JUL05	1	0.004730	0
RBE	As	2005	18AUG05	1	0.022100	0
RBE	As	2005	14SEP05	1	0.021200	0
RBE	As	2006	31MAY06	1	0.015200	0
RBE	As	2006	20JUL06	1	0.013300	0
RBE	As	2006	12AUG06	1	0.025600	0
RBE	As	2006	11SEP06	1	0.023680	0
RBE	CN	2007	27MAY07	1	0.250000	1
RBE	CN	2007	23JUL07	1	2.500000	1
RBE	Cd	1996	28AUG96	1	0.003480	0
RBE	Ni	1996	28AUG96	1	0.021500	0
RBE	Nitrate	1996	28AUG96	1	2.500000	1

Notes: Censored values were replaced by ½ of the detection limit.

Table Marine-3. Summary of Test for No Difference in Mean between Before and After Periods for Marine Water Quality Parameters

	Effect								
	Period Site			Period*Season Site			Season Site		
	RBE	RBW	REF-Marine 1	RBE	RBW	REF-Marine 1	RBE	RBW	REF-Marine 1
Parameter	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F
Al	0.649	0.086	0.508	0.913	0.243	.	0.775	0.057	0.373
Alk	0.051	.	.	0.602	.	.	0.017	0.178	0.472
Ammonia	0.372	0.118	0.298	0.851	0.181	.	0.482	0.181	0.921
As	0.783	0.193	0.142	0.159	0.423	.	0.477	0.220	0.802
CN	0.779	.	.	0.964	.	.	0.851	0.051	0.695
Cd	0.243	0.205	0.210	0.016	0.277	.	0.015	0.098	0.390
Cu	0.624	0.502	0.805	0.642	0.645	.	0.477	0.728	0.716
Fe	0.674	0.185	0.654	0.875	0.917	.	0.374	0.354	0.530
Hardness	0.507	0.826	.	0.734	.	.	0.147	0.617	0.616
Hg	0.760	0.298	0.056	0.140	0.298	.	0.010	0.298	0.056
Mo	0.424	0.456	0.674	0.569	0.112	.	0.089	0.066	0.624
Ni	0.895	0.515	0.374	0.690	0.645	.	0.696	0.803	0.842
Nitrate	0.964	0.783	.	0.386	0.698	.	0.989	0.985	**<.001**
Pb	0.870	0.593	0.604	**<.001**	0.532	.	**<.001**	0.593	0.572
Ra	0.937	.	.	.	.	.	0.851	0.281	0.609
TSS	0.250	**<.001**	0.139	0.545	**<.001**	.	0.613	**<.001**	0.667
Zn	0.619	0.022	**<.001**	0.197	0.198	.	0.735	0.118	**<.001**
pH	0.514	0.055	0.213	0.818	0.142	.	0.740	0.047	0.240

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
Seasonal effects are not of interest.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Marine-4. Summary of BACI Comparison of Water Quality Parameters for Individual Project Marine Sites

	Marine Project Site					
	RBE			RBW		
	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
Parameter						
Al	-0.0794	0.2370	0.741	-0.0014	0.0106	0.903
Alk	.	.	.	.	.	.
Ammonia	0.0048	0.0082	0.566	0.0046	0.0026	0.133
As	-0.0004	0.0002	0.177	-0.0000	0.0002	0.845
CN	.	.	.	.	.	.
Cd	-0.0000	0.0000	0.599	-0.0000	0.0000	0.908
Cu	-0.0002	0.0016	0.879	0.0004	0.0004	0.412
Fe	-0.0490	0.1725	0.779	-0.0017	0.0258	0.950
Hardness	.	.	.	.	.	.
Hg	0.0000	0.0000	0.528	0.0000	0.0000	0.873
Mo	-0.0004	0.0028	0.881	0.0035	0.0028	0.262
Ni	-0.0007	0.0016	0.679	-0.0000	0.0003	0.905
Nitrate	-0.0393	0.0692	0.577	0.0623	0.1248	0.639
Pb	-0.0005	0.0004	0.238	0.0001	0.0013	0.926
Ra	.	.	.	.	.	.
TSS	-7.1377	7.8192	0.372	-1.6625	0.8629	0.112
Zn	-0.0004	0.0022	0.871	0.0017	0.0004	0.010
pH	0.0345	0.2876	0.906	-0.0462	0.0727	0.553

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Small Lake-1. Summary of the Proportion of Measurements that were Below Detection Limit (Before Outliers Removed) for Small Lake Sampling

	Lake	
	Little Roberts	Reference D
Parameter	Proportion Censored	Proportion Censored
Al	0.00	0.00
Alk	0.03	0.00
Ammonia	0.23	0.75
As	0.09	0.00
CN	0.64	0.00
Cd	0.67	0.75
Cu	0.00	0.00
Fe	0.00	0.00
Hardness	0.00	0.00
Hg	0.57	0.25
Mo	0.00	0.00
Ni	0.03	0.00
Nitrate	0.66	0.75
Pb	0.08	0.25
Ra	0.90	0.88
TSS	0.11	0.38
Zn	0.29	0.75
pH	0.00	0.00

Table Small Lake-2. Summary of Potential Outliers from the Small Lake Data

Lake	Parameter	Year	Date	Rep	Reading	Censored (1=yes 0=no)
Little Roberts	Ammonia	2007	24MAY07	1	0.240000	0
Little Roberts	Cd	1995	07MAY95	1	0.000100	1
Little Roberts	Cd	1995	07JUN95	1	0.000100	1
Little Roberts	Cd	1996	27AUG96	1	0.000025	1
Little Roberts	Cd	1996	27AUG96	2	0.000025	1
Little Roberts	Cd	1997	15JUL97	1	0.000100	1
Little Roberts	Cd	1997	15JUL97	2	0.000100	1
Little Roberts	Hg	2003	27JUL03	1	0.000230	0
Little Roberts	Mo	1997	15JUL97	1	0.000500	1
Little Roberts	Mo	1997	15JUL97	2	0.000500	1
Little Roberts	Nitrate	2004	13SEP04	1	5.300000	0
Little Roberts	Ra	2004	13SEP04	1	0.060000	0
Little Roberts	Zn	1995	07MAY95	1	0.327000	0

Notes: Censored values were replaced by ½ of the detection limit.

Table Small Lake-3. Summary of Test for No Difference in Mean between Before and After Periods for Small Lake Water Quality Parameters

	Effect					
	Period		Period*Season		Season	
	Lake		Lake		Lake	
	Little Roberts	Reference D	Little Roberts	Reference D	Little Roberts	Reference D
Parameter	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F
Al	0.785	.	0.462	.	0.382	**0.006**
Alk	0.964	.	0.737	.	**0.001**	**0.001**
Ammonia	0.387	.	0.120	.	**<.001**	**<.001**
As	0.468	.	0.134	.	0.038	0.003
CN	**<.001**	.	**<.001**	.	**<.001**	0.012
Cd	**0.009**	.	0.329	.	0.294	**<.001**
Cu	0.596	.	0.679	.	0.156	0.107
Fe	0.822	.	0.405	.	0.014	**<.001**
Hardness	0.963	.	0.606	.	**<.001**	**0.003**
Hg	0.663	.	0.670	.	0.200	0.009
Mo	0.399	.	0.911	.	**0.004**	0.439
Ni	0.853	.	0.437	.	**0.005**	**0.002**
Nitrate	0.146	.	0.030	.	**<.001**	**<.001**
Pb	0.715	.	0.065	.	0.468	0.029
Ra	.	.	.	.	.	0.667
TSS	0.377	.	0.027	.	0.575	**0.002**
Zn	0.357	.	0.402	.	0.402	**<.001**
pH	0.034	.	0.445	.	0.169	0.845

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
Seasonal effects are not of interest.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Large Lake-1. Summary of the Proportion of Measurements that were Below Detection Limit (Before Outliers Removed) for Large Lake Sampling

	Lake		
	Doris North	Doris South	Reference B
Parameter	Proportion Censored	Proportion Censored	Proportion Censored
Al	0.00	0.05	0.00
Alk	0.00	0.00	0.00
Ammonia	0.24	0.58	0.43
As	0.08	0.26	0.14
CN	0.67	0.30	0.00
Cd	0.71	0.93	0.86
Cu	0.01	0.00	0.07
Fe	0.05	0.12	0.50
Hardness	0.00	0.00	0.00
Hg	0.48	0.72	0.43
Mo	0.07	0.13	0.93
Ni	0.00	0.24	0.36
Nitrate	0.64	0.59	0.64
Pb	0.16	0.36	0.29
Ra	0.84	0.57	0.78
TSS	0.08	0.19	0.86
Zn	0.20	0.52	0.71
pH	0.00	0.00	0.00

Table Large Lake-2. Summary of Potential Outliers from the Large Lake Data

Lake	Parameter	Year	Date	Rep	Reading	Censored (1=yes 0=no)
Doris North	As	1995	20AUG95	1	0.003000	0
Doris South	As	1996	28AUG96	1	0.005000	0
Doris South	As	1996	28AUG96	1	0.004000	0
Doris South	As	1996	28AUG96	1	0.007000	0
Doris South	As	1996	28AUG96	1	0.015000	0
Doris North	Cd	1995	04MAY95	1	0.000100	1
Doris North	Cd	1995	07JUN95	1	0.000100	1
Doris North	Cd	1995	20AUG95	1	0.000050	1
Doris North	Cd	1995	20AUG95	1	0.000050	1
Doris North	Cd	1995	20AUG95	1	0.000050	1
Doris North	Cd	1995	20AUG95	1	0.000050	1
Doris North	Cd	1995	20AUG95	1	0.000050	1
Doris South	Cd	1995	04MAY95	1	0.000100	1
Doris South	Cd	1995	07JUN95	1	0.000100	1
Doris South	Cd	1995	20AUG95	1	0.000050	1
Doris South	Cd	1995	20AUG95	1	0.000050	1
Doris South	Cd	1995	20AUG95	1	0.000050	1
Doris South	Cd	1995	20AUG95	2	0.000050	1
Doris South	Cd	1997	18APR97	1	0.000100	1
Doris South	Cd	1997	18JUL97	1	0.000100	1
Doris South	Cd	1997	18JUL97	1	0.000100	1
Doris South	Cd	1997	18JUL97	2	0.000100	1
Doris South	Cd	1997	18JUL97	2	0.000100	1
Doris South	Cd	1997	22AUG97	1	0.000100	1
Doris South	Cd	1997	22AUG97	1	0.000100	1
Doris South	Cd	1998	25APR98	1	0.000100	1
Doris South	Cd	1998	25APR98	2	0.000100	1
Doris South	Cd	1998	25APR98	3	0.000100	1
Doris South	Hg	1997	22AUG97	1	0.000025	1
Doris South	Hg	1997	22AUG97	1	0.000025	1
Doris South	Hg	1998	25APR98	1	0.000025	1
Doris South	Hg	1998	25APR98	2	0.000025	1
Doris South	Hg	1998	25APR98	3	0.000025	1
Doris South	Hg	2000	24JUL00	1	0.000025	1
Doris South	Hg	2000	24JUL00	2	0.000025	1

Table Large Lake-2. Summary of Potential Outliers from the Large Lake Data

Lake	Parameter	Year	Date	Rep	Reading	Censored (1=yes 0=no)
Doris South	Hg	2000	24JUL00	1	0.000025	1
Doris South	Hg	2000	24JUL00	2	0.000025	1
Doris South	Hg	2000	22AUG00	1	0.000025	1
Doris South	Hg	2000	22AUG00	2	0.000025	1
Doris South	Mo	1997	18APR97	1	0.000500	1
Doris South	Mo	1997	18JUL97	1	0.000500	1
Doris South	Mo	1997	18JUL97	1	0.000500	1
Doris South	Mo	1997	18JUL97	2	0.000500	1
Doris South	Mo	1997	18JUL97	2	0.000500	1
Doris South	Mo	1997	22AUG97	1	0.000500	1
Doris South	Mo	1997	22AUG97	1	0.000500	1
Doris South	Mo	1998	25APR98	1	0.000500	1
Doris South	Mo	1998	25APR98	2	0.000500	1
Doris South	Mo	1998	25APR98	3	0.000500	1
Doris North	Ni	2005	19JUL05	1	0.028300	0
Doris North	Pb	2004	05JUN04	1	0.006690	0
Doris South	Nitrate	1996	28AUG96	1	4.510000	0
Doris North	Ra	2004	10SEP04	1	0.060000	0

Notes: Censored values were replaced by ½ of the detection limit.

Table Large Lake-3. Summary of Test for No Difference in Mean between Before and After Periods for Large Lake Water Quality Parameters

	Effect								
	Period Lake			Period*Season Lake			Season Lake		
	Doris North	Doris South	Reference B	Doris North	Doris South	Reference B	Doris North	Doris South	Reference B
Parameter	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F
Al	0.705	0.699	0.131	0.468	0.554	0.162	**0.002**	0.947	0.085
Alk	0.531	0.394	0.118	0.363	0.637	0.651	0.023	0.212	**0.004**
Ammonia	0.434	0.247	0.636	0.853	0.196	0.973	0.149	0.509	0.466
As	**0.007**	0.427	0.151	0.069	0.764	0.240	0.121	0.861	0.538
CN	0.010	0.256	.	0.498	.	.	0.971	0.869	0.651
Cd	0.671	0.502	**<.001**	0.969	0.295	**<.001**	0.969	0.255	**<.001**
Cu	0.460	0.370	0.405	0.475	0.093	0.998	0.396	0.058	0.315
Fe	0.836	0.646	0.801	0.257	0.548	0.969	0.014	0.822	0.616
Hardness	0.133	0.085	0.635	0.228	0.263	0.338	**<.001**	**<.001**	**0.009**
Hg	0.904	**<.001**	**<.001**	0.461	**<.001**	**0.003**	0.471	**<.001**	**<.001**
Mo	0.047	0.921	0.782	0.373	0.907	0.782	0.166	0.985	0.782
Ni	0.882	0.916	0.615	0.165	0.914	0.949	0.265	0.829	0.805
Nitrate	0.461	0.372	0.034	0.590	0.233	0.043	0.017	0.233	0.005
Pb	0.862	0.915	0.832	0.942	0.115	0.783	0.218	0.366	0.877
Ra	0.331	.	.	0.331	.	.	0.228	0.839	**<.001**
TSS	0.731	0.643	0.033	0.519	0.961	0.782	0.270	0.597	0.782
Zn	0.548	0.444	**<.001**	0.466	0.468	**<.001**	0.466	0.468	**<.001**
pH	0.355	0.582	0.656	0.512	0.938	0.678	0.870	0.959	0.277

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
Seasonal effects are not of interest.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no “before” data available).

Table Large Lake-4. Summary of BACI Comparison of Water Quality Parameters for Individual Project Large Lake Sites

	Large Project Lake					
	Doris North			Doris South		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
Al	0.0028	0.0193	0.887	-0.0165	0.0767	0.833
Alk	0.5412	3.6244	0.882	0.8911	6.7319	0.896
Ammonia	0.0002	0.0058	0.974	-0.0103	0.0120	0.404
As	-0.0003	0.0001	0.021	-0.0001	0.0002	0.484
CN	.	.	.	.	.	.
Cd	0.0000	0.0000	0.904	0.0000	0.0000	0.678
Cu	-0.0005	0.0006	0.458	-0.0005	0.0006	0.456
Fe	0.0337	0.0566	0.556	-0.0331	0.1478	0.826
Hardness	2.7788	3.3075	0.409	3.0995	3.1350	0.343
Hg	0.0000	0.0000	0.030	0.0000	0.0000	0.032
Mo	0.0000	0.0000	0.112	-0.0000	0.0001	0.968
Ni	-0.0000	0.0001	0.842	-0.0002	0.0003	0.584
Nitrate	-0.0043	0.0201	0.831	-0.0312	0.0172	0.090
Pb	-0.0003	0.0003	0.263	0.0002	0.0006	0.744
Ra	.	.	.	.	.	.
TSS	1.6903	2.2161	0.451	2.7484	2.0400	0.197
Zn	-0.0049	0.0193	0.803	-0.0244	0.0435	0.581
pH	0.1311	0.4918	0.792	-0.1657	0.2796	0.563

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Appendix B.2.3. Statistical Methodology and Results for Sediment Quality Evaluation of Effects, Doris North Project, 2011

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1. Analysis Methods

1.1 ASSUMPTIONS

There are several assumptions made for the analyses in this section. The key assumption is that the samples taken are a random sample of the site's sediment for that monitoring period.

Samples were typically collected only once per year (usually August). Consequently no information is available on month-to-month variation in sediment parameters, and inference will be limited to the sampled months.

For the marine environment, the sampling years before construction are quite different (2002 and 2009) for the two sites for which historical data are available (RBW and REF-Marine 1). Consequently, care must be taken in the interpretation of any comparisons between sites as the results may be artifacts of the specific years chosen.

1.2 DEALING WITH CENSORING (VALUES BELOW DETECTION LIMITS)

The proportion of data with readings below the detection limit varies by waterbody and by chemical parameter. The analyses below follow the advice of McBride (2005; Section 11.4.3).

- When the dataset includes a small number of below detection values, these values will be replaced by ½ of the detection limit for the analysis.
- When the majority of the dataset consists of values below the detection limit (e.g., more than about 70% below detection limit), there is very little that can be done as there is essentially no information (other than the values are below the detection limit). The analyses will be performed as above, but interpreting the results should be done carefully. Helsel (2005) has other suggestions for analysis (e.g., comparing the proportions below the detection limits) but these tests will require much larger sample sizes than available here.
- When there is an intermediate amount of censoring, a more complex analysis can be conducted that fully integrates the information from the censored values with the known values. This is most easily done using Bayesian methods using MCMC methods as likelihood methods would require integration of the likelihood for each censored value over and above dealing with the other random effects in the model. There is currently, no readily available software available for the latter.

Fortunately, most sediment quality parameters fall into one of the two first categories.

1.3 TRANSFORMATIONS

For most parameters, the values were fairly homogeneous and no obvious transformation was suggested, i.e., metals analyzed on the ppm scale (mg/kg).

1.4 COMPOSITIONAL DATA

The measurements of the particle size composition of the sediment (sand, gravel, etc.) are compositional with the values necessarily adding to 100%. Each component has been analyzed separately, but it is impossible to have changes in the percent composition of one component without changes in other components. Alternative methods dealing with compositional data are available

(Aitchison 1986), but have not been used in this report because they cannot easily deal with censoring and because the number of samples is limited.

1.5 OUTLINE OF ANALYSIS PLAN

There are several classes of statistical tests that can be done to assess evidence of change in the mean of the sediment quality parameter over time and to assess if changes in the means may reflect an impact of the Project.

1.5.1 Before vs. After Analysis

The first analysis conducted compares the mean readings for all years prior to 2010 (before initiation of construction) to the mean for 2011 (year 2 of construction). Each waterbody is treated independently, and each sediment quality parameter is treated separately.

The final statistical model (in standard shorthand notation) is:

Y = Period Year(period)-R

where *Y* is the (mean) parameter reading in a year; *Period* is the effect of before vs. after Project initiation (which is the effect of interest), and *Year(Period)* is a random year effect (applicable if more than one year was sampled during each period).

This model is preferable to simply treating all measurement within a period (e.g., over all baseline years) as having the same mean and assuming that they are completely independent of each other. This model also “averages” the sediment quality values collected over the baseline years in a way that weights each year equally rather than weighting by the sample size. For example, suppose that the sediment quality parameter measured in 2008 was 22 ppm, while the two readings measured in 2009 were 25 and 27 ppm. The simple mean (22+25+27)/3=24.7 ppm would be more heavily weighted toward the mean in the second year. In order to give each year’s data equal weight, the reading over both years is computed as an average of averages:

$$\frac{\frac{22}{1}+\frac{25+27}{2}}{2}=24.0\text{ ppm}$$

This can be extended to multiple years in a similar fashion. Note that in the case of balanced data, i.e. equal number of replicates in all years, the average-of-the-averages and simple-average will be identical. The model with a random year effect is still preferred in the case of balanced data because the readings within a year may be correlated due to year-specific random factors that cause all the readings within a year to increase or decrease in step.

This model was fit using Proc Mixed in SAS 9.2. In order to reduce the number of “false positives” because a large number of statistical tests are done, a reduced significance level (e.g. 0.01) should be used when reviewing the results.

The key disadvantage of this model is that changes over time may be unrelated to the effects of the Project, e.g., the mean sediment quality readings 2011 could be worse than expected because of long term climate change that is unrelated to the Project. Consequently, if a statistically significant effect is detected, it will require further investigation.

1.5.2 BACI Analysis

The standard method to assess an environmental impact is through a Before-After-Control-Impact (BACI) analysis (Smith 2002). The analysis of these designs looks for non-parallelism in response over time between the Project and reference waterbodies.

For the lake environments, no “before” sediment quality data was available for the reference lakes. Consequently, no BACI analysis can be performed for the lake environments.

For marine and stream environments, the formal statistical model (in standard shorthand notation) is:

*Y = Period Class Period*Class*

where *Y* is the sediment quality parameter reading; *Period* is the effect of period (before or after construction); *Class* is the effect of water body classification (Project or reference); and *Period*Class* is the BACI effect of interest, i.e., is the effect of *Period* the same (parallel) for both classes of waterbody. For the stream environments, a term *Body(Class)-R* (the random site effect within each class) would also be added to the model so that the change in the mean for each Project stream is compared to the average change in the mean for the reference bodies. Sites that were measured only in one period (e.g., Reference D OF measured only post-construction) contribute some information on the year-effect which improves precision of the BACI estimate. Only one year of baseline data are available for stream and marine sites; therefore, the model does not include a random year effect.

The key parameter of interest is the *Period*Class* effect as this measures the amount of non-parallelism between the changes in the mean (Before-After) over the two classes of waterbodies (Project or reference).

The BACI estimate is computed as the “difference in the differences”:

$$BACI = (\mu_{PA} - \mu_{PB}) - (\mu_{RA} - \mu_{RB})$$

where μ_{PA} is the mean parameter reading in the *Project* class of sites *after* Project initiation, μ_{PB} is the mean parameter reading in the *Project* class of sites *before* Project initiation, μ_{RA} is the mean parameter reading in the *reference* class of sites *after* Project initiation, and μ_{RB} is the mean parameter reading in the *reference* class of sites *before* Project initiation. The BACI contrast is estimated by replacing the population means above by the model-based estimates. Estimated differences close to 0 would indicate no evidence of non-parallelism.

Note that the hypothesis that the BACI contrast has the value of zero is identical to the hypothesis that the Period*Class interaction is zero with identical p-values. Consequently, only the results for the BACI contrast are reported in here.

This model was fit using Proc Mixed in SAS 9.2.

1.5.3 Multivariate Approaches

All of the approaches above analyze each sediment quality parameter independently of any other. However, the chemical constituents do not occur independently of each other, and presumably higher power would result if a multivariate approach were used. However, because of the censoring and missing data, no simple multivariate approach is possible and such an analysis would likely require the use of a full Bayesian MCMC approach. This has not been attempted in this report.

2. Results

2.1 STREAM DATA

A summary of the amount of censoring (values below the detection limit) for the stream data is found in Table Stream-1. High levels of censoring in all streams were found for Cd and the results of the analyses for this parameter will be non-informative. Preliminary plots of the data failed to show any outliers.

The results from the analysis that compared the means before and after Project construction are presented in Table Stream-2. Differences between before and after means were detected for Cd and % sand in Doris OF; and for % clay, % silt, Cd, Pb, Hg, and TOC in Little Roberts OF.

The results of the BACI comparison (Table Stream-3) failed to find evidence of a differential change in the mean of any parameter between Doris OF and reference streams over the before and after periods. For Little Roberts OF, differential changes were detected for % clay, Pb, Hg, and Zn. BACI and before-after comparisons could not be done for Roberts OF because sediment quality data was not collected pre-construction.

2.2 MARINE DATA

A summary of the amount of censoring (values below the detection limit) for the marine data is found in Table Marine-1. High levels of censoring in all sites were found for the Cd, Hg, and % gravel parameters and the results of the analyses for these parameters will be non-informative. Preliminary plots of the data showed no outliers.

The results from the analysis that compared the means before and after Project construction are presented in Table Marine-2. There was evidence of a difference in means across the periods for % clay, % sand, As, Cd (highly censored), Cr, Cu, and total organic carbon at RBW.

The results of the BACI comparison (Table Marine-3) found evidence of a differential change in the mean between Project and reference sites over the before and after periods for nearly all parameters (except % gravel). BACI and before-after comparisons could only be done for RBW because sediment quality data was not collected pre-construction and RBE.

2.3 LAKE DATA

A summary of the amount of censoring (values below the detection limit) for the lake data is found in Table Lake-1. High levels of censoring were found for the % gravel parameter and the results of the analyses for this parameter will be non-informative. Preliminary plots of the data showed no evidence of outliers.

There was evidence of a change between the before and after periods in the mean Cu and Pb in Doris Lake North; % gravel (highly censored) in Doris Lake South; and % clay, % gravel (highly censored), and % silt in Little Roberts Lake (Table Lake-2). Because no reference lakes were measured in the before period, no BACI comparisons are possible.

References

Aitchison, J. (1986). The Statistical Analysis of Compositional Data, Chapman & Hall.

Helsel, D.R. (2005). Nondetects and data analysis. Wiley:New York.

McBride, G.B. (2005). Using statistical methods for water quality management. Wiley: New York.

Smith, E. P. (2002). BACI Design. Encyclopedia of Environmetrics, Wiley: New York.

Table Stream-1. Summary of the Proportion of Measurements that were Below Detection Limit

	Stream Site					
	Doris OF	Little Roberts OF	Reference B OF	Reference D OF	Roberts OF	All Sites
Parameter	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored
% Clay (<4um)	0.33	0.00	0.50	0.00	0.00	0.21
% Gravel (>2mm)	0.00	0.33	0.00	0.00	0.67	0.17
% Sand (2.0mm - 0.063mm)	0.00	0.00	0.00	0.00	0.00	0.00
% Silt (0.063mm - 4um)	0.17	0.00	0.00	0.00	0.00	0.04
Arsenic (As)	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium (Cd)	1.00	1.00	0.83	1.00	0.00	0.83
Chromium (Cr)	0.00	0.00	0.00	0.00	0.00	0.00
Copper (Cu)	0.00	0.00	0.00	0.00	0.00	0.00
Lead (Pb)	0.33	0.00	0.33	0.00	0.00	0.17
Mercury (Hg)	0.83	0.50	0.83	1.00	0.33	0.71
Total Organic Carbon	0.17	0.17	0.00	0.00	0.00	0.08
Zinc (Zn)	0.00	0.00	0.00	0.00	0.00	0.00

Table Stream-2. Summary of Test for No Difference in Mean between Before and After Periods for Stream Sediment Quality Parameters

	Doris OF	Little Roberts OF	Reference B OF	Reference D OF	Roberts OF
Parameter	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F
% Clay (<4um)	0.404	**<.001**	0.238	.	.
% Gravel (>2mm)	0.015	0.014	0.377	.	.
% Sand (2.0mm - 0.063mm)	**0.004**	0.802	0.706	.	.
% Silt (0.063mm - 4um)	0.965	**<.001**	0.385	.	.
Arsenic (As)	0.889	0.110	0.170	.	.
Cadmium (Cd)	**<.001**	**<.001**	0.876	.	.
Chromium (Cr)	0.144	0.249	0.531	.	.
Copper (Cu)	0.775	0.015	0.561	.	.
Lead (Pb)	0.423	**0.003**	0.947	.	.
Mercury (Hg)	0.374	**0.004**	0.374	.	.
Total Organic Carbon	0.468	**<.001**	0.489	.	.
Zinc (Zn)	0.502	0.017	0.256	.	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Stream-3. Summary of BACI Comparison of Sediment Quality Parameters for Individual Project Stream Sites

Parameter	Stream Site					
	Doris OF			Little Roberts OF		
	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
% Clay (<4um)	-1.0650	2.7970	0.711	-11.222	1.7305	**<.001**
% Gravel (>2mm)	-32.667	16.1476	0.068	35.6333	17.0663	0.061
% Sand (2.0mm - 0.063mm)	25.5500	10.3014	0.031	-1.1833	13.2579	0.930
% Silt (0.063mm - 4um)	7.8850	8.0461	0.348	-23.362	7.9072	0.013
Arsenic (As)	-0.2012	0.5920	0.740	-1.1032	0.4223	0.024
Cadmium (Cd)	-0.0150	0.0268	0.586	-0.0150	0.0268	0.586
Chromium (Cr)	39.5033	17.0536	0.041	67.8367	38.6889	0.107
Copper (Cu)	0.1317	5.9799	0.983	-4.7183	3.4722	0.201
Lead (Pb)	-1.5000	1.4957	0.337	-2.7667	0.6590	**0.001**
Mercury (Hg)	-0.0029	0.0030	0.344	-0.0125	0.0031	**0.002**
Total Organic Carbon	-0.4800	0.9269	0.615	-2.0167	0.9259	0.052
Zinc (Zn)	3.5500	9.5221	0.716	-23.183	6.8826	**0.006**

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
A BACI analysis could not be performed for Roberts OF as no "before" data was available for this site.

Table Marine-1. Summary of the Proportion of Measurements that were Below Detection Limit

Parameter	Marine Site			All Sites
	RBE	RBW	REF-Marine 1	
	Proportion Censored	Proportion Censored	Proportion Censored	Proportion Censored
% Clay (<4um)	0.00	0.00	0.00	0.00
% Gravel (>2mm)	1.00	0.88	0.67	0.82
% Sand (2.0mm - 0.063mm)	0.00	0.00	0.00	0.00
% Silt (0.063mm - 4um)	0.00	0.00	0.00	0.00
Arsenic (As)	0.00	0.00	0.00	0.00
Cadmium (Cd)	1.00	1.00	0.50	0.82
Chromium (Cr)	0.00	0.00	0.00	0.00
Copper (Cu)	0.00	0.00	0.00	0.00
Lead (Pb)	0.00	0.00	0.50	0.18
Mercury (Hg)	1.00	0.88	0.50	0.76
Total Organic Carbon	0.67	0.63	0.00	0.41
Zinc (Zn)	0.00	0.00	0.00	0.00

Table Marine-2. Summary of Test for No Difference in Mean between Before and After Periods for Marine Sediment Quality Parameters

	Marine Site		
	RBE	RBW	REF-Marine 1
Parameter	Pr > F	Pr > F	Pr > F
% Clay (<4um)	.	**<.001**	**<.001**
% Gravel (>2mm)	.	0.482	0.065
% Sand (2.0mm - 0.063mm)	.	**0.002**	**<.001**
% Silt (0.063mm - 4um)	.	0.054	**<.001**
Arsenic (As)	.	**<.001**	**<.001**
Cadmium (Cd)	.	**<.001**	**<.001**
Chromium (Cr)	.	**0.003**	**<.001**
Copper (Cu)	.	**<.001**	**<.001**
Lead (Pb)	.	0.662	**<.001**
Mercury (Hg)	.	0.039	**0.005**
Total Organic Carbon	.	**<.001**	**0.002**
Zinc (Zn)	.	0.136	**<.001**

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Table Marine-3. Summary of BACI Comparison of Sediment Quality Parameters for Individual Project Marine Sites

	Marine Site					
	RBE			RBW		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
% Clay (<4um)	.	.	.	-31.540	1.5855	**<.001**
% Gravel (>2mm)	.	.	.	0.6267	0.8463	0.476
% Sand (2.0mm - 0.063mm)	.	.	.	80.5067	2.6027	**<.001**
% Silt (0.063mm - 4um)	.	.	.	-49.147	2.5784	**<.001**
Arsenic (As)	.	.	.	-3.1533	0.2715	**<.001**
Cadmium (Cd)	.	.	.	-0.1583	0.0060	**<.001**
Chromium (Cr)	.	.	.	-24.867	1.4596	**<.001**
Copper (Cu)	.	.	.	-6.9333	1.1652	**<.001**
Lead (Pb)	.	.	.	-4.2100	0.4052	**<.001**
Mercury (Hg)	.	.	.	-0.0152	0.0023	**<.001**
Total Organic Carbon	.	.	.	-1.6633	0.2098	**<.001**
Zinc (Zn)	.	.	.	-28.400	1.5796	**<.001**

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
A BACI analysis could not be performed for RBE as no "before" data was available for this site.

Table Lake-1. Summary of the Proportion of Measurements that were Below Detection Limit

	Lake Site					
	Doris North	Doris South	Little Roberts	Reference B	Reference D	All Sites
Parameter	Proportion censored	Proportion censored	Proportion censored	Proportion censored	Proportion censored	Proportion censored
% Clay (<4um)	0.00	0.00	0.00	0.00	0.00	0.00
% Gravel (>2mm)	0.83	1.00	1.00	1.00	1.00	0.96
% Sand (2.0mm - 0.063mm)	0.17	0.17	0.00	0.00	0.00	0.08
% Silt (0.063mm - 4um)	0.00	0.00	0.00	0.00	0.00	0.00
Arsenic (As)	0.00	0.00	0.00	0.00	0.00	0.00
Cadmium (Cd)	0.00	0.14	0.14	0.00	0.00	0.08
Chromium (Cr)	0.00	0.00	0.00	0.00	0.00	0.00
Copper (Cu)	0.00	0.00	0.00	0.00	0.00	0.00
Lead (Pb)	0.00	0.00	0.00	0.00	0.00	0.00
Mercury (Hg)	0.00	0.00	0.00	0.00	0.00	0.00
Total Organic Carbon	0.00	0.00	0.00	0.00	0.00	0.00
Zinc (Zn)	0.00	0.00	0.00	0.00	0.00	0.00

Table Lake-2. Summary of Test for No Difference in Mean between Before and After Periods for Lake Sediment Quality Parameters

	Lake Site				
	Doris North	Doris South	Little Roberts	Reference B	Reference D
Parameter	Pr > F	Pr > F	Pr > F	Pr > F	Pr > F
% Clay (<4um)	0.068	0.114	**<.001**	.	.
% Gravel (>2mm)	0.238	**<.001**	**<.001**	.	.
% Sand (2.0mm - 0.063mm)	0.809	0.285	0.046	.	.
% Silt (0.063mm - 4um)	0.093	0.099	**<.001**	.	.
Arsenic (As)	0.076	0.118	0.340	.	.
Cadmium (Cd)	0.012	0.869	0.932	.	.
Chromium (Cr)	0.756	0.728	0.768	.	.
Copper (Cu)	**<.001**	0.045	0.728	.	.
Lead (Pb)	**<.001**	0.311	0.099	.	.
Mercury (Hg)	0.012	0.969	0.814	.	.
Total Organic Carbon	0.647	0.743	0.569	.	.
Zinc (Zn)	**0.006**	0.671	0.898	.	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In some cases, no analysis can be done because of the high degree of censoring, the lack of variation in a parameter over time, or data are only available from one period (i.e., no "before" data available).

Appendix B.2.4. Statistical Methodology and Results for Phytoplankton and Periphyton Evaluation of Effects, Doris North Project, 2011

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1. Analysis Methods

1.1 ASSUMPTIONS

The key assumption of this analysis is that the samples collected are representative of each site's periphyton or phytoplankton biomass (estimated from chlorophyll *a* levels) for that monitoring period.

1.2 REPLICATE SAMPLES

Replicate samples collected on the same date were averaged prior to analysis. For some historical data, only the mean value was available.

1.3 DEALING WITH CENSORING (VALUES BELOW DETECTION LIMITS)

Some phytoplankton chlorophyll *a* concentrations in the marine environment were below analytical detection limits. The analyses below follow the advice of McBride (2005; Section 11.4.3).

- When the dataset includes a small number of below detection values, these values will be replaced by ½ of the detection limit for the analysis.
- When the majority of the dataset consists of values below the detection limit (e.g., more than about 70% below detection limit), there is very little that can be done as there is essentially no information (other than the values are below the detection limit). The analyses will be performed as above, but interpreting the results should be done carefully. Helsel (2005) has other suggestions for analysis (e.g., comparing the proportions below the detection limits) but these tests will require much larger sample sizes than available here.
- When there is an intermediate amount of censoring, a more complex analysis can be conducted that fully integrates the information from the censored values with the known values. This is most easily done using Bayesian methods using MCMC methods as likelihood methods would require integration of the likelihood for each censored value over and above dealing with the other random effects in the model. There is currently, no readily available software available for the latter.

Fortunately, the marine phytoplankton biomass dataset falls into the first category (few censored values), and the lake and stream datasets did not contain censored values.

1.4 TRANSFORMATIONS

A preliminary analysis found that the variance of the periphyton and phytoplankton biomass values tended to increase with the mean and that the distribution of values was skewed. This suggested that a logarithmic transformation was appropriate.

1.5 OUTLINE OF ANALYSIS PLAN

There are several classes of statistical tests that can be done to assess evidence of change in the mean periphyton or phytoplankton biomass over time and to assess if changes in the means may reflect an impact of the Project.

1.5.1 Before vs. After Analysis

The first analysis conducted compares the mean readings for all years prior to 2010 (before initiation of construction) to the mean for 2011 (year 2 of construction). Each waterbody is treated independently.

The final statistical model (in standard shorthand notation) is:

Y = Period Season Year(period)-R

where *Y* is the biomass reading of periphyton or phytoplankton in a year; *Period* is the effect of before vs. after Project initiation (which is the effect of interest); *Season* is the effect of season (4 seasons in the sampling year: 1) April or May (under ice), 2) July, 3) August, 4) September); and *Year(Period)* is a random year effect (applicable if more than one year was sampled during each period).

This model is preferable to simply treating all measurement within a period (e.g., over the baseline years) as having the same mean and assuming that they are completely independent of each other. This model also “averages” the phytoplankton values collected over the baseline years in way that weights each year equally rather than weighting by the sample size. For example, suppose that the phytoplankton biomass measured in 2008 was 22 µg chl a/L, while the two readings measured in 2009 were 25 and 27 µg chl a/L. The simple mean (22+25+27)/3=24.7 would be more heavily weighted toward the mean in the second year. In order to give each year’s data equal weight, the reading over both years is computed as an average of averages:

$$\frac{\frac{22}{1}+\frac{25+27}{2}}{2}=24.0$$

This can be extended to multiple years in a similar fashion. Note that in the case of balanced data, i.e., equal number of replicates in all years, the average-of-the-averages and simple-average will be identical. The model with a random year effect is still preferred in the case of balanced data because the readings within a year may be correlated due to year-specific random factors that cause all the readings within a year to increase or decrease in step.

This model was fit using Proc Mixed in SAS 9.2. In order to reduce the number of “false positives” because a large number of statistical tests are done, a reduced significance level (e.g., 0.01) should be used when reviewing the results.

The key disadvantage of this model is that changes over time may be unrelated to the effects of the Project, e.g., the average periphyton or phytoplankton biomass readings in 2011 could be higher or lower than expected because of long term climate change that is unrelated to the Project. Consequently, if a statistically significant effect is detected, it will require further investigation.

1.5.2 BACI Analysis

The standard method to assess an environmental impact is through a Before-After-Control-Impact (BACI) analysis (Smith 2002). The analysis of these designs looks for non-parallelism in response over time between the Project and reference waterbodies. A BACI analysis was performed for each Project waterbody versus the corresponding reference waterbody.

The formal statistical model (in standard shorthand notation) is:

*Y = Period Season Class Period*Class Year(Period)-R*

where *Y* is the parameter of interest; *Period* is the effect of period (before or after construction); *Season* is the effect of season (4 seasons in the sampling year: 1) April or May (under ice), 2) July, 3) August, 4) September); *Class* is the effect of waterbody classification (Project or reference); *Period*Class* is the BACI effect of interest (i.e., is the effect of *Period* the same (parallel) for both classes of sites); and *Year(Period)* is the random year effect within each period (applicable if more than one year was sampled during each period). Not all sites were measured in all years and only those Project-reference pairs of sites that were measured both in the before and after period can be used to estimate this BACI contrast. The results from this comparison are specific to the particular Project-reference sites. If there were multiple reference waterbodies (as is the case for streams), a term *Body(Class)-R* (the random site effect within each class) would also be added to the model so that the change in the mean for the Project site is compared to the average change in the mean for the reference bodies. Sites that were measured only in one period (e.g., Reference D OF measured only post-construction) contribute some information on the year-effect which improves precision of the BACI estimate.

The key parameter of interest is the *Period*Class* effect as this measures the amount of non-parallelism between the changes in the mean (Before-After) over the two classes of sites (Project or reference). The BACI estimate is computed as the “difference in the differences”:

$$BACI = (\mu_{PA} - \mu_{PB}) - (\mu_{RA} - \mu_{RB})$$

where μ_{PA} is the mean parameter reading in the *Project* class of sites *after* Project initiation, μ_{PB} is the mean parameter reading in the *Project* class of sites *before* Project initiation, μ_{RA} is the mean parameter reading in the *reference* class of sites *after* Project initiation, and μ_{RB} is the mean parameter reading in the *reference* class of sites *before* Project initiation. The BACI contrast is estimated by replacing the population means above by the model-based estimates. Estimated differences close to 0 would indicate no evidence of non-parallelism.

Note that the hypothesis that the BACI contrast has the value of zero is identical to the hypothesis that the *Period*Class* interaction is zero with identical p-values. Consequently, only the results for the BACI contrast are reported here.

This model was fit using Proc Mixed in SAS 9.2.

For all environments, caution should be used in interpreting the results from the BACI analysis because there was only one reading for phytoplankton or periphyton biomass in one reference site before Project initiation.

2. Results

2.1 STREAM DATA

There was no censoring of the stream periphyton biomass values. Preliminary plots of the data showed one outlier from 1997 which was removed (Table Stream-1).

The results from the analysis that compared the means before and after Project construction are presented in Table Stream-2. Because of the scarcity of baseline data available for Little Roberts OF (too few degrees of freedom to fit the model) and the absence of baseline data for Roberts OF, before-after comparisons were not possible for these streams. There was no evidence of a change in the mean *log(periphyton)* for Doris OF.

The BACI comparison failed to detect evidence of a differential change in before-after trends for either Little Roberts OF or Doris OF compared to the reference streams (Table Stream-3). A BACI analysis could not be conducted for Roberts OF because there was no baseline periphyton data available.

2.2 MARINE DATA

A few marine phytoplankton biomass values were censored (Table Marine-1). No outliers were detected. Because of the scarcity of baseline data available for all marine sites, before-after comparisons could not be conducted (too few degrees of freedom to fit the model).

BACI comparisons for both RBE and RBW sites failed to detect evidence of a differential change compared to the reference site (Table Marine-2).

2.3 LAKE DATA

The lake data was divided into small lakes (Little Roberts and Reference D) and large lakes (Doris South, Doris North, and Reference B). No censoring was observed for the lake phytoplankton data. Preliminary plots of the data did not show any evidence of outliers.

There was no evidence of a change in the mean *log(phytoplankton)* in any lake between the before and after period (Tables Large Lake-1 and Small Lake-1). There was also no evidence of a differential change in the mean *log(phytoplankton)* levels between before/after periods in the large Project lakes compared to Reference Lake B (Table Lake-Large-2). Because phytoplankton biomass levels in Reference Lake D were not measured pre-construction, no BACI comparison is possible for small lakes.

References

Helsel, D.R. (2005). Nondetects and data analysis. Wiley:New York.

McBride, G.B. (2005). Using statistical methods for water quality management. Wiley: New York.

Smith, E. P. (2002). BACI Design. Encyclopedia of Environmetrics, Wiley: New York.

Table Stream-1. Outlier Periphyton Biomass Values

Site	Parameter	Year	Date	Rep	Value	Censored (1=yes 0=no)
Doris OF	Periphyton	1997	19-Jul-1997	1	194.4	0
Doris OF	logPeriphyton	1997	19-Jul-1997	1	5.27	0

Table Steam-2. Summary of Test for No Difference in Mean between Before and After Periods for Stream Periphyton Biomass

Parameter	Proportion Censored	Doris OF Pr > F	Little Roberts OF Pr > F	Reference B OF Pr > F	Reference D OF Pr > F	Roberts OF Pr > F
logPeriphyton	0.00	0.354	.	0.216	.	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In Roberts OF and Reference D OF streams, no readings were taken pre-construction, so no before-after comparison is possible.

Table Stream-3. Summary of BACI Comparison of Stream Periphyton Biomass for Individual Project Sites

	Doris OF			Little Roberts OF		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
logPeriphyton	2.6930	1.3343	0.053	-1.0393	1.3919	0.462

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
In Roberts OF stream, no readings were taken pre-construction, so no BACI comparison is possible.

Table Marine-1. Summary of the Amount of Censoring in the Marine Sites

	Marine Site			
	RBE Proportion Censored	RBW Proportion Censored	REF-Marine 1 Proportion Censored	All Sites Proportion Censored
logPhytoplankton	0.20	0.20	0.00	0.13

Table Marine-2. Summary of BACI Comparison of Marine Phytoplankton Biomass for Individual Project Sites

	Marine Site					
	RBE			RBW		
Parameter	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
logPhytoplankton	2.3270	1.5856	0.239	2.1550	0.9972	0.119

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.

Table Large Lake-1. Summary of Test for No Difference in Mean between Before and After Periods for Large Lake Phytoplankton Biomass

Parameter	Proportion Censored	Large Lake Site		
		Doris North	Doris South	Reference B
		Pr > F	Pr > F	Pr > F
logPhytoplankton	0.00	0.687	0.547	0.965

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.

Table Large Lake-2. Summary of BACI Comparison of Large Lake Phytoplankton Biomass for Individual Project Sites

Parameter	Large Lake Site					
	Doris North			Doris South		
	BACI est	BACI SE	p-value	BACI est	BACI SE	p-value
logPhytoplankton	-0.4462	1.0921	0.704	0.0428	0.3594	0.911

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.

Table Small Lake-1. Summary of Test for No Difference in Mean between Before and After Periods for Small Lake Phytoplankton Biomass

Parameter	Proportion Censored	Period	
		Little Roberts	Reference D
		Pr > F	Pr > F
logPhytoplankton	0.00	0.888	.

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
No pre-construction readings

Appendix B.2.5. Statistical Methodology and Results for Benthos Evaluation of Effects, Doris North Project, 2011

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1. Analysis Methods

1.1 ASSUMPTIONS

The key assumption of this analysis is that the samples collected are representative samples of the site and year of sampling. Since all samples were taken at the same time of year (August), inference is restricted to comparisons during this period.

1.2 TRANSFORMATIONS

A preliminary analysis found that the variance of several parameter values tended to increase with the mean in some waterbodies, but there was no consistent pattern. Given that only two years of data are available, the evidence for a transformation is weak and so no transformation was done.

1.3 OUTLINE OF ANALYSIS PLAN

1.3.1 Impact Level-by-time Analysis

The benthos data has only been collected since 2010 (post-construction); there is no information available pre-construction. Consequently, before/after or BACI comparisons cannot be done.

In cases where no pre-project data are available, Wiens and Parker (1995) suggest several alternatives, especially for long-term monitoring. One of their suggestions is the level-by-time comparisons where the trend-lines for project and reference waterbodies are compared to see if there is evidence of non-parallelism over time.

The final statistical model (in standard shorthand notation) is:

*Y = Class Year Class*Year*

where *Y* is the reading for the benthic parameter; *Class* is the effect of waterbody classification (Project or reference); *Year* is the effect of year; and *Class*Year* is the non-parallelism in the response over time. For marine and lake sites, there is a single site in each class and separate comparisons are made for each site against its corresponding reference site. For streams, multiple reference waterbodies are available for comparison against a single Project waterbody; therefore, the term *Body(Class)-R* (the random site effect within each class) is added for the multiple sites within the classification.

The Class*Year term is the effect of interest representing non-parallel changes over time between the sites.

This model is fit using Proc Mixed in SAS 9.2. In order to reduce the number of "false positives" because a large number of statistical tests are done, a reduced significance level (e.g., 0.01) should be used when reviewing the results.

1.3.2 Multivariate Approaches

The approach outlined above analyzes each benthic parameter independently. However, the parameters are likely not independently of each other, and presumably higher power would result if a multivariate approach were used. Because only two years of data are available, this has not been attempted in this report.

2. Results

2.1 STREAM DATA

The results from the analysis that tests for parallelism in the mean parameter value over time is presented in Table Stream-1. There was evidence of non-parallel response for density in Little Roberts OF and Simpson's Evenness Index in Doris OF.

2.2 MARINE DATA

The marine data was analyzed in two ways: 1) with data for adults and juveniles pooled together and 2) with data for adults only. Results for the tests for parallelism are presented in Tables Marine-1 and Marine-2, respectively.

For the pooled adult and juvenile data, non-parallelism was detected in the Bray-Curtis Index in RBE, density in RBW, and richness in both RBE and RBW.

For the adult-only data, non-parallelism was detected in the Bray-Curtis Index in RBE, density in both RBE and RBW, Simpson's Evenness Index in RBW, and richness in both RBE and RBW.

2.3 LAKE DATA

The lakes data was divided into large lakes (Doris Lake South, Doris Lake North, and Reference Lake B) and small lakes (Little Roberts Lake and Reference Lake D). Results of the tests for parallelism are presented in Tables Large Lake-1 and Small Lake-1.

There was evidence of non-parallelism in the Bray-Curtis Index and Simpson's Diversity Index in Doris Lake North. 2010 data for Doris Lake South were not included in the analysis because of a change in sampling location between 2010 and 2011; therefore, nothing can be said about parallelism over time for this lake site. No evidence of non-parallelism was found for any benthos parameter in Little Roberts Lake (small lake).

References

Wiens, J. A., and K. R. Parker. 1995. Analyzing the effects of accidental environmental impacts: approaches and assumptions. Ecological Applications 5(4), 1069-1083.

Table Stream-1. Summary of Tests for Parallelism for the Stream Benthos Data

	Effect								
	Class Stream Site			Class*Year Stream Site			Year Stream Site		
	Doris OF	Little Roberts OF	Roberts OF	Doris OF	Little Roberts OF	Roberts OF	Doris OF	Little Roberts OF	Roberts OF
Parameter	**p-value**	**p-value**	**p-value**	**p-value**	**p-value**	**p-value**	**p-value**	**p-value**	**p-value**
Bray-Curtis	0.196	0.470	0.275	0.951	0.454	0.466	0.519	0.218	0.200
Density	**<.001**	0.079	**<.001**	0.425	**0.009**	0.566	**0.003**	**<.001**	**0.009**
Diversity	**<.001**	0.583	0.868	0.024	0.757	0.362	0.126	**<.001**	0.027
Evenness	**<.001**	0.455	0.327	**<.001**	0.522	0.349	0.117	**<.001**	0.047
Richness	0.089	0.016	0.022	0.211	0.634	0.880	0.008	0.272	0.181

Notes: To *reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.*

Table Marine-1. Summary of Tests for Parallelism for the Marine Benthos Data (Adults and Juveniles Pooled)

	Effect					
	Class Marine Site		Class*Year Marine Site		Year Marine Site	
	RBE	RBW	RBE	RBW	RBE	RBW
Parameter	**p-value**	**p-value**	**p-value**	**p-value**	**p-value**	**p-value**
Bray-Curtis	**<.001**	**<.001**	**0.002**	0.489	0.725	**<.001**
Density	**<.001**	**<.001**	0.561	**<.001**	0.907	**<.001**
Diversity	0.013	0.032	0.855	0.200	**<.001**	**<.001**
Evenness	**<.001**	**<.001**	0.541	0.112	0.522	0.129
Richness	**<.001**	**0.002**	**0.004**	**0.002**	**<.001**	**<.001**

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.

Table Marine-2. Summary of Tests for Parallelism for the Marine Benthos Data (Adults Only)

	Effect					
	Class Marine Site		Class*Year Marine Site		Year Marine Site	
Parameter	RBE p-value	RBW p-value	RBE p-value	RBW p-value	RBE p-value	RBW p-value
Bray-Curtis	**<.001**	**<.001**	**0.001**	0.819	0.819	**<.001**
Density	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**	**0.001**
Diversity	**0.008**	**<.001**	0.204	0.249	**<.001**	**<.001**
Evenness	**<.001**	**<.001**	0.798	**<.001**	**0.001**	0.011
Richness	**<.001**	**<.001**	**0.002**	**<.001**	**<.001**	**<.001**

Table Large Lake-1. Summary of Tests for Parallelism for the Large Lake Benthos Data

	Effect					
	Class Large Lake Site		Class*Year Large Lake Site		Year Large Lake Site	
Parameter	Doris North p-value	Doris South p-value	Doris North p-value	Doris South p-value	Doris North p-value	Doris South p-value
Bray-Curtis	**<.001**	**<.001**	**<.001**	.	**<.001**	0.040
Density	0.893	0.058	0.046	.	0.817	0.232
Diversity	**<.001**	**0.007**	**0.003**	.	0.011	0.771
Evenness	**<.001**	0.247	0.907	.	0.451	0.749
Richness	0.011	0.073	0.085	.	0.085	1.000

Notes: To reduce the number of false positives, a smaller alpha level (0.01) was used to screen for effects and p-values less than 0.01 are bolded.
2010 data for Doris South was not used because of a change in sampling location between 2010 and 2011; consequently, no test for parallelism is possible.

Table Lake-Small-1. Summary of Tests for Parallelism for the Small Lake Benthos Data

	Effect		
	Class Small Lake Site	Class*Year Small Lake Site	Year Small Lake Site
Parameter	Little Roberts p-value	Little Roberts p-value	Little Roberts p-value
Bray-Curtis	**<.001**	0.917	0.312
Density	0.202	0.733	0.249
Diversity	**<.001**	0.830	0.107
Evenness	**0.003**	0.329	0.078
Richness	0.014	0.587	0.587