Appendix V5-3U

Hope Bay Project:
2017 Madrid-Boston Freshwater Baseline Report

TMAC RESOURCES






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HOPE BAY PROJECT

2017 Madrid-Boston Aquatic Baseline Report

December 2017

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TMAC Resources Inc.

HOPE BAY PROJECT
2017 Madrid-Boston Aquatic Baseline Report

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EXECUTIVE SUMMARY

Freshwater baseline studies were conducted during both the under-ice and open-water seasons of 2017 to supplement existing baseline data in support of the Madrid-Boston Final Environmental Impact Statement (EIS) and future Aquatic Effects Monitoring Program (AEMP) for the Madrid-Boston development area. The 2017 program focused on lakes having the most potential to be affected by future Madrid-Boston project activities, with a total of six sites sampled across five study lakes, including two sites in Aimaokatalok Lake. Open-water season physical limnology profiles were collected at four additional sites in Aimaokatalok Lake. This report presents the findings of the 2017 study, including a comparison to historically collected water and sediment quality data. A brief summary of the findings of the baseline program is provided below.

Under-ice water column structure was typical of ice-covered lakes with the coldest water lying just below the ice and temperatures warming with depth. During the open-water season all lakes except Aimaokatalok Lake were well-mixed. Weak thermal stratification was observed at all six sites sampled in Aimaokatalok Lake. Both under-ice and open-water dissolved oxygen (DO) concentrations were higher than the CCME oxygen guidelines throughout the water column in deeper lakes (Patch, Windy and Aimaokatalok), with the exception of at Aimaokatalok Station 6 where under-ice DO concentrations were lower than the minimum CCME oxygen guideline of 6.5 mg/L at depth. DO concentrations were far below the minimum guideline (<2 mg/L) in the shallow Wolverine and Stickleback lakes during the under-ice season, but higher than both CCME guidelines during open-water. Open-water season euphotic zone depths ranged from 2.3 to 11.8 m and extended throughout the water column in Stickleback Lake and at the Aimaokatalok Outfall site.

Water quality varied among lakes in 2017. Wolverine, Patch, Windy, and Stickleback lakes had higher pH, were less sensitive to acid inputs (i.e., higher alkalinity), and contained harder water with higher conductivity and concentrations of TSS, chloride, and fluoride compared to Aimaokatalok Lake. These parameters, as well as most nutrients and metals, tended to be higher during the ice-covered season than the open-water season. The largest seasonal differences were generally observed in the shallow lakes. Total suspended solids concentrations and turbidity were low in 2017, reflecting the relatively high water clarity observed through euphotic zone estimates from Secchi depth measurements. Concentrations of nutrients and most metals were also generally low. Trophic categorizations based on total phosphorus concentrations ranged from ultra-oligotrophic to mesotrophic with shallow sites tending to have higher concentrations of total phosphorus. The 2017 means for most water quality parameters were lower than CCME guidelines; exceptions included chloride and iron in Wolverine and Stickleback lakes during the under-ice season.

Sediments at all sites in 2017 were relatively fine, consisting mainly of silt and clay. Mean concentrations of sediment cadmium, copper, lead, mercury, and zinc were similar among sites in 2017 likely reflecting their similarities in particle size. Arsenic and chromium were more variable across sites and differences did not reflect patterns in particle size. The 2017 means for most sediment quality parameters were lower than CCME guidelines. However, sediments had sediment parameter with concentrations greater than the PEL in 2017 was arsenic (Windy Lake). Wolverine and Windy lake sediments exceeded the most guidelines.

Low to moderate primary producer biomass was observed at all lakes during both seasons, with the exception of under-ice in Stickleback Lake where high primary producer biomass was observed.

Shallow sites tended to have higher benthic invertebrate densities than deep sites. Benthic communities were dominated by dipterans (true flies), except at Wolverine Lake where oligochaetes (segmented worms) were dominant, and at Aimaokatalok Station 6 where dipterans and pelecypods (bivalves) were co-dominant. Mean whole community genera richness ranged from three to 12 genera/sample and mean dipteran genera richness accounted for 50% or more of total genera richness at any given site. Mean whole community and dipteran Simpson's diversity were variable across lakes (mean ranges = 0.45 to 0.80 and 0.17 to 0.69, respectively) and there were no apparent correlations between diversity and density, watersheds, or site depths.

ACKNOWLEDGEMENTS

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Field-related logistics support was provided by TMAC, Acasta HeliFlight, Braden Burry Expediting, and Nuna Logistics.

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2017 Madrid-Boston Aquatic Baseline Report

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ACRONYMS 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.

AEMP	Aquatic Effects Monitoring Program
ALS	ALS Environmental Services
BC	British Columbia
Benthos	Benthic invertebrates
CCME	Canadian Council of Ministers of the Environment
Chl *a*	Chlorophyll *a*
COC	Chain of custody
CTD	Conductivity, temperature, depth
DDI	Double de-ionized
DO	Dissolved oxygen
Ds	Secchi depth
EEM	Environmental Effects Monitoring
EIS	Environmental Impact Statement
EZD	Euphotic zone depth
IQR	Interquartile range
ISQG	Interim sediment quality guideline
NIRB	Nunavut Impact Review Board
NT	Northwest Territories
NTU	Nephelometric turbidity unit
PEL	Probable effects level
QA/QC	Quality assurance and quality control
TDS	Total dissolved solids
TMAC	TMAC Resources Ltd.

TOC	Total organic carbon
TSS	Total suspended solids
the Project	the Madrid-Boston Project

1. INTRODUCTION

The Madrid-Boston Project (the Project) is a part of the Hope Bay Project property owned by TMAC Resources Ltd. (TMAC), and is approximately 153 km southwest of Cambridge Bay, Nunavut, on the southern shore of Melville Sound in the West Kitikmeot region of Nunavut. The Hope Bay property comprises several existing and approved projects and is contained within a greenstone belt running 80 km in a north-south direction that varies in width between 7 km and 20 km (Figure 1-1). The Project consists of proposed mine operations at the Madrid North, Madrid South, and Boston deposits within the property, and is part of a staged approach to continuous development along the belt.

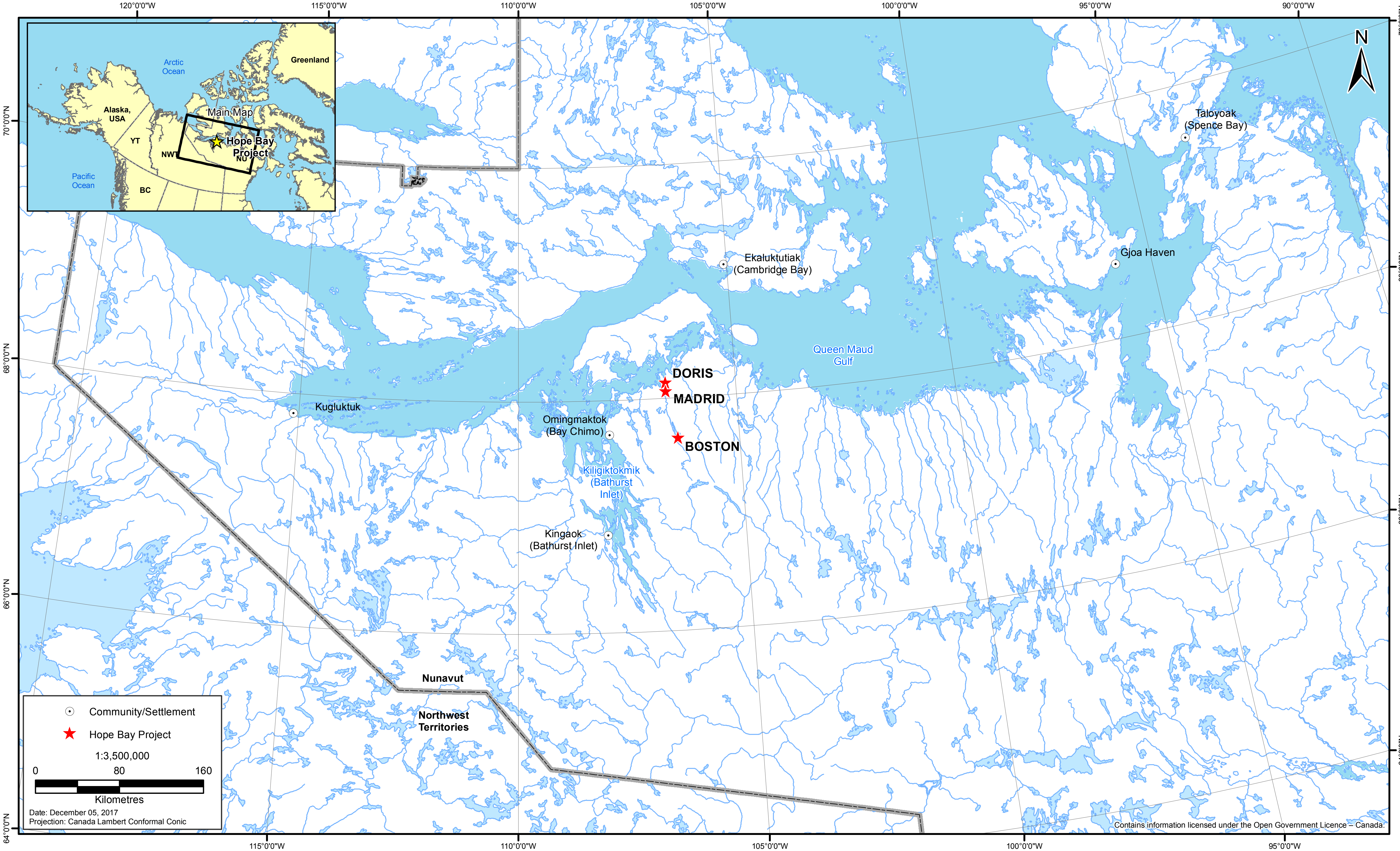
TMAC submitted the *Phase 2 Draft Environmental Impact Statement* (EIS) for the Project to the Nunavut Impact Review Board (NIRB) in December 2016 (TMAC 2016) as a first step to obtain the necessary licences and certificates to operate. Information requests and technical comments that followed this submission identified requirements for additional baseline freshwater data to support TMAC's *Madrid-Boston Final Environmental Impact Statement* (TMAC 2017). This report presents the baseline information collected under ice (April) and in open water (August) in five lakes that are proximate to proposed Project activities. This baseline information was used to support the freshwater assessments and predictive surface water quality modeling (SRK 2017) within the *Madrid-Boston Final Environmental Impact Statement* (TMAC 2017), and will be used to assess potential future Project effects under the Madrid-Boston Project: Aquatic Effects Monitoring Program (AEMP).

The specific objectives of this *Hope Bay Project: 2017 Madrid-Boston Aquatic Baseline Report* were to sample the following freshwater components in Wolverine, Patch, Windy, Stickleback, and Aimaokatalok lakes during the under-ice and open-water seasons:

- Physical profiles (temperature and dissolved oxygen);
- Water quality;
- Sediment quality (open-water-only);
- Primary producer biomass (phytoplankton); and
- Benthic invertebrates (open-water-only).

Chapter 2 of this report presents the sampling locations and methods used for the 2017 freshwater baseline work. Chapter 3 presents the results, including comparisons with historical water and sediment quality data. Chapter 4 summarizes the results of the baseline study and all data collected during the 2017 surveys are included in appendices that follow the report.

Figure 1-1
Hope Bay Project Location



2. METHODOLOGY

2.1 STUDY DESIGN

The 2017 program was focused on lakes having the most potential to be affected by future Madrid-Boston project activities. The program included sampling in Windy, Wolverine, and Patch lakes, which are proximate to the proposed Madrid North and Madrid South mines, and Stickleback and Aimaokatalok lakes which are in the Boston development area (Figure 2.1-1).

Physical limnology, water quality, sediment quality, primary producer, and benthic invertebrate data were collected from the deepest area within each of the five study lakes, as well as near the proposed discharge outfall into Aimaokatalok Lake (Figure 2.1-1). Physical limnology, water quality, and primary producer biomass sampling were conducted during both the under-ice (April) and open-water seasons (August), while sediment quality and benthic invertebrate sampling were conducted during the open-water season in August. Open-water season physical limnology profiles were collected from four additional sites (2017-1, 2017-2, 2017-3, and 2017-4) along the western section of Aimaokatalok Lake (Table 2.1-1; Figure 2.1-1).

Table 2.1-1. Sampling Locations, Madrid-Boston Aquatic Baseline, 2017

Sampling Location	Site	Physical Limnology	Water Quality	Sediment Quality	Primary Producers	Benthic Invertebrates
Doris Watershed						
Wolverine Lake	Wolverine	X	X	X	X	X
Patch Lake	Patch	X	X	X	X	X
Windy Watershed						
Windy Lake	Windy	X	X	X	X	X
Aimaokatalok Watershed						
Stickleback Lake	Stickleback	X	X	X	X	X
Aimaokatalok Lake	Outfall	X	X	X	X	X
	Station 6	X	X	X	X	X
	2017-1	X	-	-	-	-
	2017-2	X	-	-	-	-
	2017-3	X	-	-	-	-
	2017-4	X	-	-	-	-

Table 2.1-1 presents the aquatic sampling conducted at each lake and site in 2017. Table 2.1-2 provides a general overview of the sampling and methods, including: the measured parameters, the sampling replication and depths, the sampling frequency and timing, and the sampling devices used. Figure 2.1-1 presents an overview of the 2017 study area and sampling locations along with the major drainage basins and permitted and proposed infrastructure. Lake maps depicting bathymetry and 2017 sampling locations are presented in Figures 2.1-2 to 2.1-6. Methodological details of the sampling program are provided in Sections 2.2 to 2.6.

Table 2.1-2. Sampling Program Summary, Madrid-Boston Aquatic Baseline, 2017

Sampling Component	Sample Replication and Depths	Sampling Frequency and Timing	Sampling Device
Physical Limnology			
Physical profile (temperature, dissolved oxygen)	1 profile/site	2× (April, August)	Multi-parameter probe with optical dissolved oxygen sensor
Secchi depth	1/site	1× (August)	Secchi disk
Water Quality			
Physical parameters, anions, nutrients, cyanide, organic carbon, total metals	Deep sites[1]: 2 depths/site @ 1 m (surface) and 1-2 m above sediment (bottom) 10% replication Shallow sites[1]: 1 depth/site @ 1 m (surface) 10% replication	2× (April, August)	Niskin (April) GO-FLO (August)
Sediment Quality			
Particle size composition, organic carbon, metals	3 samples/site	1× (August)	Ekman, plastic bowl and spoon
Primary Producers			
Biomass (as chl *a*)	3 samples/site @ 1 m	1× (August)	GO-FLO, 0.45 µm filter
Benthic Invertebrates			
Density and taxonomy	5 sample/site; composite sample consisting of 3 pooled subsamples	1× (August)	Ekman; 500 µm sieve

Note:
[1] Deep sites for water quality where maximum depth was greater than 5 m, shallow sites were less than 5 m deep.

2.2 Physical Limnology

2.2.1 Sampling Methodology

2.2.1.1 Under-ice Season

Vertical profiles of dissolved oxygen (DO) and temperature were collected during the under-ice season in April 2017. To conduct the under-ice profiling, a hole was first drilled through the ice with an auger fitted with a 25-cm diameter bit. Once the hole was drilled, a depth sounder attached to a pole was lowered into the hole and hooked onto the under-side of the ice to measure ice thickness and test water depth. Temperature and DO profiles were collected throughout the water column using a YSI EXO multiparameter probe equipped with an optical DO sensor. Profiles were collected from the ice-water interface to approximately 0.5 to 1 m above the sediment surface to minimize disturbance of bottom sediments.

Figure 2.1-1
Madrid-Boston Baseline Sampling Locations, 2017

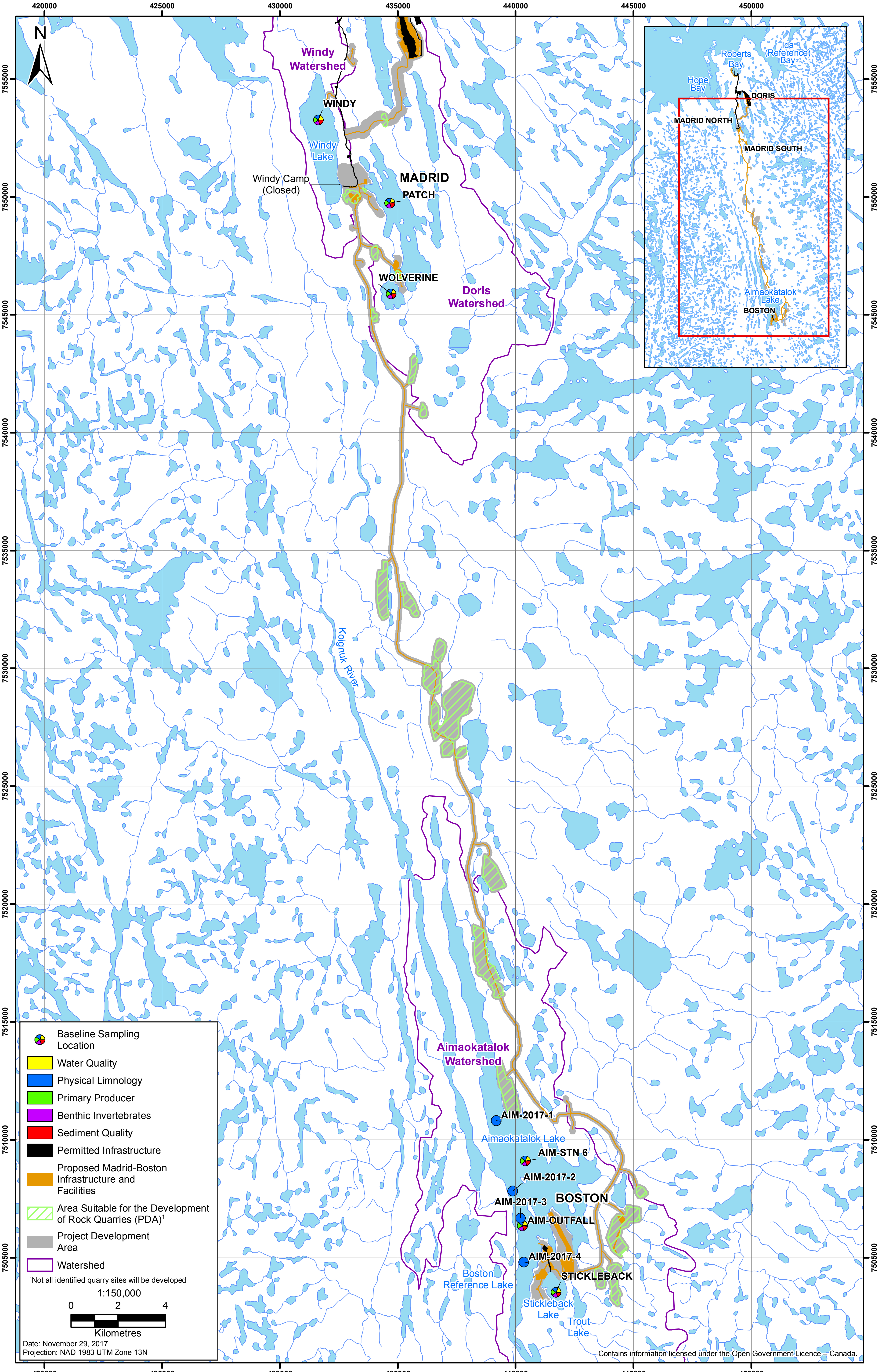


Figure 2.1-2
Sampling Location in Wolverine Lake, 2017

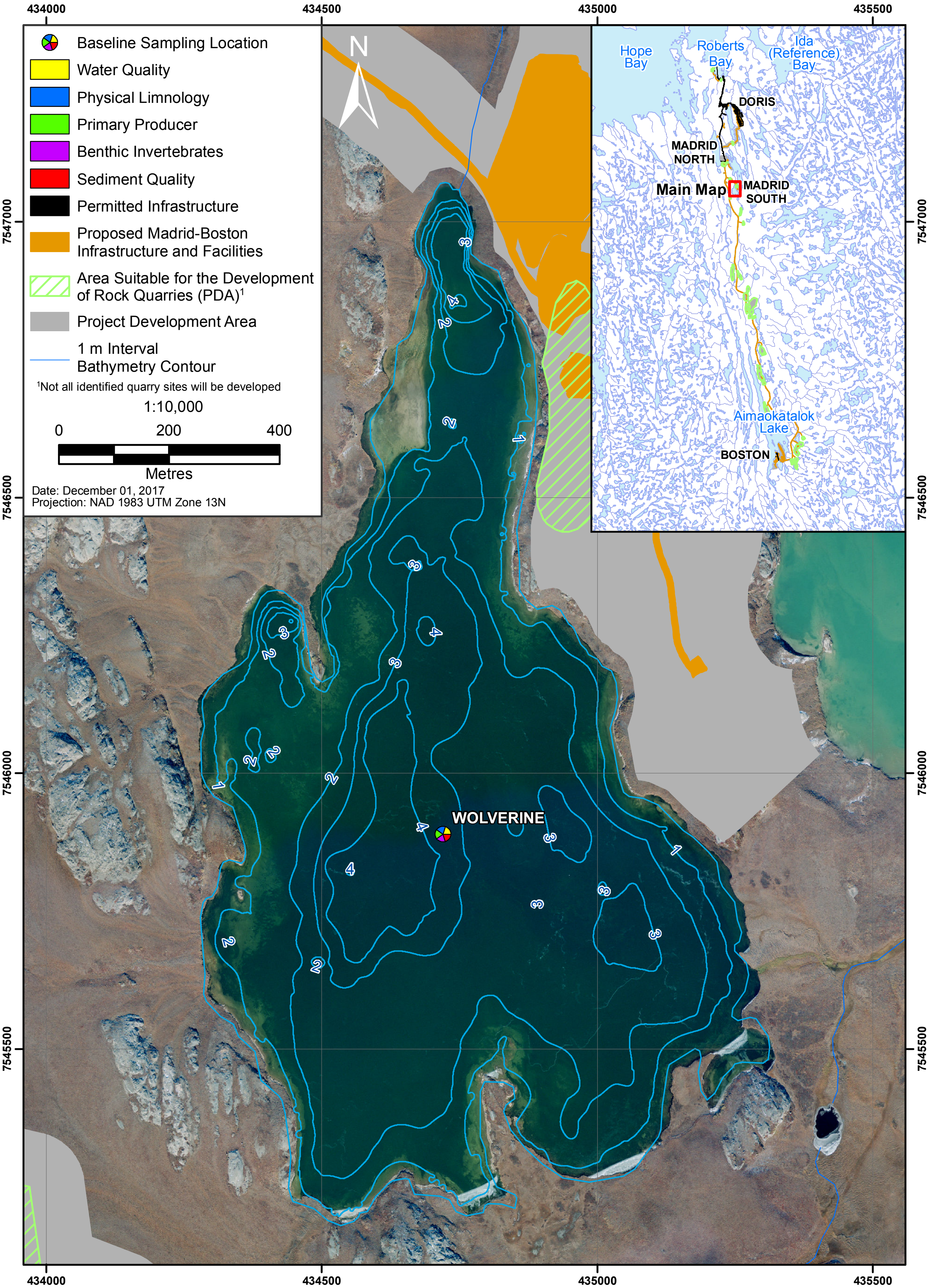


Figure 2.1-3
Sampling Location in Patch Lake, 2017

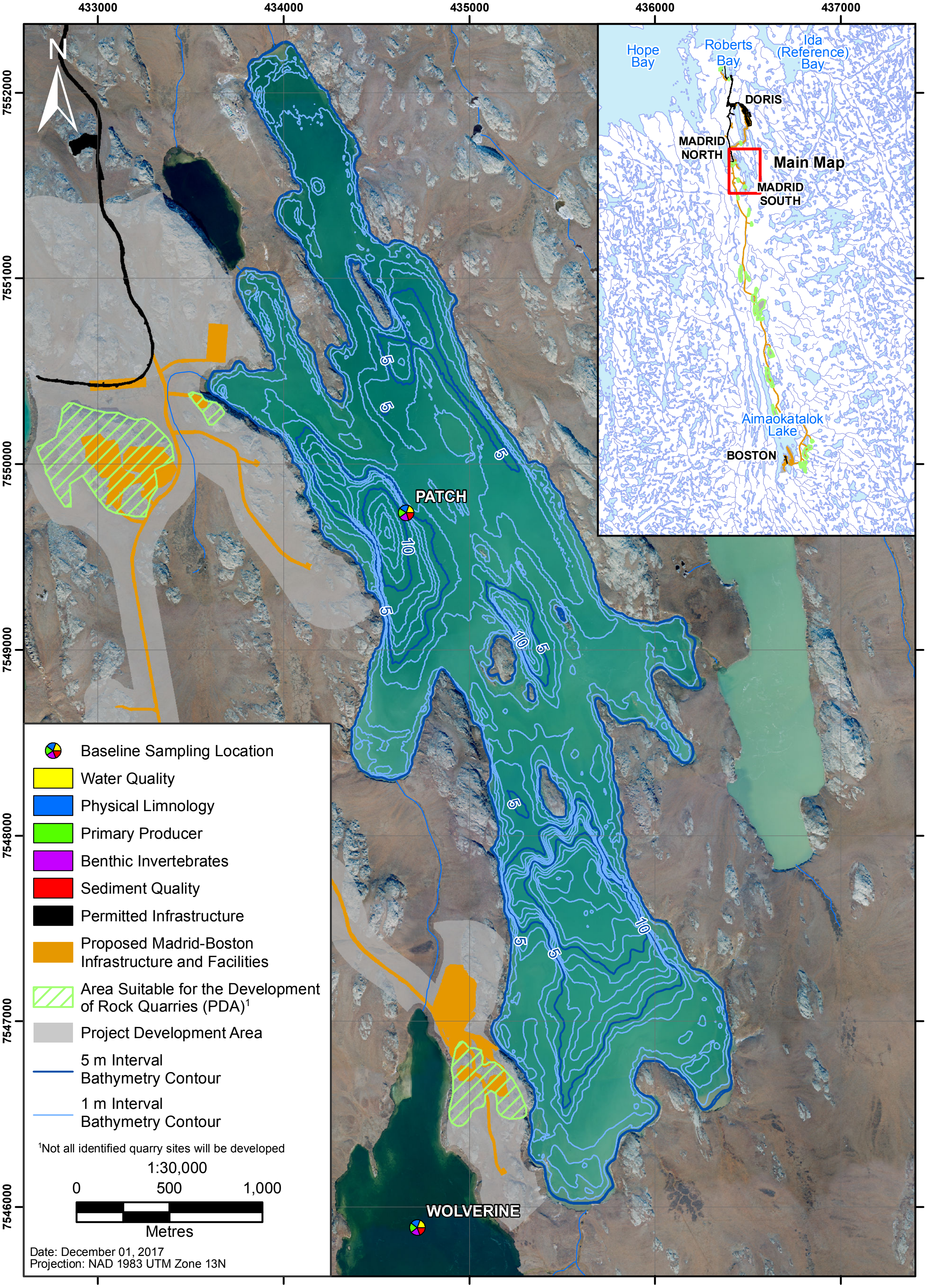


Figure 2.1-4
Sampling Location in Windy Lake, 2017

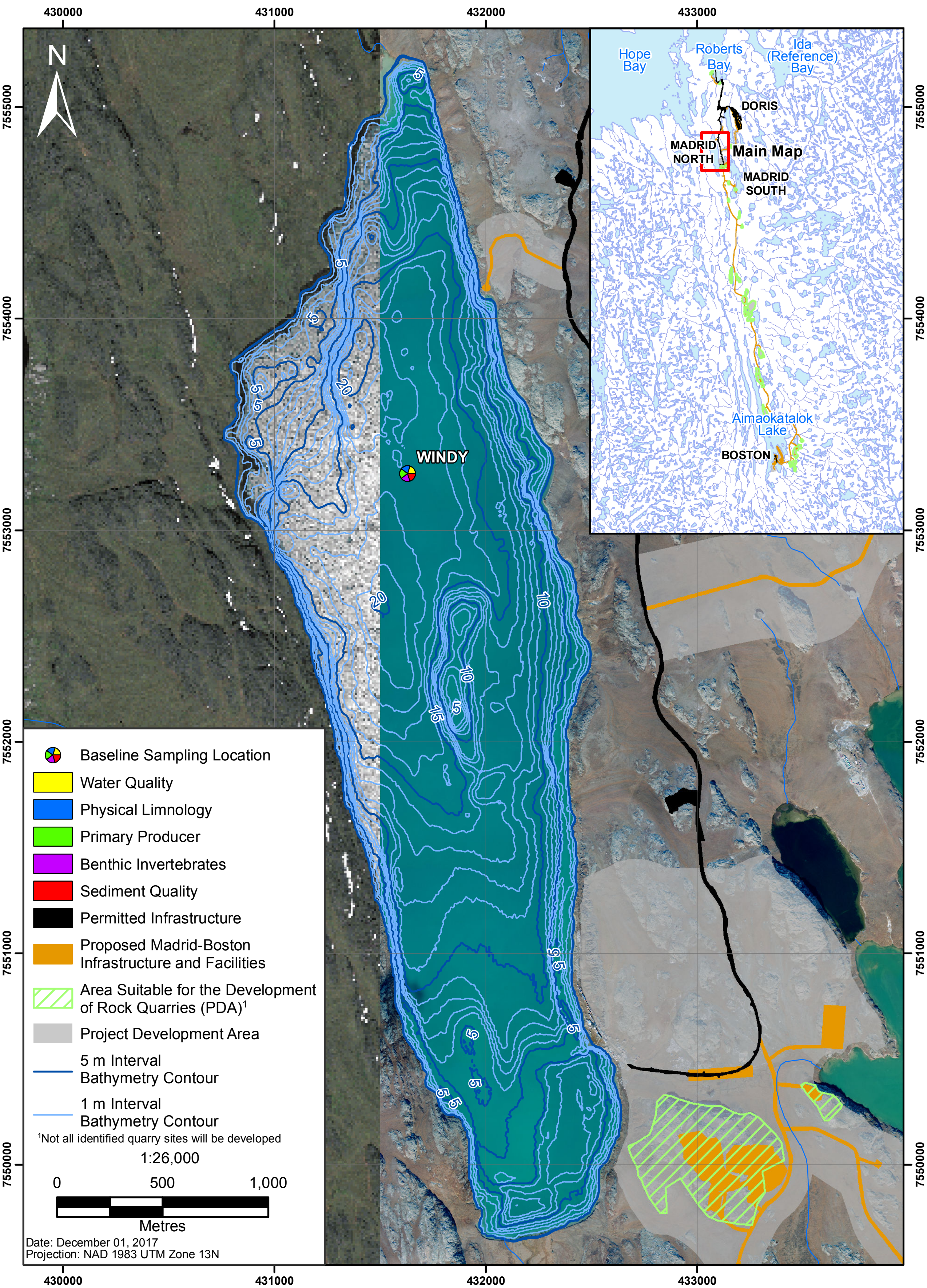


Figure 2.1-5
Sampling Location in Stickleback Lake, 2017

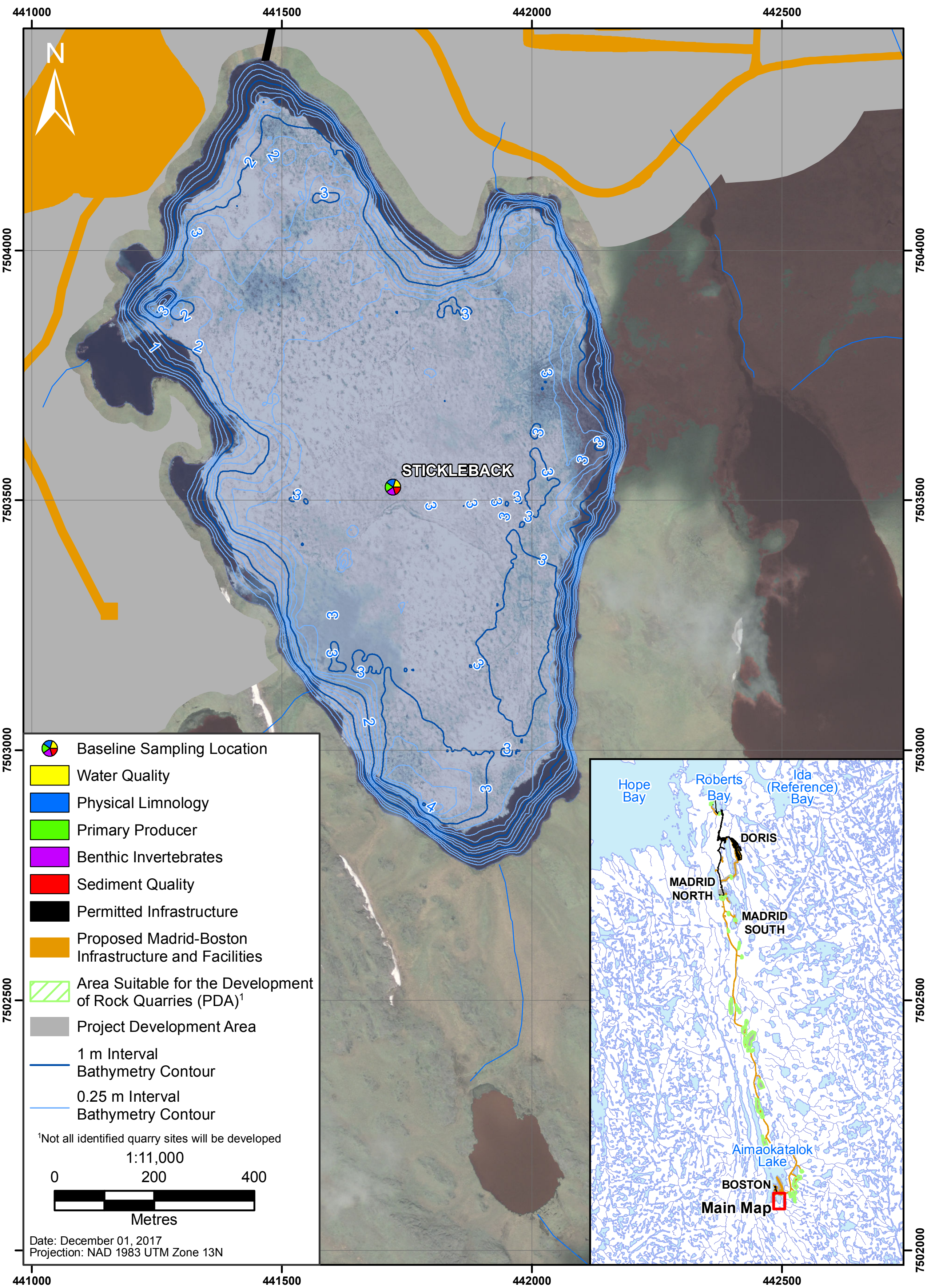
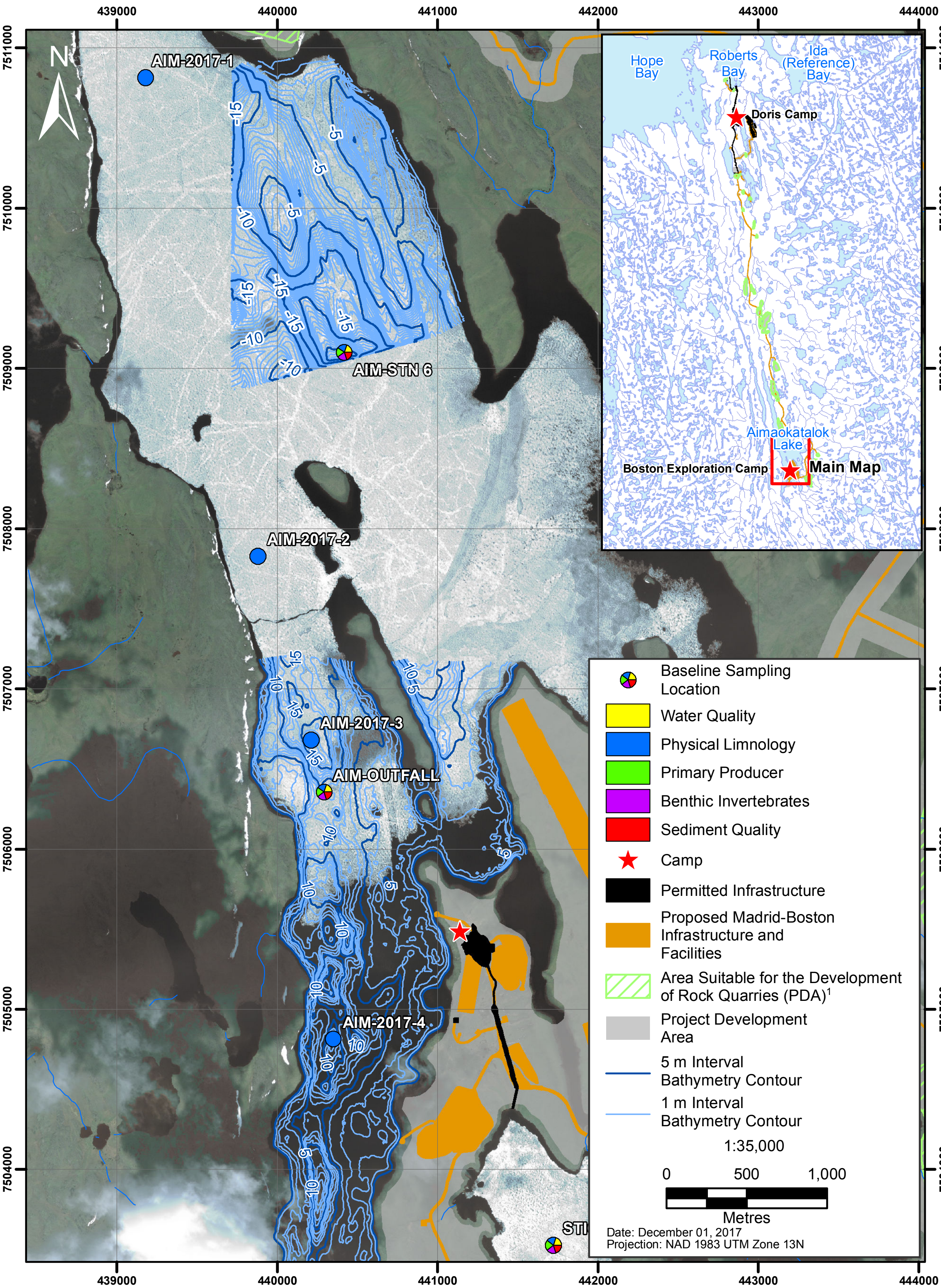


Figure 2.1-6
Sampling Locations in Aimaokatalok Lake, 2017



2.2.1.2 Open-water Season

During the open-water season, vertical profiles of DO and temperature, as well as Secchi depths were collected in August 2017. Open-water season physical limnology profiles were recorded at the same locations as the under-ice profiles using a RBR Ltd. XR-620 CTD (conductivity, temperature, depth) sonde equipped with a Rinko optical DO sensor. Bottom depths were measured using a handheld digital depth finder. Profiles were collected from the surface of the water to approximately 0.5 to 1 m above the sediment surface to minimize disturbance of bottom sediments.

Secchi depths were collected at each site by lowering a 20-cm diameter, 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. The disk was then slowly raised until it once again became visible and this depth was also recorded.

2.2.2 Data Analysis

Continuous data that were internally logged by the profiling instrument were post-processed by binning data into 1 m depth classes and calculating the mean for each depth class. Only data from the downcast were used. Data collected from within the augured hole were removed prior to binning the data. The mean of each depth bin are presented in this report.

Light attenuation was estimated in each lake using a Secchi disk. The average depth of disappearance (average of downcast and upcast) was recorded as the Secchi depth (Ds), which was then used to calculate the depth of the euphotic zone. Euphotic zone depth (EZD) was defined as the depth at which 1% of surface radiation occurred. This generally represents the zone in a waterbody where integrated photosynthesis equals the integrated respiration (i.e., compensation depth), and therefore above this depth represents net photosynthesis. EZD was calculated as follows:

$$k' = 1.7/D_s$$

$$EZD = 4.6/k'$$

where k′ = light extinction coefficient and 1.7 is a constant derived from experimental data (Poole and Atkins 1929).

2.2.3 Quality Assurance and Quality Control (QA/QC)

The YSI EXO multiparameter probe and CTD were calibrated before use. Profile data were reviewed to ensure that data were within expected ranges (e.g., recorded water temperatures were not below the freezing point of freshwater) and that there were no obvious outliers or anomalies.

2.3 WATER QUALITY

2.3.1 Sampling Methodology

2.3.1.1 Under-ice Season

Water quality samples were collected during the under-ice season in April 2017 following the collection of physical limnology profiles. At the deep sites (Patch, Windy, Aimaokatalok Station 6, and Aimaokatalok Outfall), samples were collected at two depths: 1 m below the water surface and approximately 1-2 m above the sediment-water interface. At the shallow lakes (Wolverine and Stickleback), samples were collected at 1 m depth only.

Using metal-clean techniques, samples were collected with an acid-washed Teflon-lined 2.5 L Niskin sampling bottle with a modified triggering mechanism to allow triggering during freezing conditions. The Niskin was securely attached to a metred line and lowered to the desired sampling depth. When triggered, the Niskin was brought to the surface and the water was distributed into the appropriate sample containers. At Stickleback Lake, the thin water layer beneath the ice was too shallow for the Niskin; therefore, the sample was collected as a grab sample by attaching the sampling bottle to a pole and lowering the bottle just below the bottom of the ice layer. Nitrile gloves were worn when filling the sample bottles and care was taken not to bring a bottle or cap into contact with the plastic spigot or other possible sources of contamination. At some sites, cold conditions froze water in the spigot and water was distributed to the sampling bottles by pouring from the top of the Niskin. Samples were collected using lab issued sampling bottles provided by ALS Environmental Services (ALS) in Burnaby, British Columbia (BC). Ultra-pure nitric acid, sulphuric acid, and sodium hydroxide were added to the total metals, nutrients, and cyanide sample bottles, respectively, at the time of sample collection.

Samples were kept cold (but unfrozen) and in the dark while in the field and were refrigerated at Doris Camp prior to shipping. Samples were sent to ALS in Yellowknife, Northwest Territories (NT) on the first available flight out of camp and subsequently transferred to ALS in Burnaby, BC for analysis.

2.3.1.2 Open-water Season

Water quality samples were collected in August 2017. At the deep sites (Patch, Windy, Aimaokatalok Station 6, and Aimaokatalok Outfall), samples were collected at two depths: 1 m below the water surface and approximately 1-2 m above the sediment-water interface. At the shallow lakes (Wolverine and Stickleback), samples were collected at 1 m depth only.

Samples were collected with an acid-washed, Teflon-lined 5 L GO-FLO sampling bottle using metal-clean techniques. The GO-FLO was securely attached to a metred line and lowered to the desired sampling depth. It was then triggered closed using a Teflon-coated brass messenger and brought aboard the boat where the water was distributed into the appropriate sample containers.

Nitrile gloves were worn when distributing the water into sample bottles and care was taken not to bring a bottle or cap into contact with the plastic spigot or other possible sources of contamination.

Samples were collected using lab issued sampling bottles provided by ALS in Burnaby, BC. Ultra-pure nitric acid and sulphuric acid were added to the total metals and nutrients samples, respectively, at the time of sample collection. The cyanide sample bottle was pre-charged with sodium hydroxide.

Samples were kept cold and in the dark while in the field and were refrigerated at Doris Camp prior to shipping. Samples were sent to ALS in Yellowknife, NT on the first available flight out of camp and subsequently transferred to ALS Burnaby for analysis.

2.3.2 Laboratory and Data Analysis

Lake water samples were analyzed for general physical parameters, nutrients, total organic carbon (TOC), cyanide, and total metals at the lowest possible detection limit. Detection limits were the lowest achievable by the lab, and were always lower than the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of aquatic life. The water quality parameters analyzed and their realized detection limits are summarized in Table 2.3-1.

For data interpretation and graphing purposes, values below the detection limit ("non-detects") were considered to be half of the detection limit. Data were summarized by site, depth, and season and compared to CCME long-term water quality guidelines for the protection of aquatic life (CCME 2017b). Parameters presented in graphical format include those with CCME long-term guidelines for the protection of aquatic life as well as select physical parameters and nutrients that provide an indication of general lake characteristics such as water hardness, acid buffering capacity, and trophic status.

2.3.3 QA/QC

To determine sources of potential contamination during water quality sampling, a separate set of bottles for equipment, travel, and field blanks were included as part of the field QA/QC program. Equipment blanks were collected on each sampling bottle prior to each sampling event (i.e., April and August). The acid-washed Niskin or GO-FLO sampling bottle was triple rinsed with double de-ionized water (DDI water; provided by ALS), filled with DDI water, and allowed sit for a few minutes (as would occur with a real sample) before drawing the sample. Equipment blanks were preserved and handled the same as regular samples. Travel blanks were pre-filled with distilled deionized water at ALS and remained closed throughout the field trip. The field blank bottles were filled with distilled deionized water in the lab, but were opened in the field for the approximate time needed to fill the respective field sample and preserved as required for analysis. The number of field and travel blanks collected was a minimum of 5% of the total number of samples collected. These blanks were used to identify potential sources of contamination to the field samples.

In addition, 10% of the water samples were collected in duplicate to assess within-site variability. Chain of Custody (COC) forms were used for all water quality samples.

Table 2.3-1. Water Quality Parameters and Realized Detection Limits, Madrid-Boston, 2017

Parameter	Realized Detection Limit (mg/L)	Parameter	Realized Detection Limit (mg/L)
Physical Tests		**Total Metals** *(cont'd)*	
Conductivity (µS/cm)	2	Cesium (Cs)	0.000005
Hardness (as $CaCO_3$)	0.5	Chromium (Cr)	0.0005
pH (pH units)	0.1	Cobalt (Co)	0.00005
Salinity (psu)	1	Copper (Cu)	0.0005
Total Suspended Solids	1	Gallium (Ga)	0.00005
Total Dissolved Solids	13 - 20	Iron (Fe)	0.03
Turbidity (NTU)	0.1	Lead (Pb)	0.00005
Anions and Nutrients		Lithium (Li)	0.0004
Total Alkalinity (as $CaCO_3$)	1	Magnesium (Mg)	0.1
Total Ammonia (as N)	0.005 - 0.25	Manganese (Mn)	0.0002
Bromide (Br)	0.05 - 2.5	Mercury (Hg)	0.0000005
Chloride (Cl)	0.5 - 2.5	Molybdenum (Mo)	0.00005
Fluoride (F)	0.02 - 0.1	Nickel (Ni)	0.0002
Nitrate (as N)	0.005 - 0.025	Phosphorus (P)	0.3
Nitrite (as N)	0.001 - 0.005	Potassium (K)	2
Orthophosphate-Dissolved (as P)	0.001	Rhenium (Re)	0.000005
Total Phosphorus (P)	0.002	Rubidium (Rb)	0.00002
Sulphate (SO_4)	0.3 - 1.5	Selenium (Se)	0.0002
Cyanides		Silicon (Si)	0.1
Total Cyanide	0.001	Silver (Ag)	0.000005
Free Cyanide	0.001	Sodium (Na)	2
Organic / Inorganic Carbon		Strontium (Sr)	0.0002
Total Organic Carbon	0.5	Tellurium (Te)	0.00001
Total Metals		Thallium (Tl)	0.000005
Aluminum (Al)	0.003	Thorium (Th)	0.000005
Antimony (Sb)	0.00003	Tin (Sn)	0.0002
Arsenic (As)	0.00005	Titanium (Ti)	0.0002
Barium (Ba)	0.0001	Tungsten (W)	0.00001
Beryllium (Be)	0.000005	Uranium (U)	0.000002
Bismuth (Bi)	0.00005	Vanadium (V)	0.00005
Boron (B)	0.01	Yttrium (Y)	0.000005
Cadmium (Cd)	0.000005	Zinc (Zn)	0.003
Calcium (Ca)	0.05	Zirconium (Zr)	0.00005

Note:
All units are mg/L unless otherwise indicated.

2.4 Sediment Quality

2.4.1 Sampling Methodology

Sediment quality samples were collected in August 2017 using an Ekman grab sampler. At each sampling site, three replicate Ekman grab samples were collected from a similar depth. To collect a sample, the Ekman was opened and then lowered slowly on a metred line until it reached the sediments. A brass messenger was released to trigger the Ekman shut and the Ekman was then lifted to the lake surface. Upon retrieval, the Ekman was inspected to ensure a complete sediment sample was collected and surface water was carefully decanted from the surface. The sediment grab was then carefully released from the Ekman onto a white tray and photographed before recording colour, texture, and organic content. The top 2 cm of sediment was collected and homogenized in a clean bowl before being sub-sampled into two pre-labelled Whirl-Pak bags, one for particle size analysis and the second for sediment chemistry analysis.

Samples were kept cold and in the dark while in the field and were refrigerated at Doris Camp prior to shipping. Samples were sent to ALS in Yellowknife on the first available flight out of camp and subsequently transferred to ALS Burnaby for analysis.

2.4.2 Laboratory and Data Analysis

Sediment quality samples were analyzed for particle size, TOC, and metals. Detection limits were the lowest achievable by the lab, and were always lower than the CCME guidelines for the protection of aquatic life. The sediment quality parameters analyzed and their realized detection limits are summarized in Table 2.4-1.

Table 2.4-1. Sediment Quality Parameters and Realized Detection Limits, Madrid-Boston, 2017

Parameter	Realized Detection Limit (mg/L)	Parameter	Realized Detection Limit (mg/L)
Physical Tests		**Metals** *(cont'd)*	
Moisture (%)	0.25	Arsenic (As)	0.10
pH (1:2 soil:water)	0.10	Barium (Ba)	0.50
Particle Size		Beryllium (Be)	0.10
% Gravel (>2mm)	1.0	Bismuth (Bi)	0.20
% Sand (2.0mm - 0.063mm)	1.0	Boron (B)	5.0
% Silt (0.063mm - 4um)	1.0	Cadmium (Cd)	0.050
% Clay (<4um)	1.0	Calcium (Ca)	50
Texture	-	Chromium (Cr)	0.50
Organic Carbon		Cobalt (Co)	0.10
Total Organic Carbon	0.050	Copper (Cu)	0.50
Metals		Iron (Fe)	50
Aluminum (Al)	50	Lead (Pb)	0.50
Antimony (Sb)	0.10	Lithium (Li)	2.0

(continued)

Table 2.4-1. Sediment Quality Parameters and Realized Detection Limits, Madrid-Boston, 2017 (completed)

Parameter	Realized Detection Limit (mg/L)	Parameter	Realized Detection Limit (mg/L)
Metals *(cont'd)*		**Metals** *(cont'd)*	
Magnesium (Mg)	20	Sodium (Na)	50
Manganese (Mn)	1.0	Strontium (Sr)	0.50
Mercury (Hg)	0.0050	Thallium (Tl)	0.050
Molybdenum (Mo)	0.10	Tin (Sn)	2.0
Nickel (Ni)	0.50	Titanium (Ti)	1.0
Phosphorus (P)	50	Uranium (U)	0.050
Potassium (K)	100	Vanadium (V)	0.20
Selenium (Se)	0.20	Zinc (Zn)	2.0
Silver (Ag)	0.10		

Note:
All units are mg/kg unless otherwise indicated.

For data interpretation and graphing purposes, values below the detection limit ("non-detects") were considered to be half of the detection limit. Data were summarized by site and compared to CCME sediment quality guidelines for the protection of aquatic life. These include the interim sediment quality guidelines (ISQGs) and the 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 occur frequently (CCME 2001).

Parameters presented in graphical format included particle size, TOC, and metals with CCME guidelines (CCME 2017a).

2.4.3 QA/QC

The sediment QA/QC program in 2017 included three sediment replicate samples collected at each site. COC forms were used for all samples.

2.5 Primary Producer Biomass

2.5.1 Sampling Methodology

Primary producer biomass (as chlorophyll *a;* chl *a*) samples were collected from lakes during April and August 2017 concurrently with water quality samples. Samples were collected from 1 m below the surface using a Niskin sampling bottle during the under-ice season and a GO-FLO sampling bottle during the open-water season. Triplicate 1 L samples were collected, transferred to opaque sampling bottles, and stored in the dark and on ice until filtering which occurred as soon as possible upon returning to camp. Sample water was filtered until a brown or green colour was visible on the 0.45 µm pore size, nitrocellulose filter, and the volume filtered was recorded. Sample filters were then placed inside a pre-labelled opaque tube, and kept frozen until they were sent to ALS in Burnaby, BC for analysis.

2.5.2 Data Analysis

Concentrations of chl *a* were calculated by dividing the micrograms of chl *a* measured by the volume of sample filtered. Results are presented as mean µg chl *a*/L and summarized by site.

2.5.3 QA/QC

The primary producer QA/QC program in 2017 included the collection of three replicate samples at each site. COC forms were used for all samples.

2.6 Benthic Invertebrates

2.6.1 Sampling Methodology

Benthic invertebrate (benthos) samples were collected concurrently with lake sediment quality samples in August 2017. Five replicate samples, each a composite of three Ekman grab samples (surface area of 0.0225 m^2), were collected at each site. Replicates at each site were collected within an approximate 15 m radius at similar depths.

To collect a sample, the Ekman was opened and then lowered slowly on a metred line until it reached the sediments. A brass messenger was released to trigger the Ekman shut and the Ekman was then lifted to the lake surface. Upon retrieval, the Ekman sampler was inspected to ensure a complete grab was obtained. Samples, including overlaying surface water, were gently sieved in the field using a 500 µm sieve bucket or bag that was repeatedly agitated at the water surface to rinse fine sediments and debris from the sample. Three grab samples were combined into a pre-labelled sampling jar to create each composite sample and preserved in 10% buffered formalin. Samples were sent for analysis to Dr. Jack Zloty in Summerland, BC, for enumeration and identification.

2.6.2 Data Analysis

Raw benthic invertebrate counts were first filtered to exclude specimens that 1) were not considered to be benthic (e.g., cladocerans, calanoid and cyclopoid copepods, and terrestrial organisms), and 2) are not efficiently sampled with a 500 µm mesh (e.g., nematodes). Total counts per replicate were converted to density (organisms/m^2) using the surface area sampled ($3 \times 0.0225\ m^2 = 0.0675\ m^2$) and averaged to represent mean site density.

Unidentified, immature, or damaged organisms that could not be identified to the genus level were included in the calculation of total densities but excluded from community composition, richness, and diversity analyses. Intact specimens that were not identified to genus level were grouped at the next possible taxonomic category. Relative abundance of benthic taxa were calculated by major groups (e.g., Diptera, Oligochaeta, etc.) and averaged across replicates to present a site mean. Richness and Simpson's diversity were calculated at the genera level for each sample according to:

- genus richness = the total number of genera present; and
- Simpson's Diversity Index (D), where n_i is the number of individuals in genera i, G is the number of genera, and N is the total number of all individuals.

$$1 - D = 1 - \sum_{i=1}^{G} \left(\frac{n_i}{N} \right)^2$$

Community parameters were averaged and presented as an overall site mean. Community analyses were also performed on the dipteran community subset because dipterans were typically the dominant taxonomic group in lake benthos samples.

2.6.3 QA/QC

The QA/QC program for benthic invertebrate sampling included the collection of replicates and composite samples to account for within-site variability and the use of chain of custody forms to track samples. The taxonomist re-sorted three randomly selected sample residues (10% of samples) to determine the sorting efficiency (i.e., the completeness of recovery of invertebrates in the sample). Sorting efficiencies of 90% or greater are considered acceptable under Environment Canada's Environmental Effects Monitoring (EEM) guidelines (Environment Canada 2012). Sorting efficiency was calculated by the following equation:

% Sorting Efficiency = [1-(# in QA/QC re-sort / (# sorted originally + # QA/QC resort))] × 100.

2.7 Historical Data

The focus of this report is on the presentation of 2017 results. However, water and sediment quality data were collected during some years from 1993 to 2010 at the sites sampled in 2017. To provide context for the 2017 results, historical water and sediment quality data are included in the figures and discussion in Chapter 3 (Sections 3.2 and 3.3). Only sites sampled in 2017 are presented below; data for other sites sampled in previous years are available in historical baseline reports (e.g., Rescan 2010, 2011). Because there are no historical data for the Aimaokatalok Outfall site, data from nearby stations were presented (Aimaokatalok Stations 1, 2, 3, 5, and 13; and Aimaokatalok WQ 4). The Patch Lake station in this report was referred to as Patch North in some previous reports.

In some cases, the detection limits of the historical data were too high to be readily compared to the most recent data. In these cases, data were removed from the analysis. The years of the presented data is noted in the figure legends.

3. RESULTS AND DISCUSSION

3.1 PHYSICAL LIMNOLOGY

Under-ice and open-water season physical limnology data were collected between April 22 and 25, 2017 and August 16 to 20, 2017, respectively (Table 3.1-1). Physical limnology data are provided in Appendix 3.1-1. Temperature and dissolved oxygen profiles for both the under-ice and open-water season of 2017 are presented in Figures 3.1-1 to 3.1-3. Secchi and euphotic depths are presented in Figure 3.1-4.

Table 3.1-1. Physical Limnology Sampling Dates, Ice Thickness, and Water Column Depths, Madrid-Boston, 2017

Sampling Location	Site	Under-ice Season	Ice Thickness (m)	Maximum Depth (m)	Open-water Season	Maximum Depth (m)
Doris Watershed						
Wolverine Lake	Wolverine	April 22, 2017	1.30	4.0	August 20, 2017	3.9
Patch Lake	Patch	April 22, 2017	1.33	8.5	August 19, 2017	8.4
Windy Watershed						
Windy Lake	Windy	April 25, 2017	1.36	17	August 19, 2017	17.6
Aimaokatalok Watershed						
Stickleback Lake	Stickleback	April 24, 2017	1.37	2.4	August 16, 2017	2.3
Aimaokatalok Lake	Outfall	April 24, 2017	1.26	7.6	August 18, 2017	8.2
	Station 6	April 24, 2017	1.24	27	August 18, 2017	27.2
	2017-1	-	-	-	August 18, 2017	27.4
	2017-2	-	-	-	August 18, 2017	16.6
	2017-3	-	-	-	August 18, 2017	18.3
	2017-4	-	-	-	August 18, 2017	14.1

3.1.1 Under-ice Season

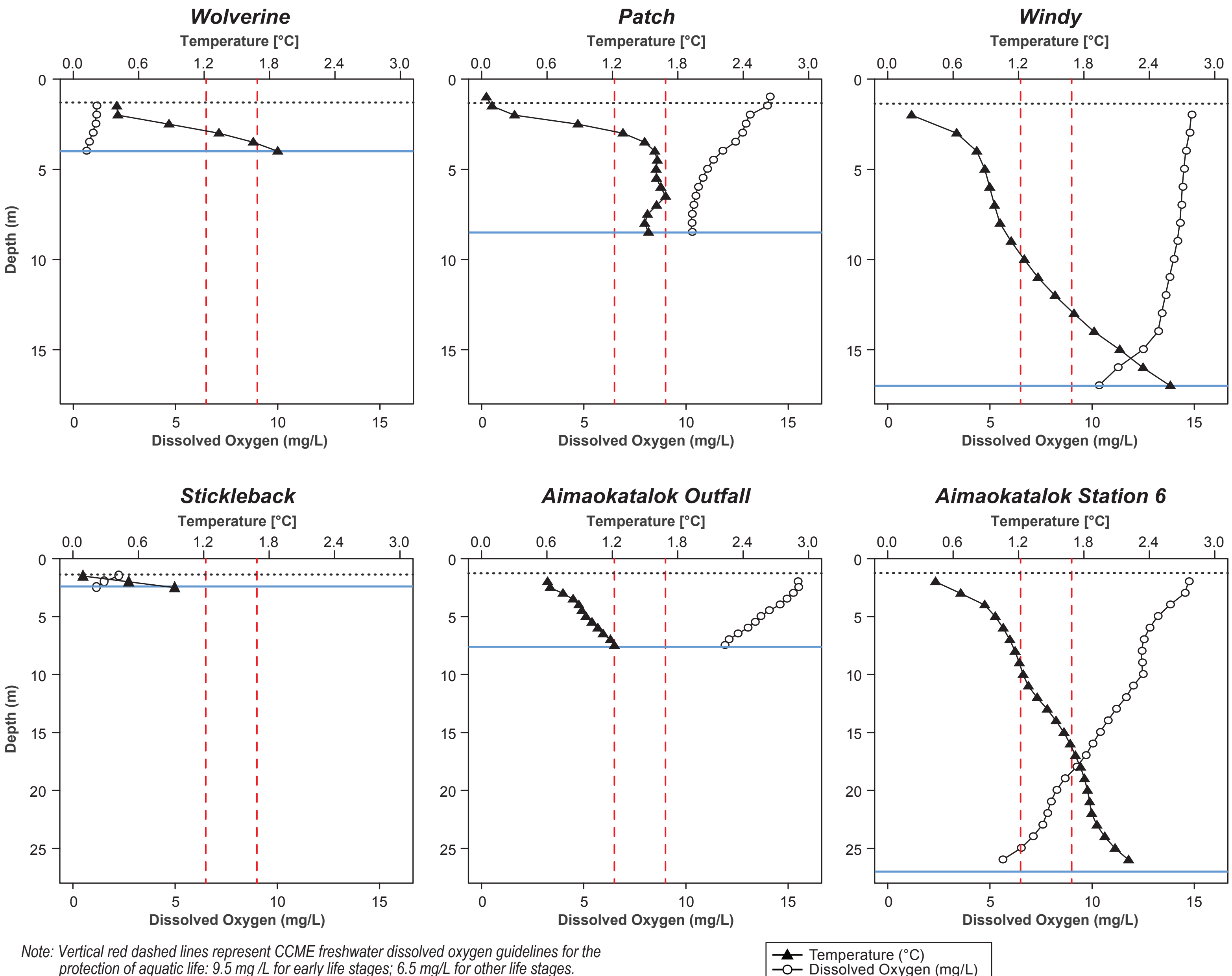
Ice thickness was similar across lakes, ranging from 1.24 to 1.37 m (Table 3.1-1). Water column structure was typical of ice-covered lakes, with the coldest water lying just below the ice (range = 0.1 to 0.6°C) and warming with depth reaching 0.9 to 2.6°C near the sediment-water interface (Figure 3.1-1). With the exception of Patch Lake, where a well-defined thermocline was established near 3 m, temperatures changed gradually with depth from the surface to the lake bottom at all sites.

Dissolved oxygen concentrations were highest near the water-ice interface, but varied widely among lakes. DO concentrations at the water-ice interface were lower in shallow lakes (Wolverine and Stickleback; range = 1.1 to 2.0 mg/L) compared to deep lakes (Patch, Windy, and Aimaokatalok; range = 13.9 to 15.5 mg/L). Dissolved oxygen concentrations gradually declined with depth at all sites, reaching 0.6 to 1.1 mg/L at shallow sites and 5.6 to 11.9 mg/L at deep sites, near the sediment-water interface (Figure 3.1-1).

Figure 3.1-1

Under-ice Physical Limnology Profiles, Madrid-Boston, 2017

ERM



Note: Vertical red 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. Solid blue lines within figure panels represent bottom depth. Dotted black lines represent ice thickness.

Concentrations of dissolved oxygen were higher than the CCME freshwater guidelines for the protection of aquatic life for other life stages (6.5 mg/L) and early life stages (9.5 mg/L) in Windy and Patch lakes and at the Aimaokatalok Outfall site. In Wolverine and Stickleback lakes, dissolved oxygen concentrations were well below both CCME guidelines (<2 mg/L) throughout the water column. At these sites, there was a relatively thin layer of water overlying the sediments resulting in low oxygen inventories (i.e., lake-wide mass of oxygen available for consumption) and relatively high oxygen demand. Dissolved oxygen concentrations in the upper portion of Aimaokatalok Station 6 (<17 m) were greater than both CCME guidelines, but concentrations declined to below 6.5 mg/L in the deepest section of the lake (Figure 3.1-1).

3.1.2 Open-water Season

In August, all lakes except Aimaokatalok Lake were well-mixed and relatively warm (range = 12.8 to 14.2°C; Figure 3.1-2). Aimaokatalok Lake was also relatively warm (range = 11.3 to 14.0°C) with weak thermal stratification observed at various depths among the six sites. Stratification was most pronounced at the deepest sites (i.e., Station 6 and 2017-1; Figure 3.1-3).

All sites were well oxygenated throughout the water columns with dissolved oxygen concentrations ranging from 9.7 to 12.0 mg/L. Only slight declines in dissolved oxygen concentration and saturation were observed near the bottom of the lake. Concentrations of dissolved oxygen were higher than the CCME freshwater dissolved oxygen guideline for the protection of aquatic life for other life stages (6.5 mg/L) and the guideline for early life stages (9.5 mg/L) throughout the water column at all sites (Figures 3.1-2 and 3.1-3).

Secchi depth, a measure of water clarity, ranged from 2.2 m in Wolverine Lake to 4.4 m in Windy Lake (Figure 3.1-4). Water clarity was generally greatest at the deepest sites (Windy Lake and Aimaokatalok Station 6). The lake bottom was visible at the most shallow site (Stickleback; maximum depth = 2.3 m). Euphotic zone depths ranged from 2.3 to 11.8 m and extended throughout the entire water column in Stickleback Lake and at the Aimaokatalok Outfall site, indicating that benthic primary production is possible at these sites (Figure 3.1-4).

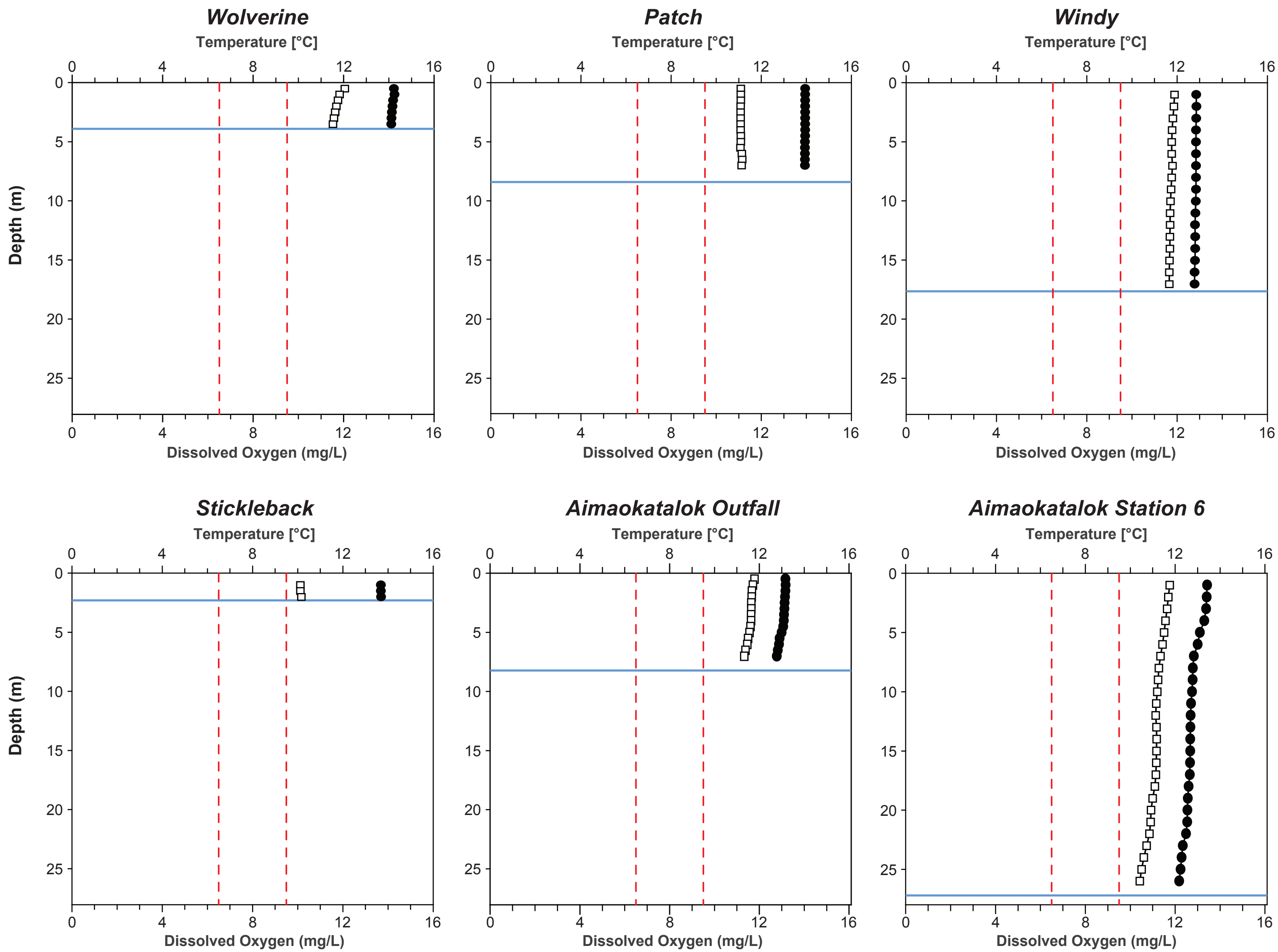
3.2 WATER QUALITY

Under-ice and open-water season water quality samples were collected between April 22 and 25, 2017 and August 16 to 20, 2017 (Table 3.2-1). The 2017 water quality results are provided in Appendix 3.2-1. Results for water quality QA/QC blanks are presented in Appendix 3.2-2. Select parameters are presented in Figures 3.2-1 to 3.2-16 and discussed relative to historical data and CCME guidelines. Historical water quality data are available in Rescan (2010, 2011).

The blank samples collected in 2017 did not show significant contamination and most parameter concentrations were below analytical detection limits or slightly above analytical detection limits; therefore, water quality data were considered to be reliable.

Figure 3.1-2

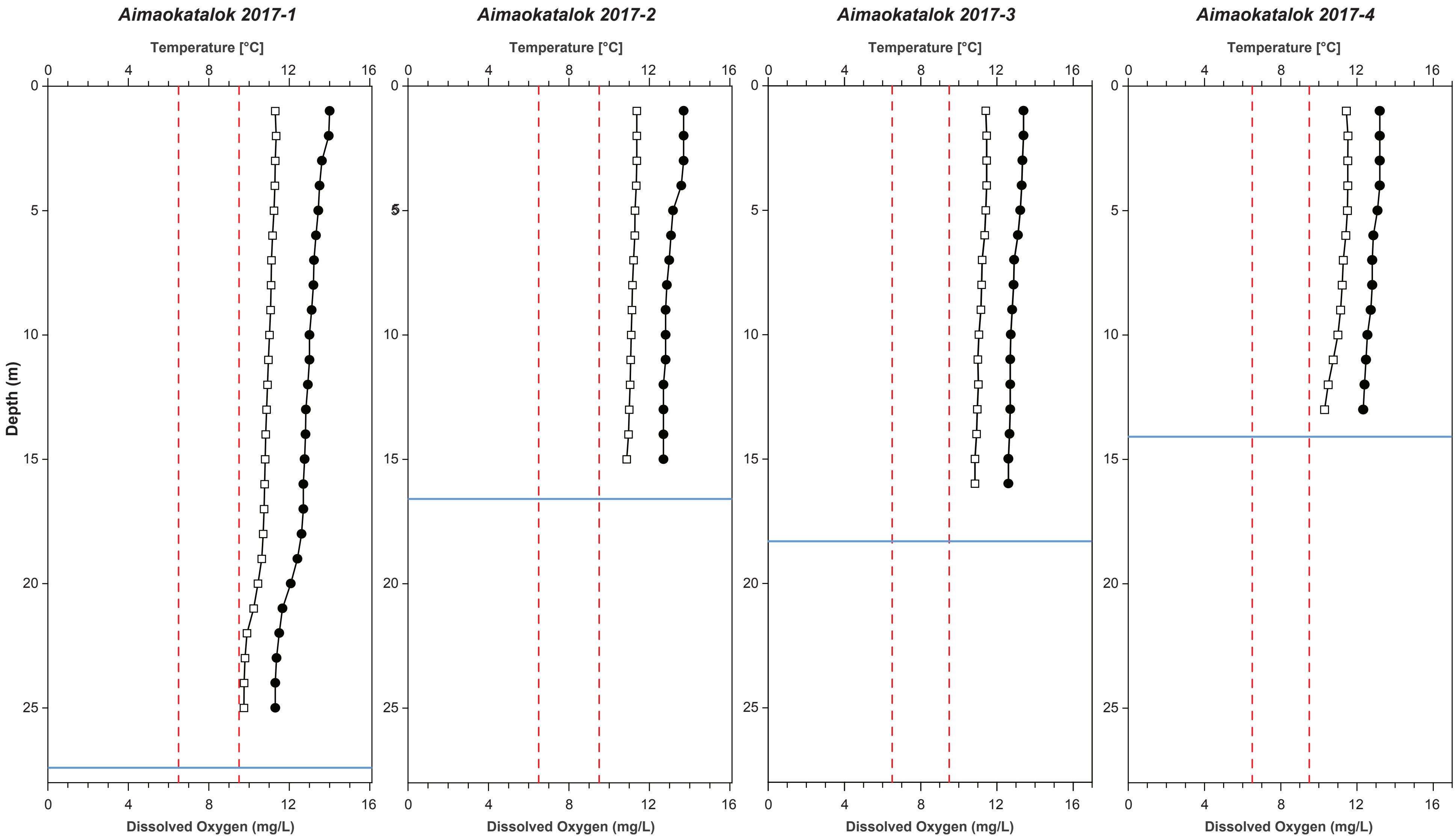
Open Water Season Physical Limnology Profiles, Madrid-Boston, 2017



Notes: Vertical red 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. Solid blue lines within figure panels represent bottom depth.

Figure 3.1-3

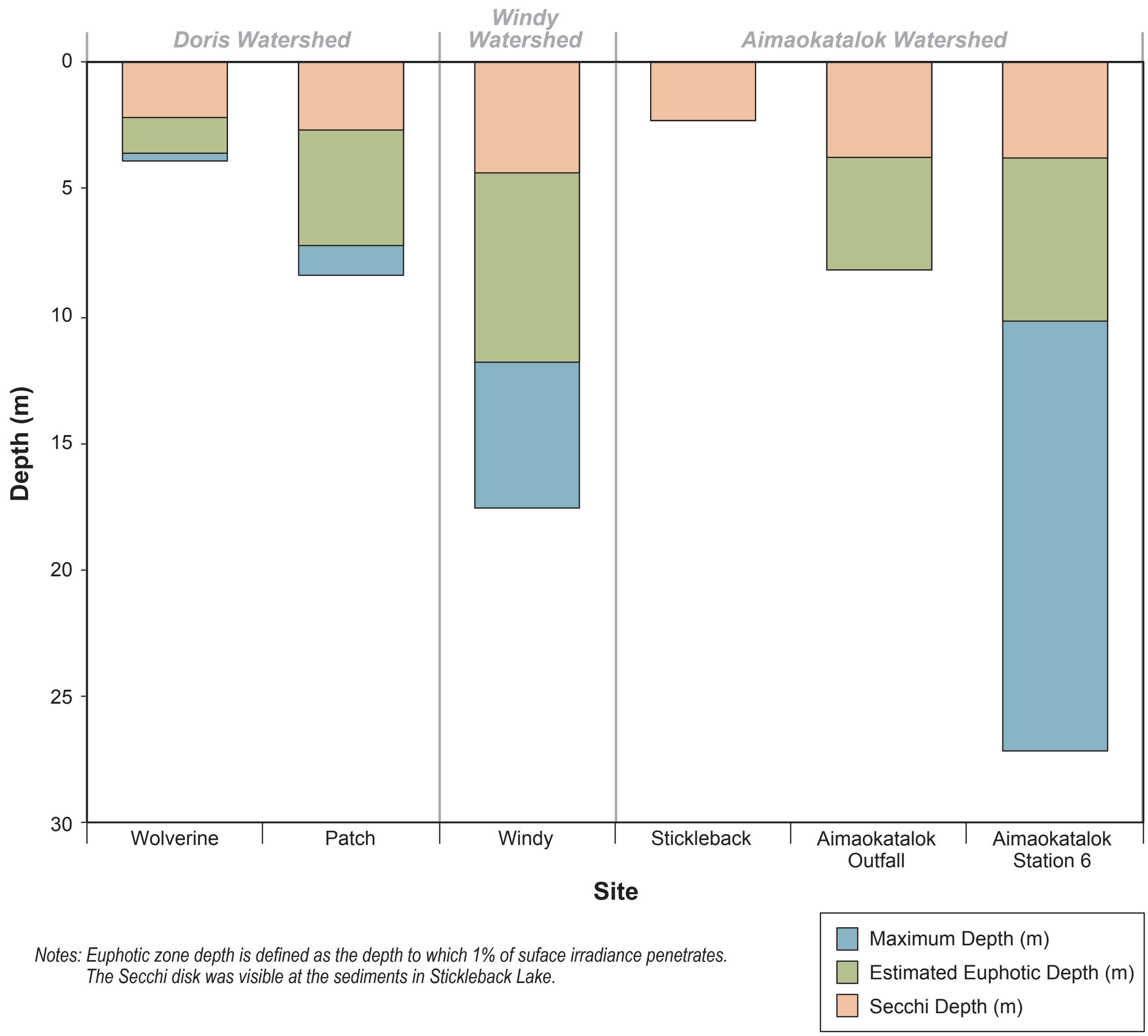
Additional Aimaokatalok Lake
Open Water Season Physical Limnology Profiles, 2017



Notes: Vertical red 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. Solid blue lines within figure panels represent bottom depth.

Figure 3.1-4

Secchi and Euphotic Depths, Madrid-Boston, 2017



Notes: Euphotic zone depth is defined as the depth to which 1% of suface irradiance penetrates. The Secchi disk was visible at the sediments in Stickleback Lake.

Table 3.2-1. Water Quality and Primary Producer Sampling Dates, Ice Thickness and Water Column Depths, Madrid-Boston, 2017

Sampling Location	Site	Under-ice Season	Sample Depth (m)[a]	Open-water Season	Sample Depth (m)[a]
Doris Watershed					
Wolverine Lake	Wolverine	April 22, 2017	2.0	August 20, 2017	1
Patch Lake	Patch	April 22, 2017	2.5, 6.5	August 19,2017	1, 6
Windy Watershed					
Windy Lake	Windy	April 25, 2017	2.5, 14	August 19, 2017	1, 16
Aimaokatalok Watershed					
Stickleback Lake	Stickleback	April 24, 2017	1.4 (grab)[b]	August 16, 2017	1
Aimaokatalok Lake	Outfall	April 24, 2017	2.5, 5.5	August 18, 2017	1, 7
	Station 6	April 24, 2017	2.5, 24	August 18, 2017	1, 25

Notes:
[a] *Water quality samples collected from both depths. Primary producer samples collected from top depth only.*
[b] *Sample collected from just beneath the ice layer.*

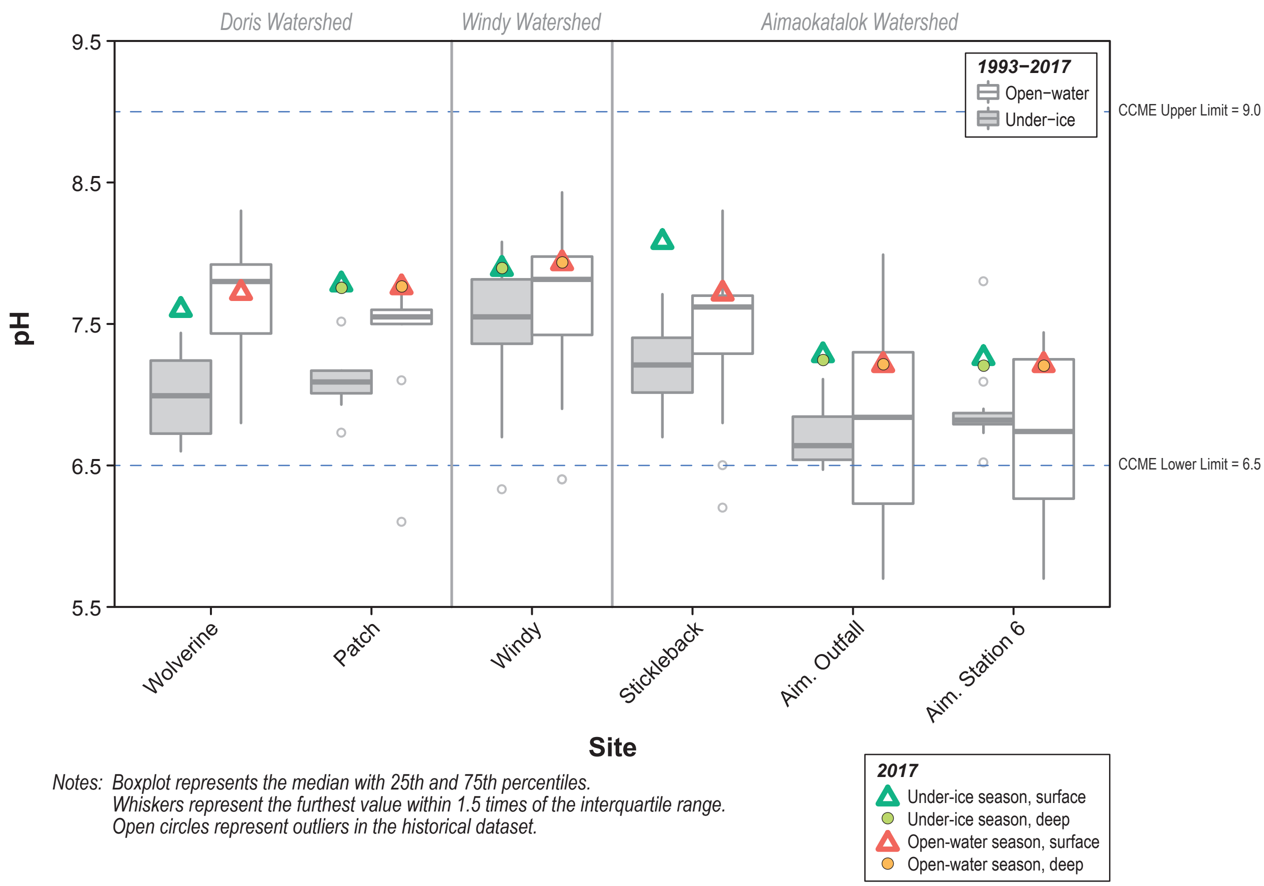
3.2.1 pH

In 2017 the sampled lakes had pH that were neutral to slightly alkaline, ranging from 7.2 in Aimaokatalok Lake during both the under-ice and open water seasons to 8.1 in Stickleback Lake during the under-ice season (Figure 3.2-1). pH was generally similar among lakes between the under-ice and open-water seasons and between sample depths. pH in 2017 fell within historical variation (i.e., inside the 1.5× interquartile range [IQR]) during the open-water season but was higher at some lakes during the under-ice season.

3.2.2 Physical Parameters

Most lakes sampled in 2017 had low sensitivity to acid inputs (i.e., high buffering capacity) as alkalinity levels were higher than 20 mg/L $CaCO_3$ (Saffran and Trew 1996). Alkalinity was slightly lower in Aimaokatalok Lake (range = 9.5 to 12.8 mg/L $CaCO_3$) compared to other lakes, indicating greater sensitivity to acid inputs. Alkalinity levels were generally similar between sample depths but tended to be higher during the ice-covered season than the open-water season due to exclusion of solutes from the ice layer. Larger differences in alkalinity between seasons were observed in the smaller shallow lakes (Figure 3.2-2). This was expected because solute exclusion from the ice layer during winter tends to have a larger effect on small shallow lakes where the proportion of water freezing into the ice layer is greater.

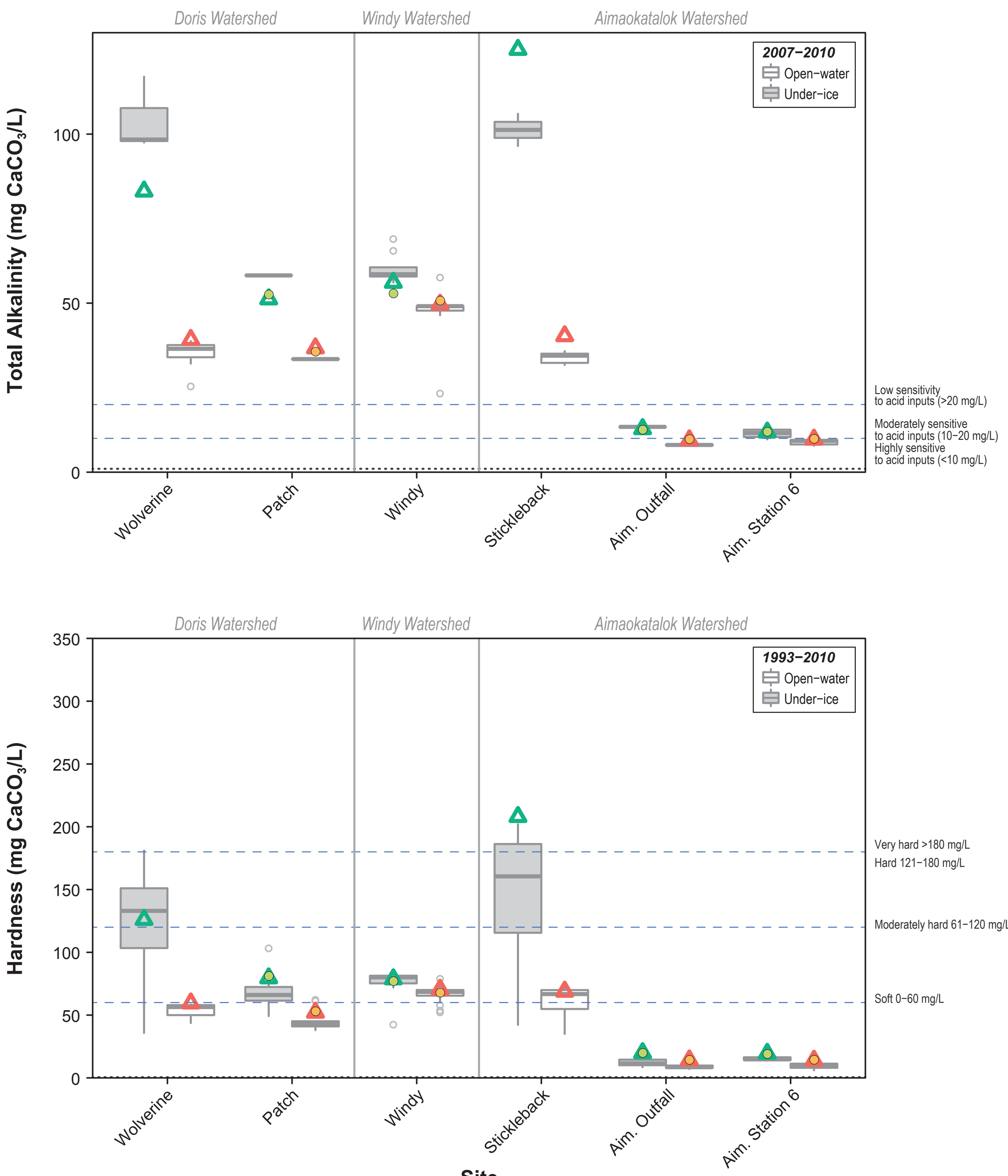
Water hardness ranged from 14 to 208 mg/L $CaCO_3$ in 2017, and all lakes were categorized as having soft (0 - 60 mg/L hardness as $CaCO_3$) to moderately hard water (61 - 120 mg/L hardness as $CaCO_3$) during the open-water season (Durfor and Becker 1962). Hardness in the shallow Wolverine and Stickleback lakes was considerably higher during the under-ice season (126 and 208 mg/L hardness as $CaCO_3$, respectively; Figure 3.2-2) due to solute exclusion from the ice layer. Only small differences in water hardness between sample depths were observed (Figure 3.2-2).



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.

Figure 3.2-2

Alkalinity and Hardness, Madrid-Boston, 1993 to 2017



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.

Conductivity was generally consistent between sample depths within a lake but highly variable among lakes and between seasons in 2017 (range = 59 to 733 µS/cm; Figure 3.2-3). As expected, total dissolved solids (TDS) concentrations matched fluctuations in conductivity across sites and season, ranging from 38 to 445 mg/L (Figure 3.2-3). Both parameters were higher at all sites during the under-ice season compared to the open-water season due to solute exclusion from the ice layer. As was observed with other physical parameters, conductivity and hardness were lowest in Aimaokatalok Lake (Figure 3.2-3).

The lakes in the study area had low total suspended solids (TSS) concentrations in 2017 (range = <0.5 to 5.7 mg/L) that were often less than the detection limit (Figure 3.2-4). Turbidity was similarly low, ranging from 0.2 to 5.5 NTU. Consistent seasonal patterns were not evident for these parameters in 2017 but TSS was highest in Windy and Stickleback lakes during the under-ice season which could have been related to increasing primary producer biomass (see Section 3.4).

Overall, the physical parameters in 2017 usually fell within historical variation, although were occasionally higher or lower (i.e., outside of their 1.5× IQR). The 2017 data also displayed patterns across lakes and seasons that were similar with historical data. For example, Aimaokatalok Lake generally contained the lowest hardness, alkalinity, conductivity, and TDS in both 2017 and historical years (Figures 3.1-2 to 3.1-4).

3.2.3 Anions

As was observed with many of the physical parameters, chloride and fluoride concentrations tended to be higher under ice than in open water in 2017 due to solute exclusion from the ice layer, with the greatest differences in the shallow lakes (Figure 3.2-5). Chloride concentrations ranged from 10 to 170 mg/L and fluoride concentrations ranged from 0.025 to 0.1 mg/L. This pattern and the observed concentrations were consistent with historical data (Figure 3.2-5).

3.2.4 Nutrients

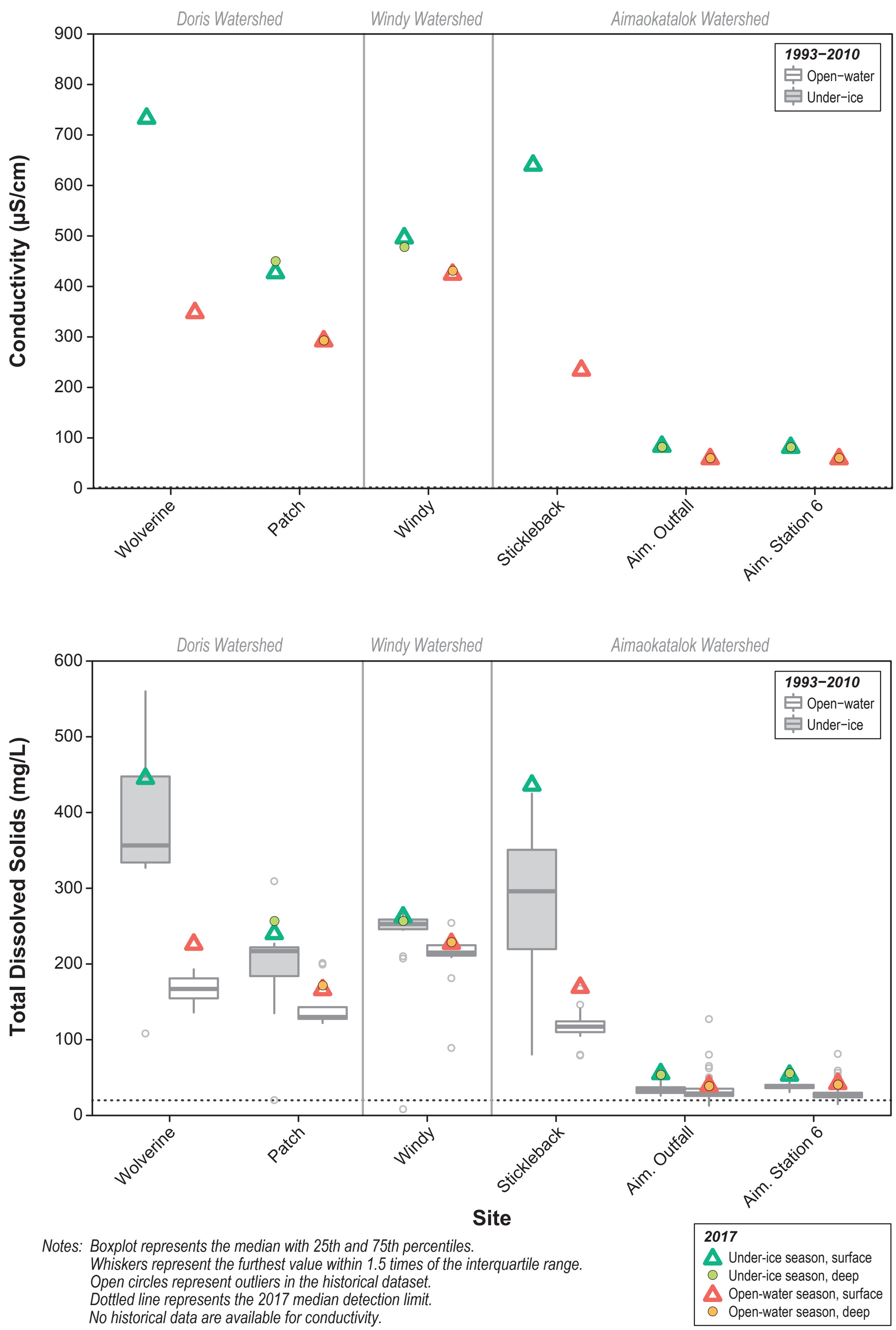
In 2017, concentrations of nitrate-N, total ammonia-N, and nitrite-N were generally low and tended to be lower in open water than under ice (Figures 3.2-6 and 3.2-7). Concentrations of all three parameters were often below the analytical detection limits, particularly during summer when biological uptake of inorganic nitrogen would be expected to be higher due to increased light and temperatures.

In 2017, total phosphorus concentrations ranged from <0.002 mg/L to 0.0174 mg/L (Figure 3.2-7). Total phosphorus concentrations were similar between seasons and sample depths in 2017. Based on the 2017 data and CCME's trophic categorizations for total phosphorus levels (CCME 2004), Windy Lake would be considered ultra-oligotrophic; Patch and Aimaokatalok lakes would be considered ultra-oligotrophic to oligotrophic; Stickleback Lake would be considered oligotrophic to mesotrophic; and Wolverine Lake would be considered mesotrophic.

Nutrient data analyzed in 2017 usually fell within historical variation, with total phosphorus concentration usually at the lower limits of variability.

Figure 3.2-3

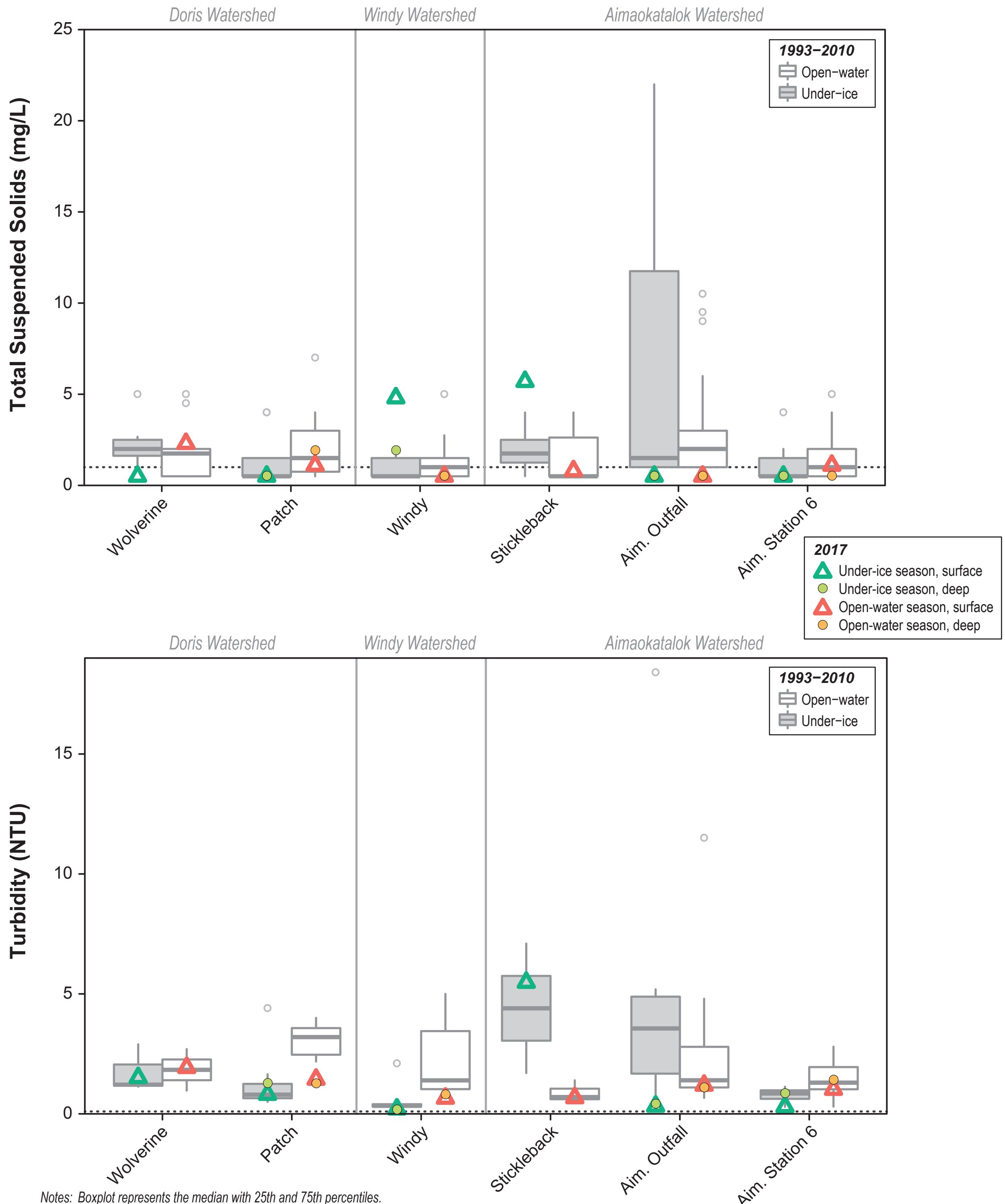
Conductivity and Total Dissolved Solids Concentrations, Madrid-Boston, 1993 to 2017



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.
No historical data are available for conductivity.

Figure 3.2-4

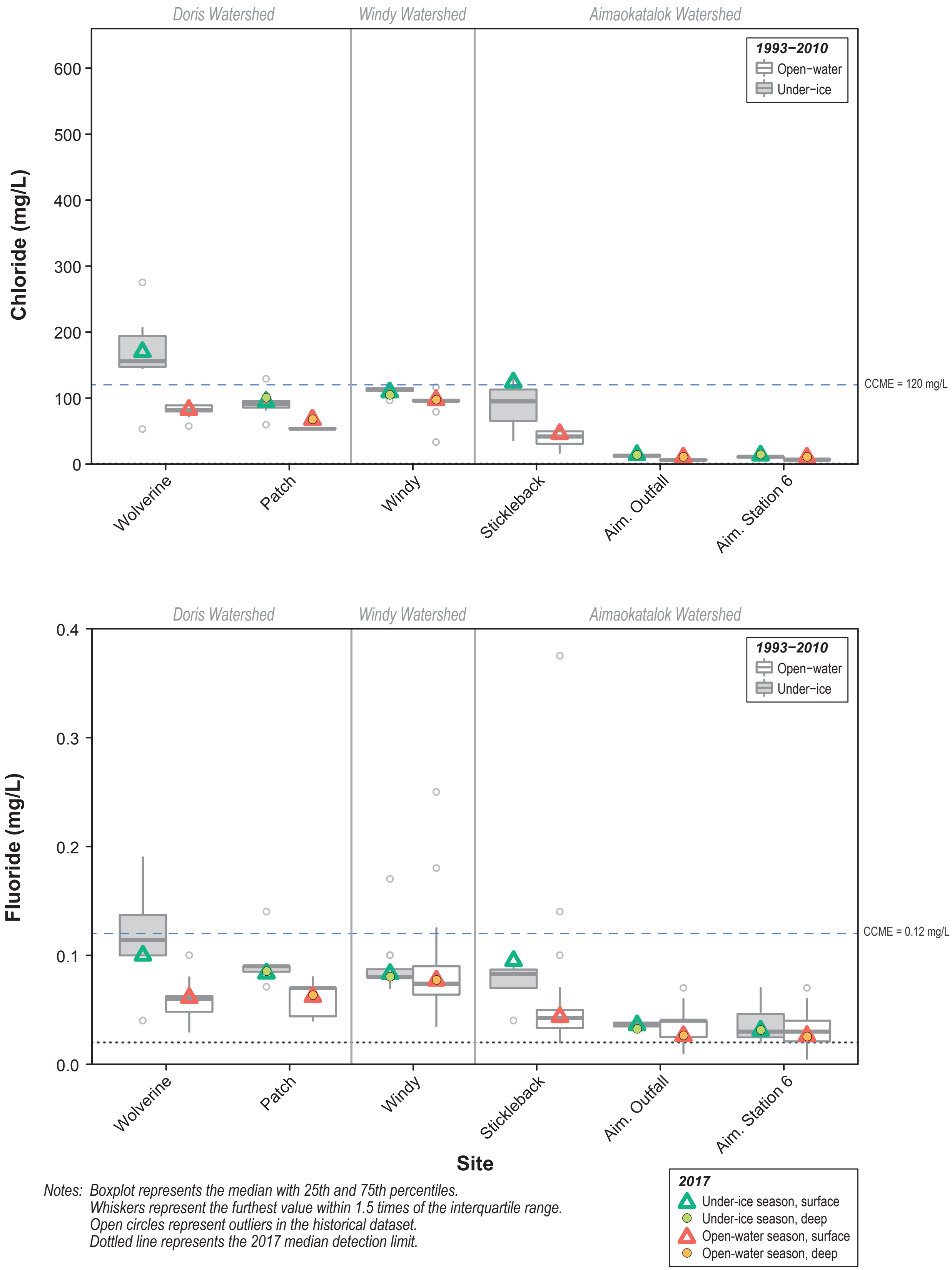
Total Suspended Solids Concentrations and Turbidity, Madrid-Boston, 1993 to 2017



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.
CCME TSS guideline for clear flow = maximum average increase of 5 mg/L from background levels for inputs lasting between 24 hours and 30 days.
CCME TSS guideline for high flow = maximum increase of 25 mg/L from background levels at any time when background levels are between 25 and 250 mg/L.
Should not increase more than 10% of background levels when background is ≥ 250 mg/L.
CCME turbidity guideline for clear flow = maximum average increase of 2 nephelometric turbidity units (NTU) from background levels for longer term exposures (e.g., 30 day period).
CCME turbidity guideline for high flow or turbid waters = maximum increase of 8 NTU from background levels at any one time when background levels are between 8 and 80 NTUs.
Should not increase more than 10% of background levels when background is > 80 NTUs.

Figure 3.2-5

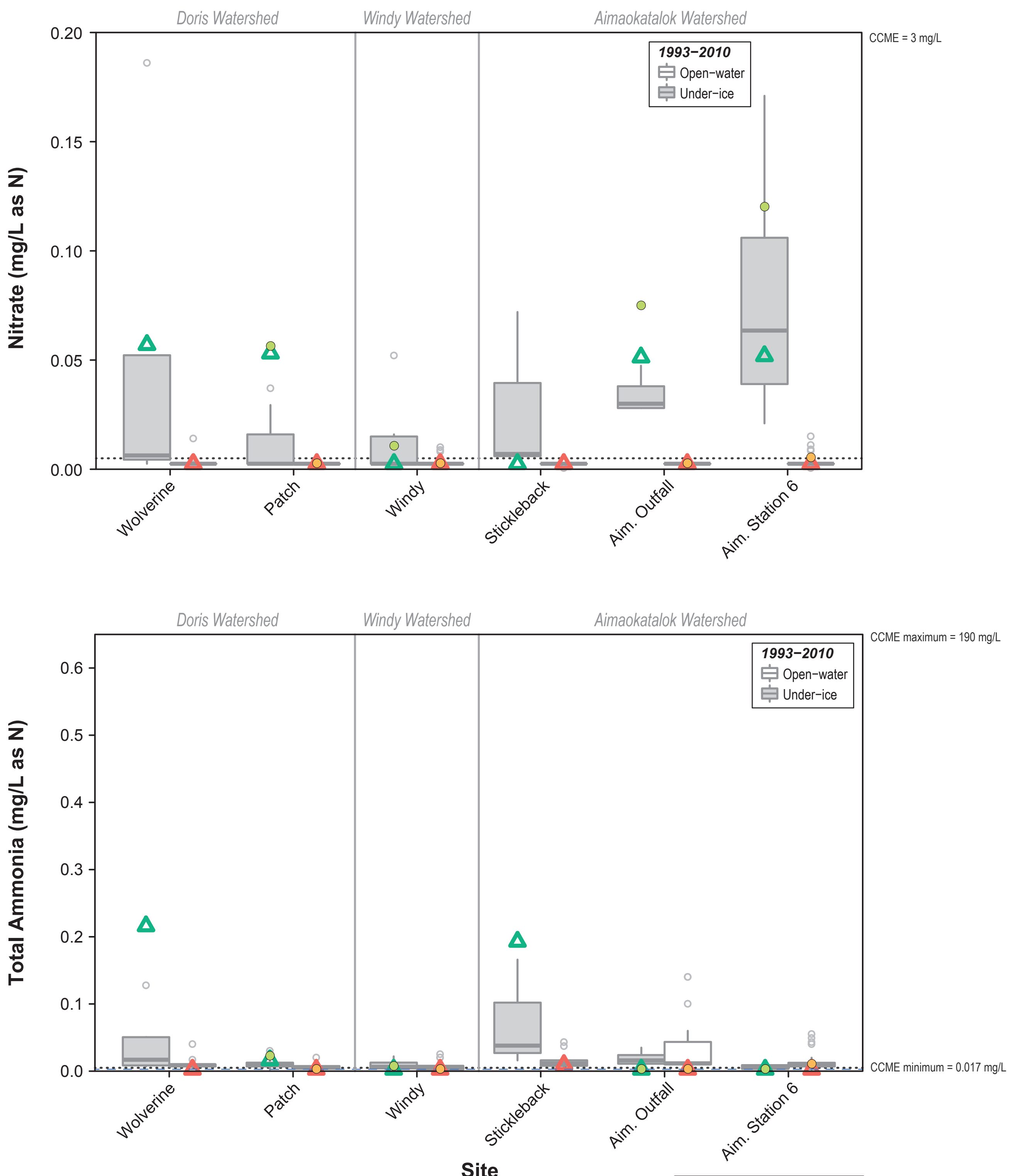
Chloride and Fluoride Concentrations, Madrid-Boston, 1993 to 2017



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.

Figure 3.2-6

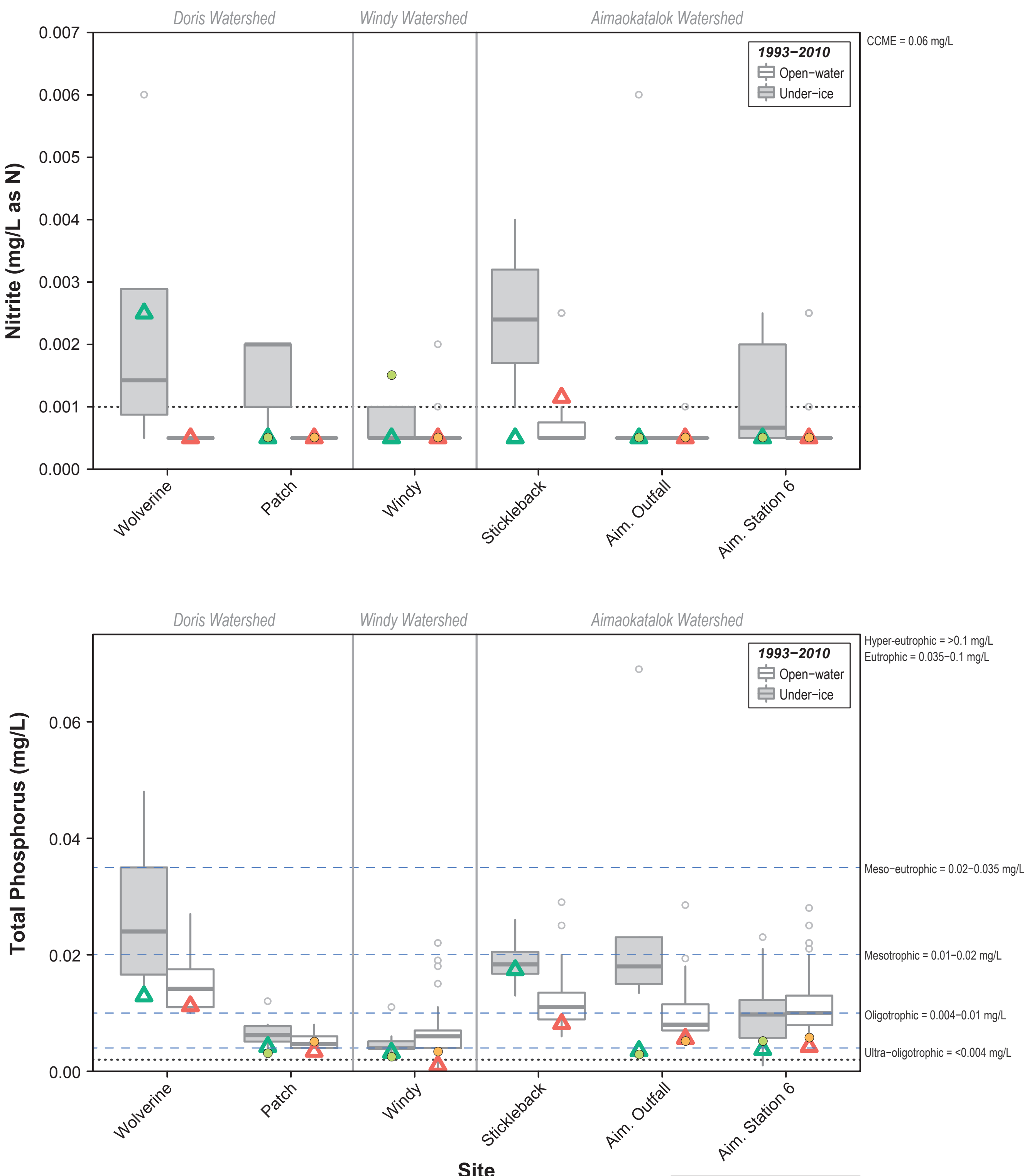
Nitrate and Total Ammonia Concentrations, Madrid-Boston, 1993 to 2017



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.

Figure 3.2-7

Nitrite and Total Phosphorus Concentrations, Madrid-Boston, 1993 to 2017



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.

3.2.5 Total Organic Carbon

TOC was generally consistent between sample depths within a lake but variable among lakes and between seasons in 2017 (range = <0.5 to 13.7; Figure 3.2-8). TOC concentrations were consistently higher during the under-ice season of 2017 compared with the open-water season and generally lowest in Windy Lake. The highest TOC concentrations were observed in Wolverine and Stickleback lakes during the under-ice season, these observations likely correspond with elevated primary producer biomass being present in these lakes at this time in addition to the effect of solute exclusion on dissolved organic carbon (Figure 3.2-8; Section 3.4).

Compared with historical data, concentrations of TOC in 2017 were often higher than 1.5 times the IQR of historical data. However, patterns across lakes and seasons in 2017 were similar to patterns observed historically (Figure 3.2-8).

3.2.6 Cyanide

Free cyanide was below detection limits (<0.001 mg/L) in all samples collected in 2017 (Figure 3.2-8). No historical data are available for free cyanide.

3.2.7 Metals

The study lakes had low levels of many metals (cadmium, chromium, lead, mercury, selenium, silver, thallium, and zinc), and concentrations were frequently below detection limits in 2017 (Figures 3.2-9 to 3.2-16). Concentrations of metals were generally similar between sample depths within a lake but sometimes variable between seasons. Most metals increased during the under-ice season due to solute exclusion during ice formation and changes in reduction-oxidation chemistry, particularly in the small, shallow lakes (Stickleback and Wolverine lakes).

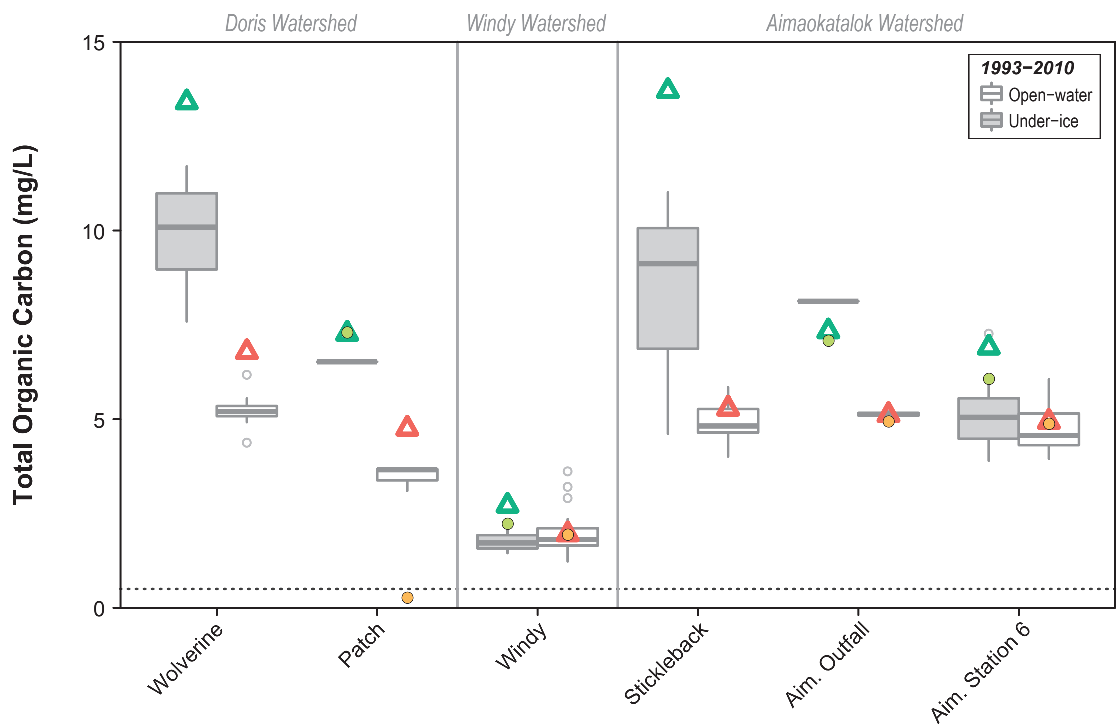
In general, metals concentrations measured in 2017 agreed well with historical data (2017 data were within 1.5 times the IQR of historical data), though there were a few exceptions. Lead and selenium concentrations were often lower than historical levels. In contrast, iron concentrations in Stickleback Lake were much higher during the 2017 under-ice season compared to historical measurements (Figures 3.2-9 to 3.2-16).

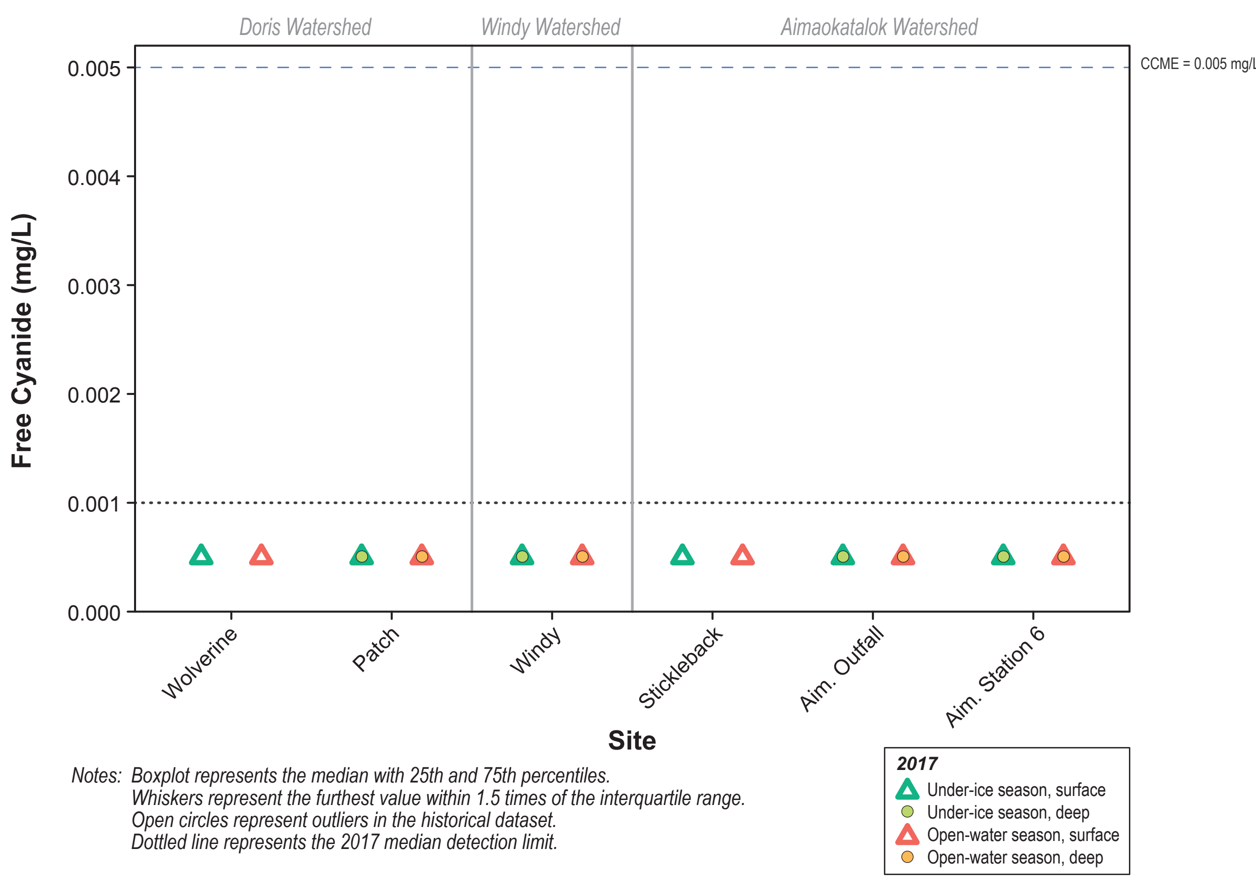
3.2.8 Comparison with CCME Guidelines

Table 3.2-2 presents the percentage of the 2017 water samples in which parameter concentrations were higher than CCME guidelines and the factor by which the mean concentrations exceeded the guidelines. The 2017 means for most water quality parameters (i.e., pH, fluoride, nitrate, total ammonia, nitrite, free cyanide, aluminum, arsenic, boron, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, silver, thallium, uranium, and zinc) were lower than CCME guidelines. Mean chloride concentrations were higher than the CCME guideline of 120 mg/L by a factor of 1.4 in Wolverine Lake and 1.03 in Stickleback Lake during the under-ice season of 2017. Mean total iron concentrations were also higher than the CCME guideline of 0.3 mg/L during the under-ice season at these two locations, by factors of 2.1 and 4.2.

Figure 3.2-8

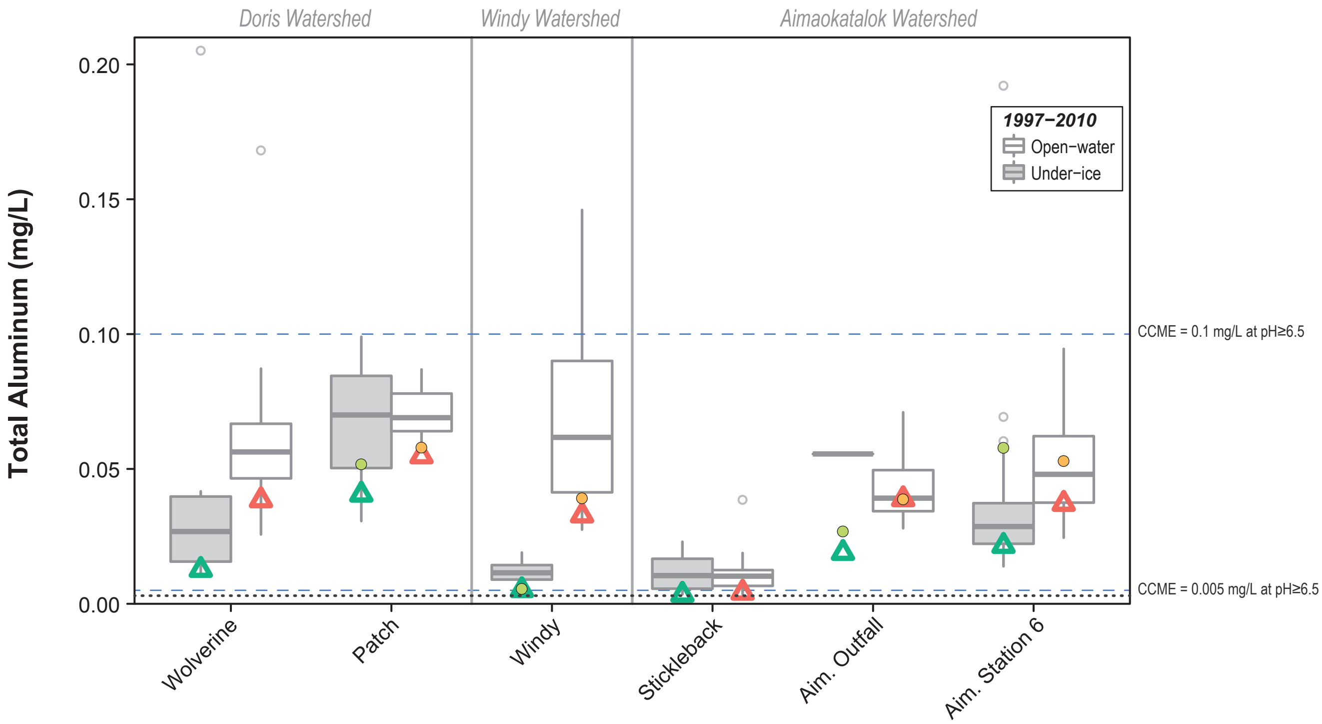
Total Organic Carbon and Free Cyanide Concentrations, Madrid-Boston, 1993 to 2017

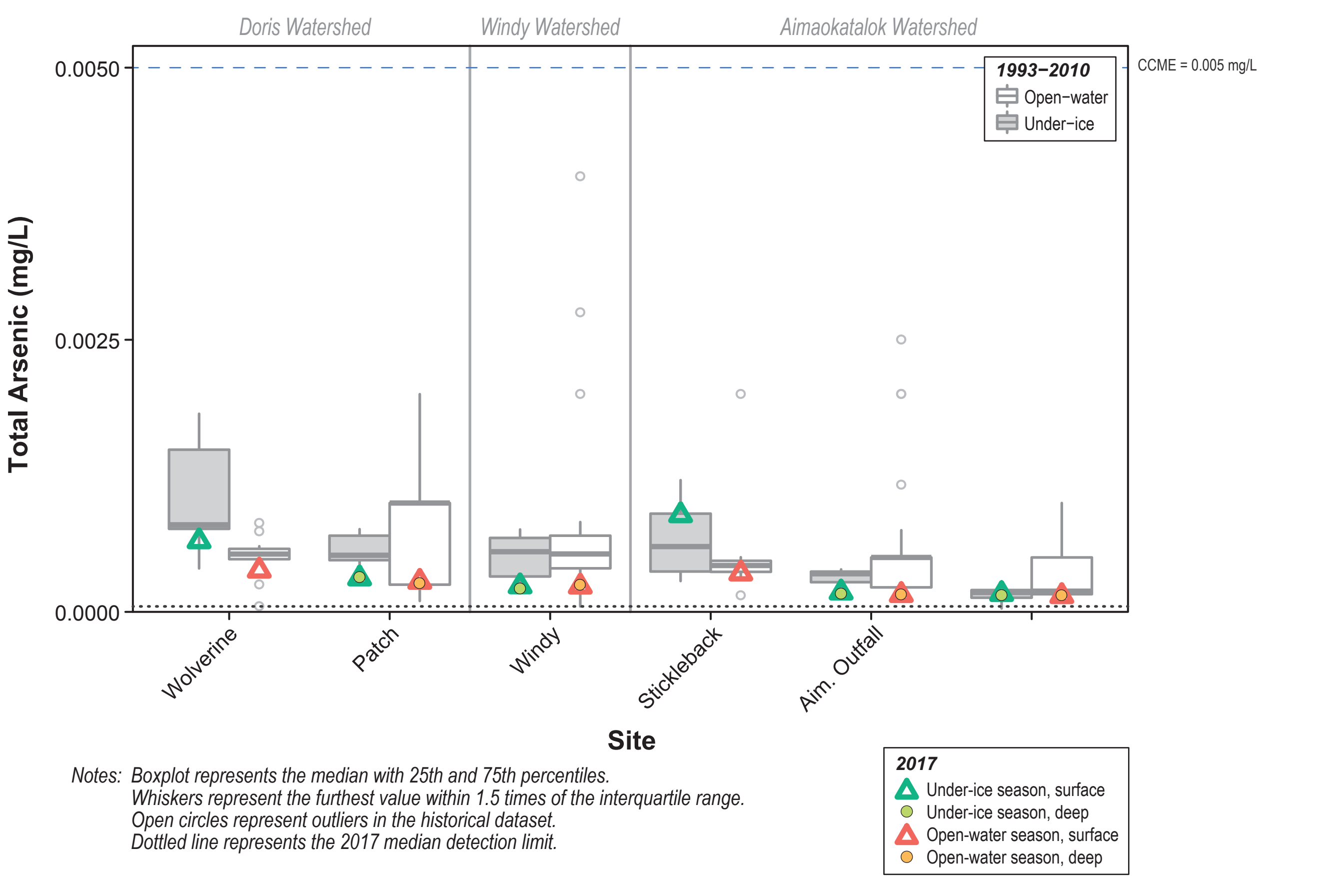




Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.

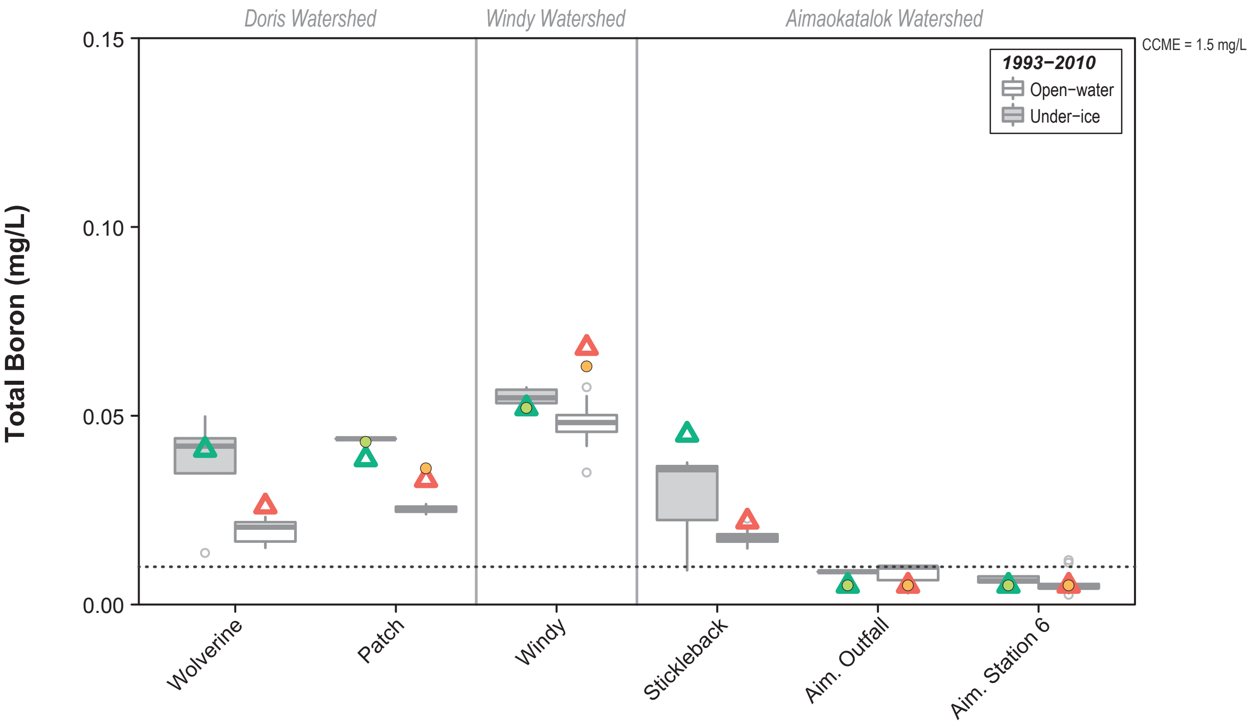
Figure 3.2-9
Total Aluminum and Total Arsenic Concentrations, Madrid-Boston, 1994 to 2017

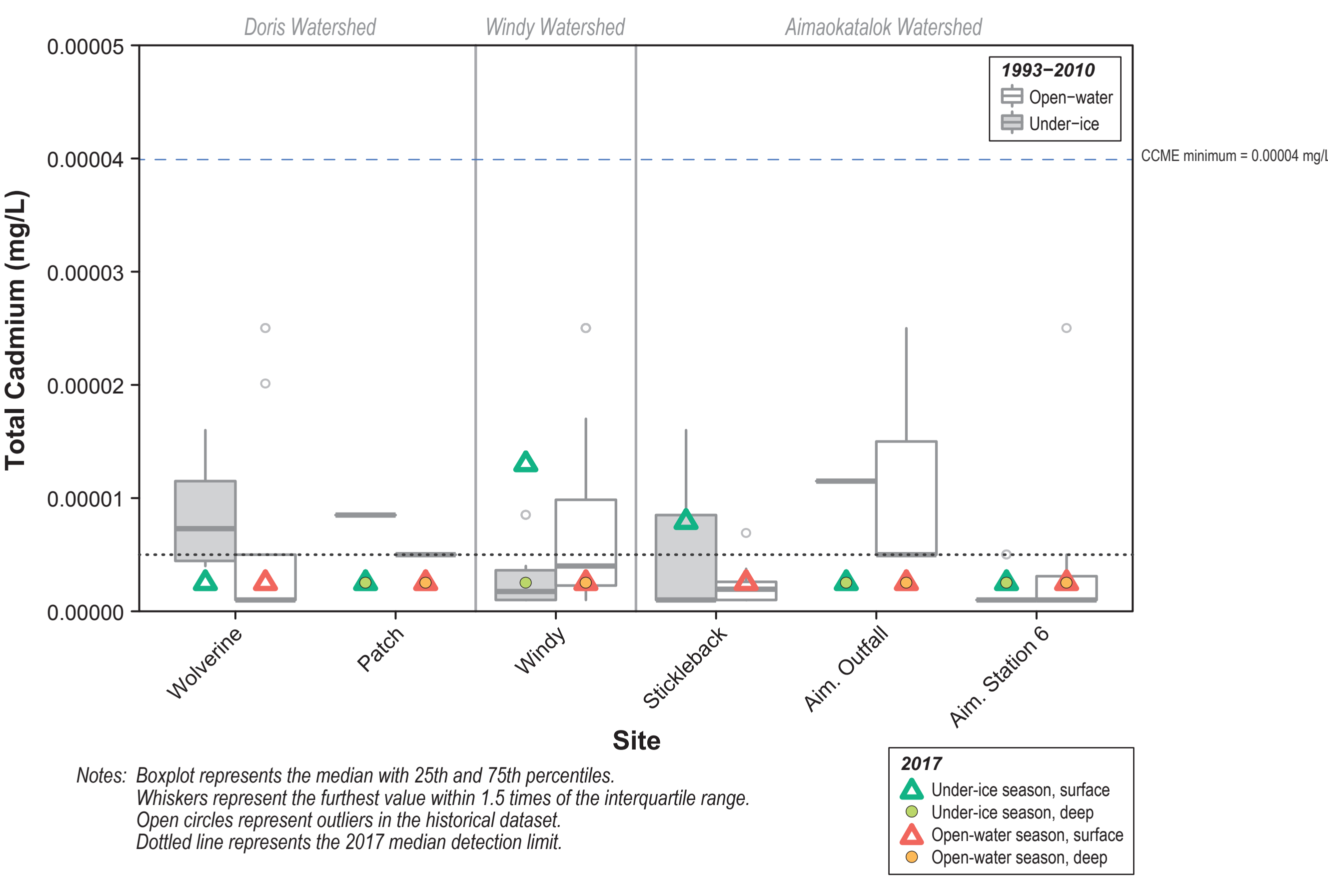




Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.

Total Boron and Total Cadmium Concentrations, Madrid-Boston, 1993 to 2017

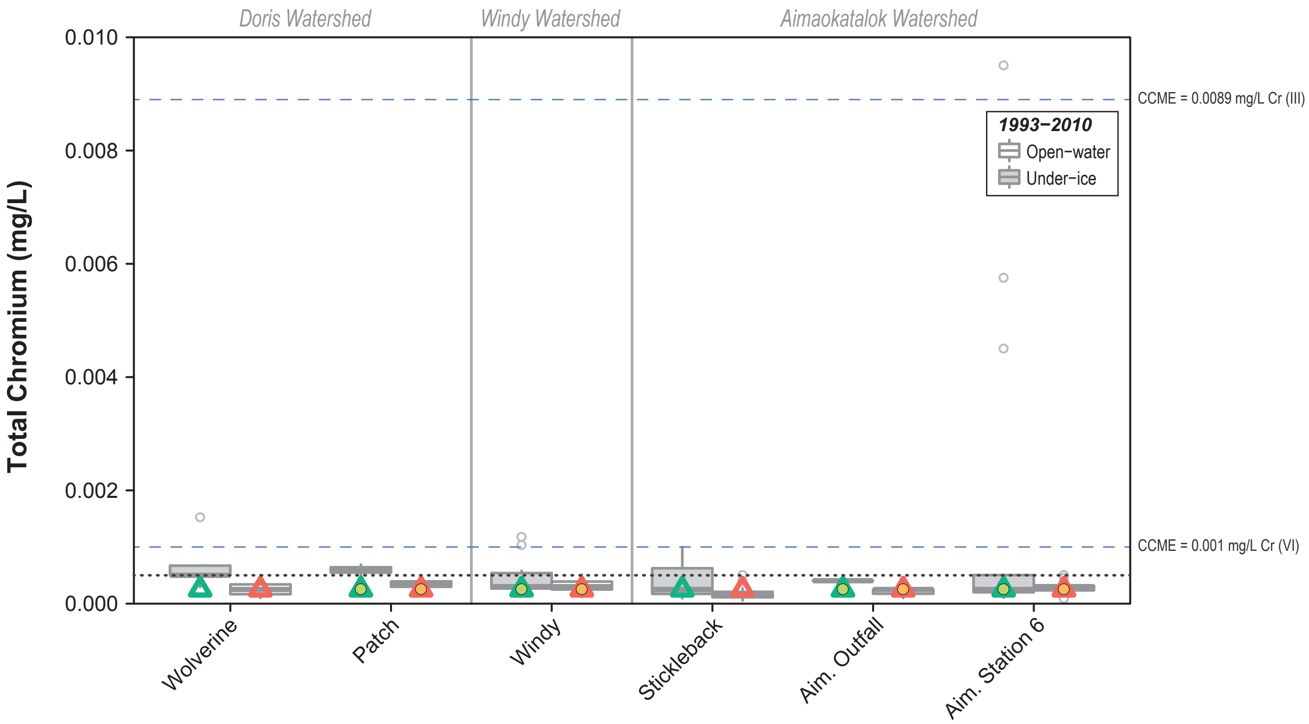


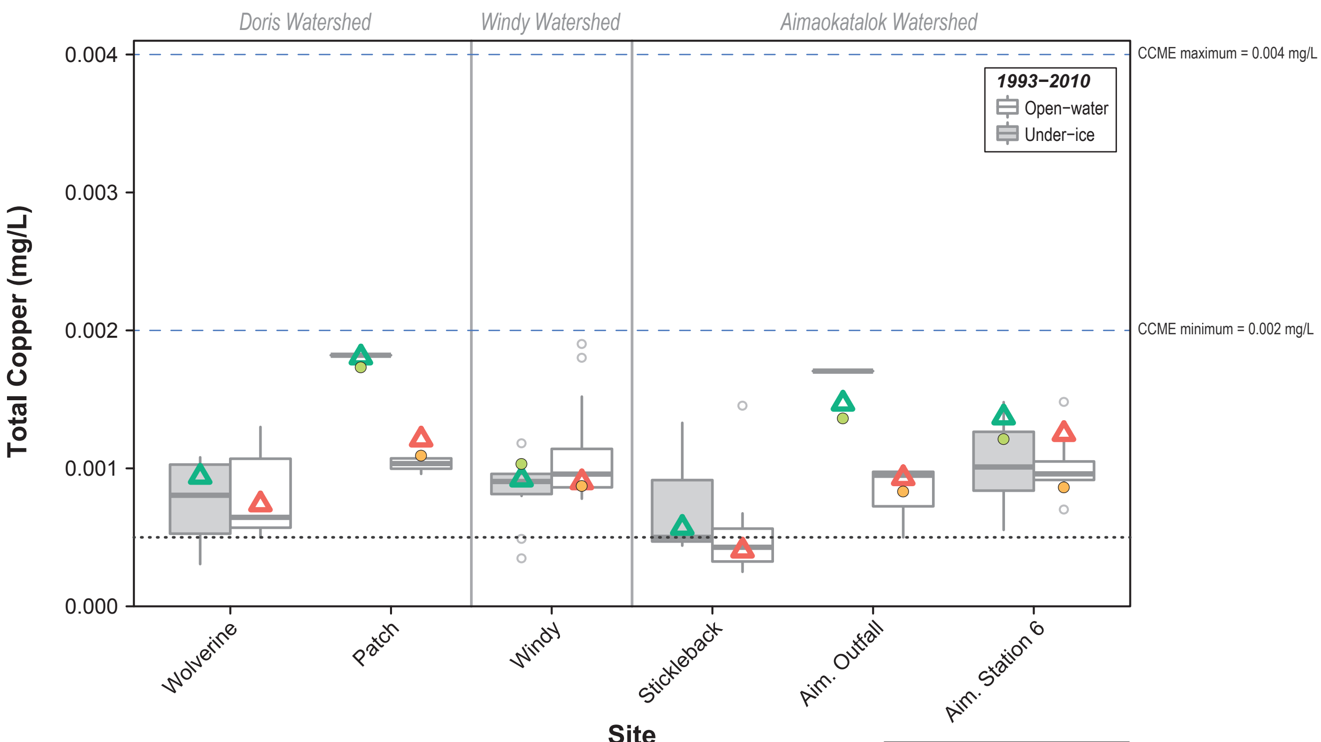


Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.

Figure 3.2-11

Total Chromium and Total Copper Concentrations, Madrid-Boston, 1993 to 2017



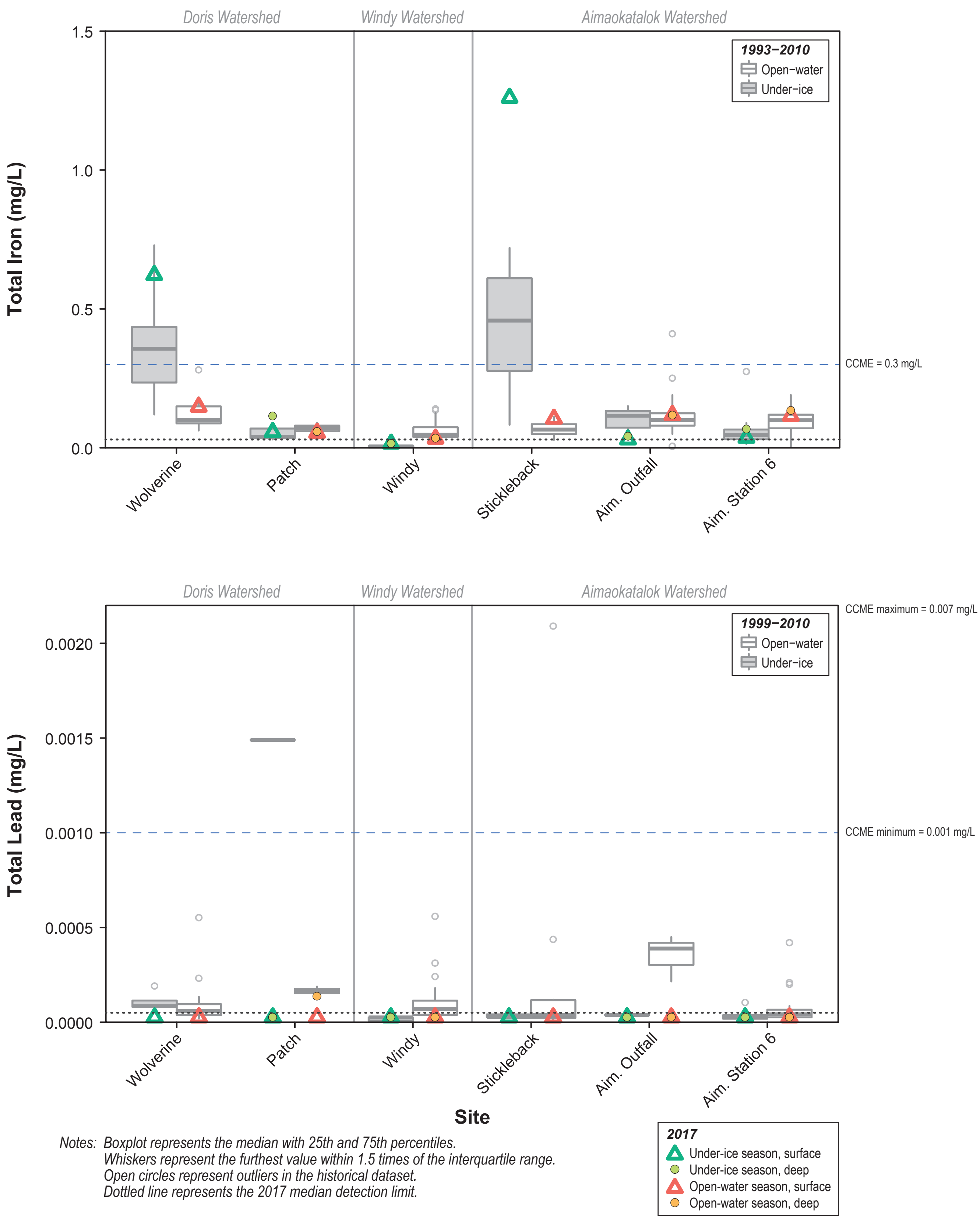


Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.

2017
- Under-ice season, surface
- Under-ice season, deep
- Open-water season, surface
- Open-water season, deep

Figure 3.2-12

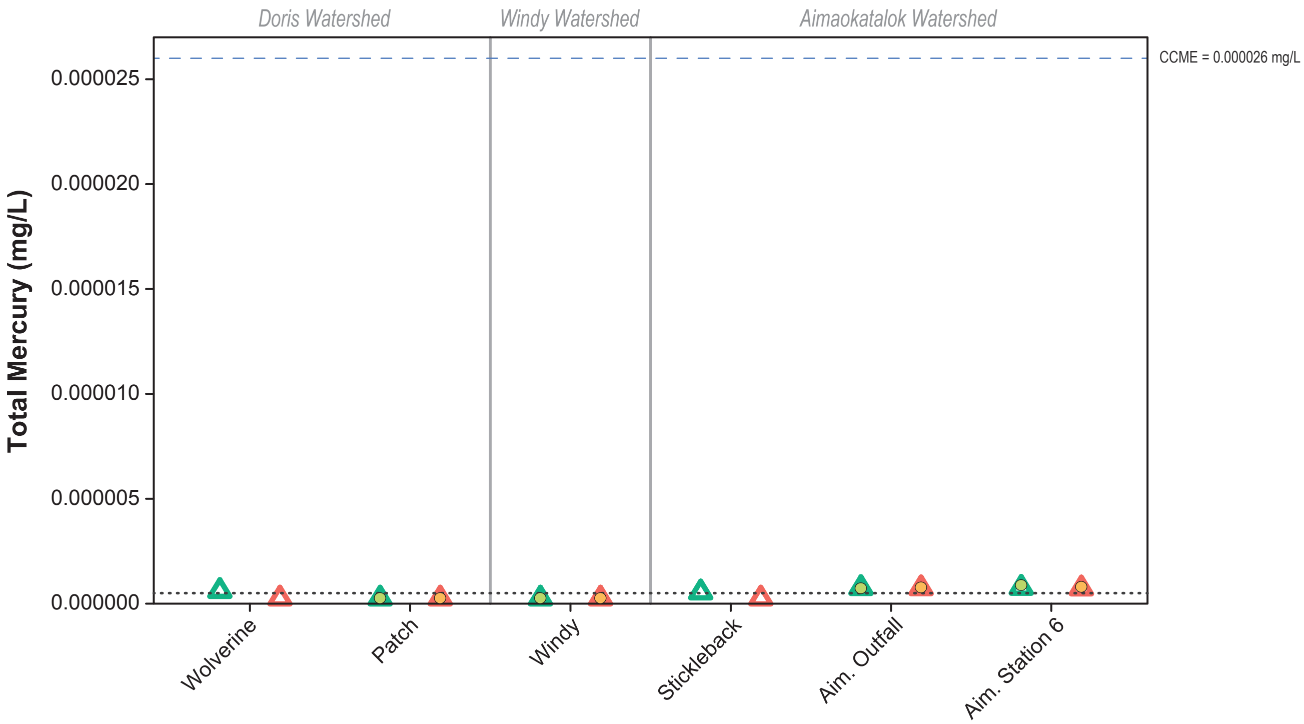
Total Iron and Total Lead Concentrations, Madrid-Boston, 1993 to 2017

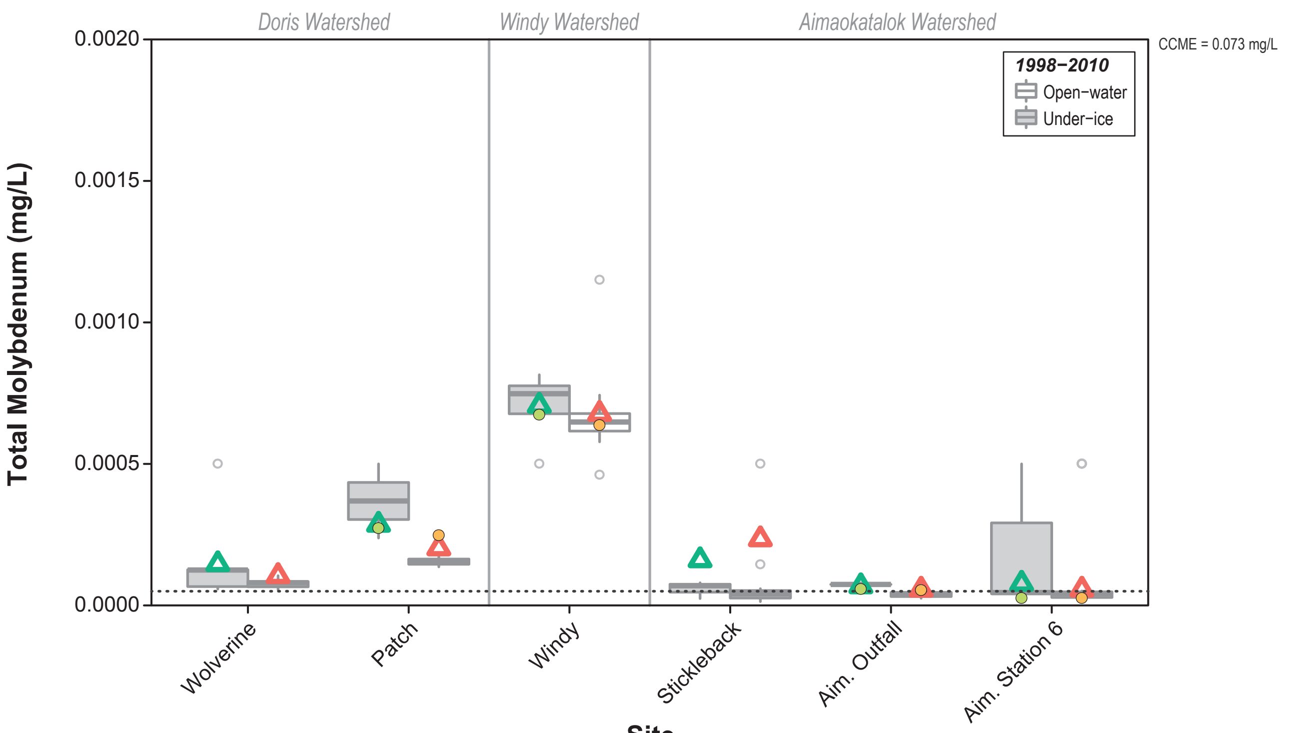


Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.

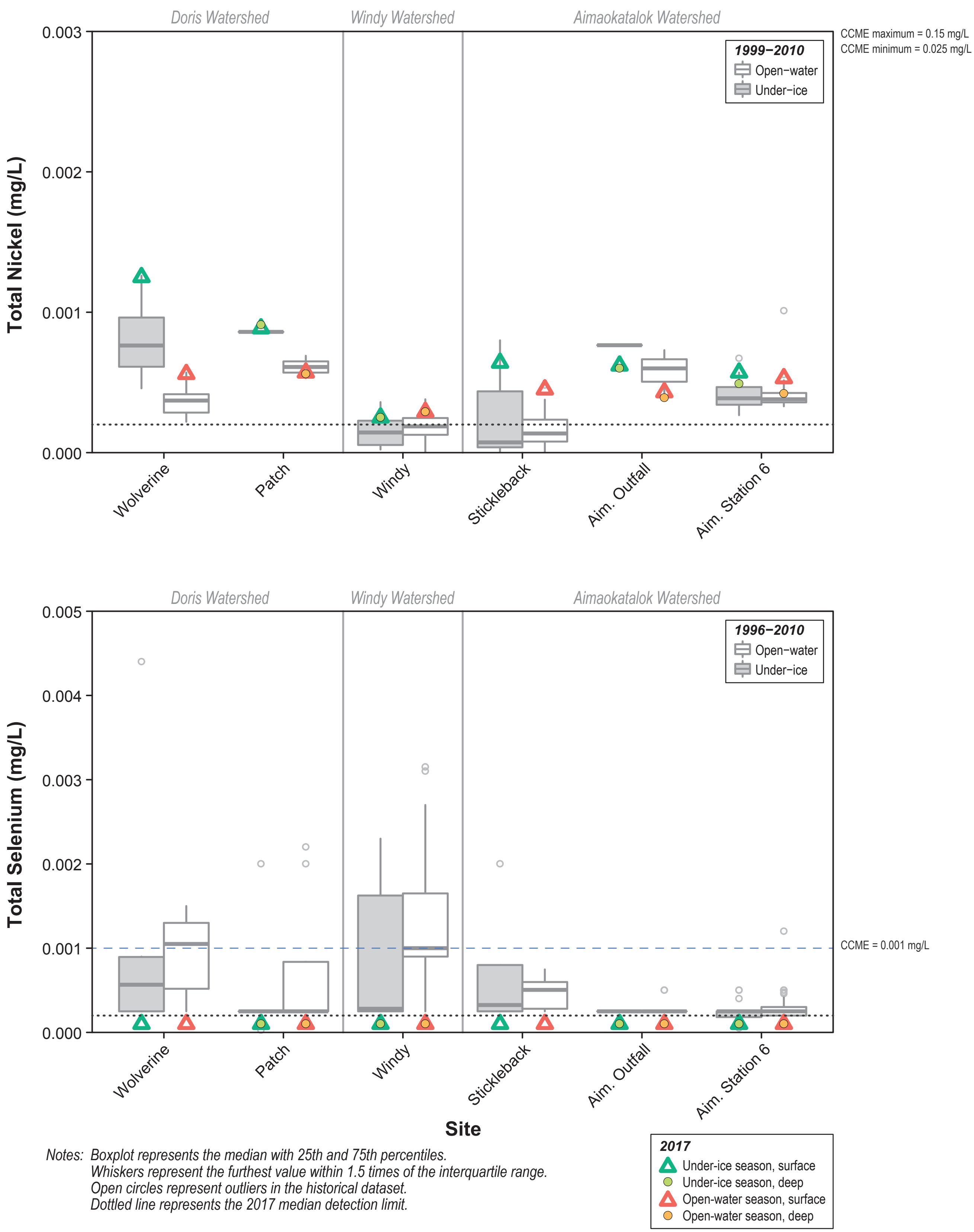
Figure 3.2-13

Total Mercury and Total Molybdenum Concentrations, Madrid-Boston, 1998 to 2017





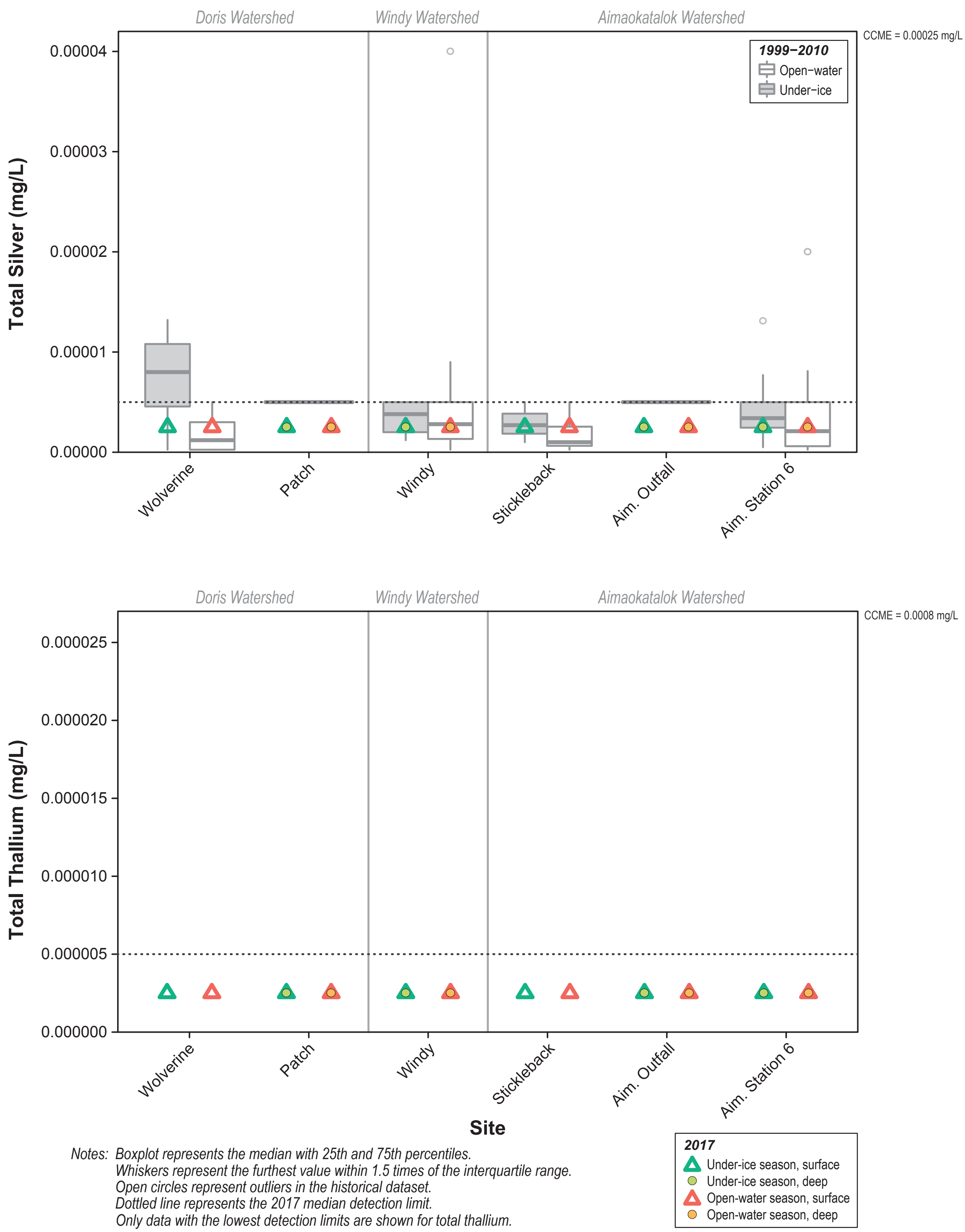
Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.
Only data with the lowest detection limits are shown for total mercury.



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.

Figure 3.2-15

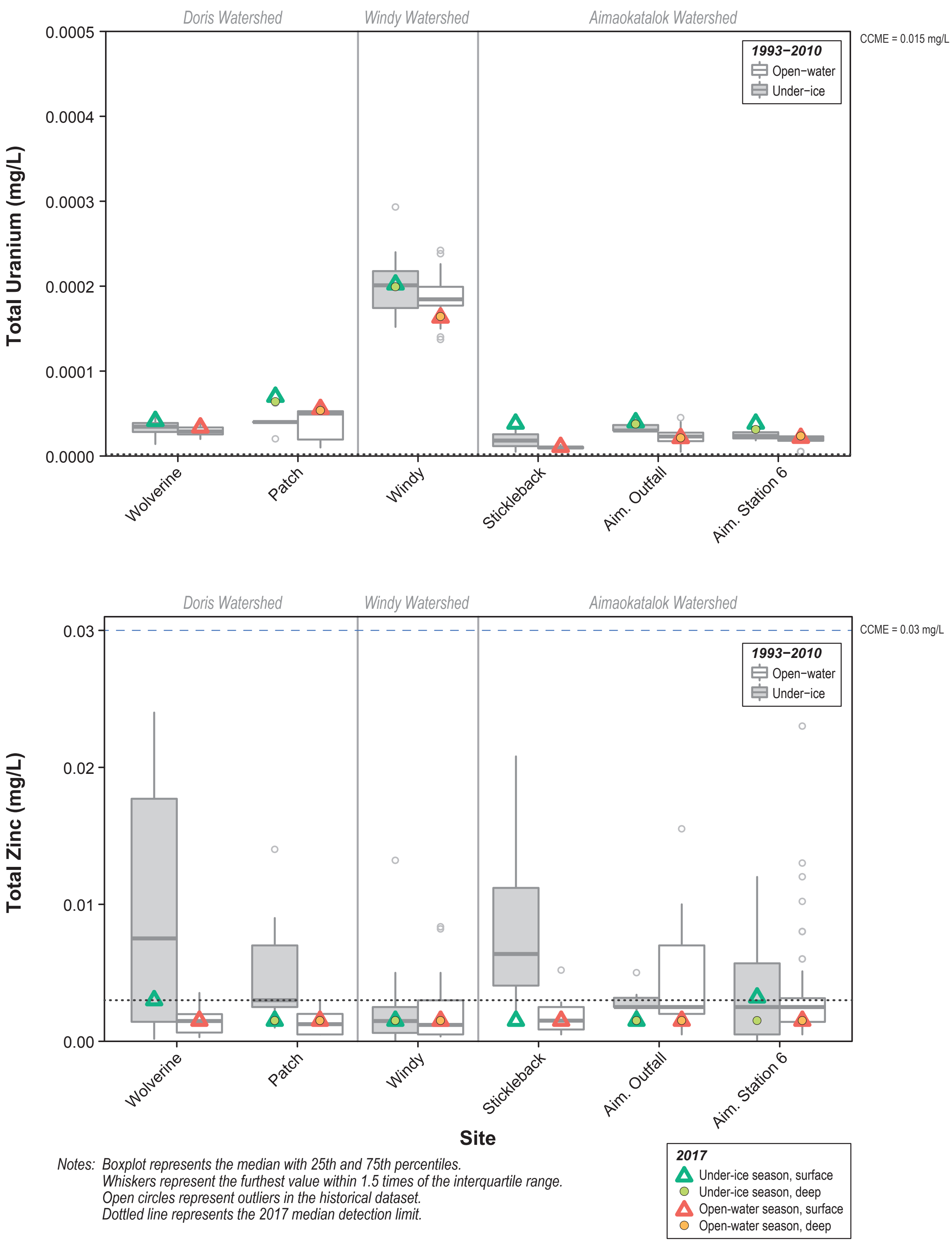
Total Silver and Total Thallium Concentrations, Madrid-Boston, 1999 to 2017



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.
Only data with the lowest detection limits are shown for total thallium.

Figure 3.2-16

Total Uranium and Total Zinc Concentrations, Madrid-Boston, 1993 to 2017



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.

Table 3.2-2. Comparison of Water Quality Data against CCME Guidelines, Madrid-Boston, 2017

CCME Guideline		Total Phosphorus	Chloride (Cl) 120 mg/L		Total Iron (Fe) 0.3 mg/L	
Site	Samples	Range	Factor	Percent	Factor	Percent
Wolverine	2	Mesotrophic	1.4	50%	2.1	50%
Patch	4	Ultra-oligotrophic - Oligotrophic	-	0%	-	0%
Windy	4	Ultra-oligotrophic	-	0%	-	0%
Stickleback	2	Oligotrophic - Mesotrophic	1.03	50%	4.2	50%
Aimaokatalok Outfall	4	Ultra-oligotrophic - Oligotrophic	-	0%	-	0%
Aimaokatalok Station 6	4	Oligotrophic	-	0%	-	0%

Notes:
Table includes total phosphorus trophic ranges and guidelines that were exceeded in 2017, only.
CCME guideline = CCME guideline for the protection of aquatic life.
Factor represents the factor by which average sample concentrations were greater than guideline concentrations.
Percent represents the percentage of replicates collected at each site that were greater than guidelines.

Historical concentrations were also typically lower than CCME guidelines for most water quality parameters (Figures 3.2-1 to 3.2-16). Similar to 2017, some historical under-ice concentrations of chloride and total iron were higher than the CCME guideline in Wolverine and Stickleback lakes (Figures 3.2-5 and 3.2-12). One historical sample from Patch Lake was also higher than the CCME chloride guideline and one historical sample from the Aimaokatalok Outfall site was also higher than the CCME iron guideline (Figures 3.2-5 and 3.2-12). Though not observed in 2017, concentrations of other water quality parameters were higher than CCME guidelines in some historical samples: pH, fluoride, aluminum, chromium, lead, and selenium. Historical exceedances of these guidelines were also generally infrequent, except fluoride in Wolverine Lake, which was often higher than the CCME guideline of 0.12 mg/L and total selenium in Windy and Wolverine lakes, which were often higher than the CCME guideline of 0.001 mg/L (Figures 3.2-5 and 3.2-14).

3.3 SEDIMENT QUALITY

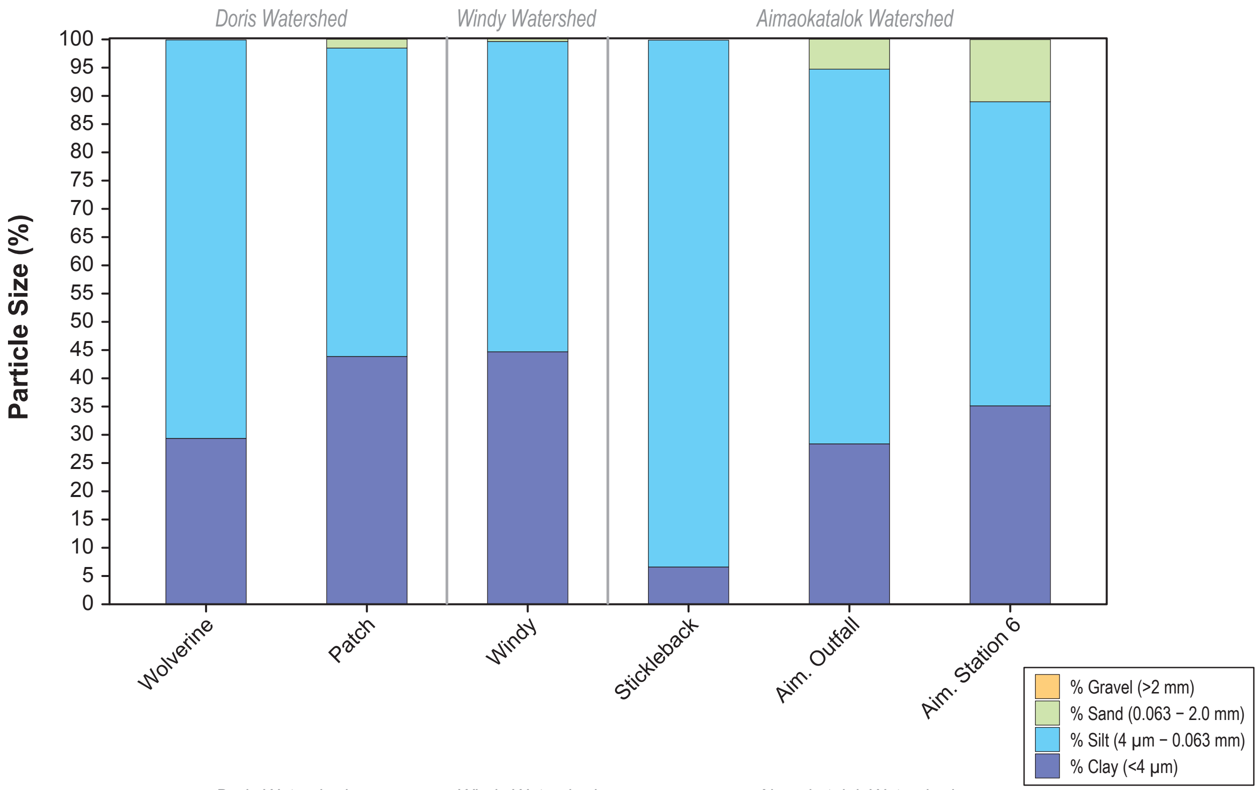
Sediment quality samples were collected between August 16 and 21, 2017 (Table 3.3-1). Results for sediment quality samples collected in 2017 are provided in Appendix 3.3-1. Sediment descriptions and photographs are presented in Appendices 3.3-2 and 3.3-3. Select parameters are presented in Figures 3.3-1 to 3.3-5 and discussed relative to historical data. Historical sediment quality data are available in Rescan (2010, 2011).

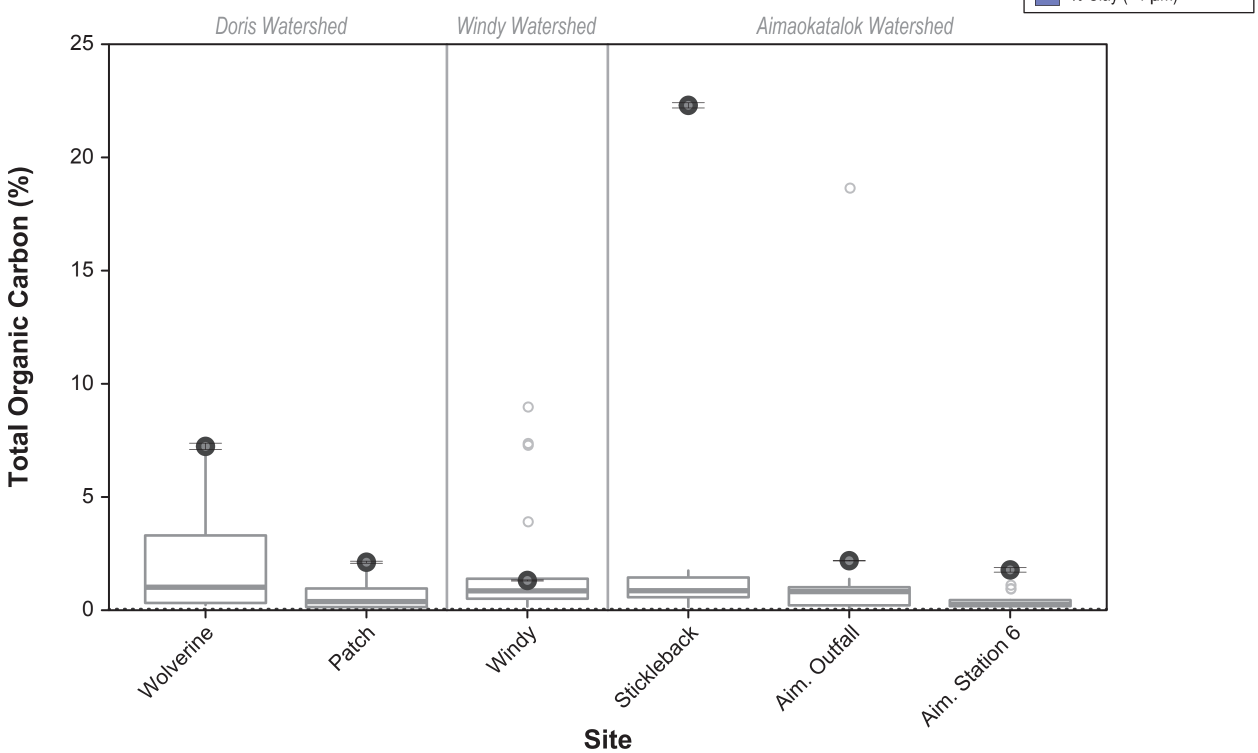
3.3.1 Particle Size

Particle size distribution was similar at all sites sampled in 2017 (Figure 3.3-1) as the sediments were largely made up of silt and clay. Sand was present in smaller proportions (mean ≤ 11%) in Patch and Aimaokatalok lakes and undetectable at other sites. No gravel was detected in any sample.

Figure 3.3-1

Particle Size and Total Organic Carbon in Sediments, Madrid-Boston, 1993 to 2017





Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.
Error bars on closed circles represent the standard error of the mean of the samples collected in 2017.

Table 3.3-1. Sediment Quality and Benthic Invertebrate Sampling Dates and Depths, Madrid-Boston, 2017

Sampling Location	Site	Open-water Season	Sediment and Benthos Depth Range (m)
Doris Watershed			
Wolverine Lake	Wolverine	August 20, 2017	3.8 – 4.0
Patch Lake	Patch	August 19 and 20, 2017[a]	7.7 – 8.4
Windy Watershed			
Windy Lake	Windy	August 19 and 21, 2017[a]	17.6 – 17.7
Aimaokatalok Watershed			
Stickleback Lake	Stickleback	August 16, 2017	2.3 – 2.4
Aimaokatalok Lake	Outfall	August 18, 2017	8.3 – 8.8
	Station 6	August 18, 2017	24.4 – 27.5

Notes:
[a] *Two replicate sediment samples and four replicate benthos samples were collected on August 20 (Patch Lake) and August 21 (Windy Lake) due to poor weather. All other sampling was completed August 19.*

3.3.2 Total Organic Carbon

Mean sediment TOC content generally followed the same pattern as particle size in 2017, with the lakes having the highest proportion of silt containing the highest percentages of TOC (Wolverine and Stickleback lakes; Figure 3.3-1). The TOC content measured in 2017 was generally higher than historical levels, except in Windy Lake where it was similar (Figure 3.3-1).

3.3.3 Metals

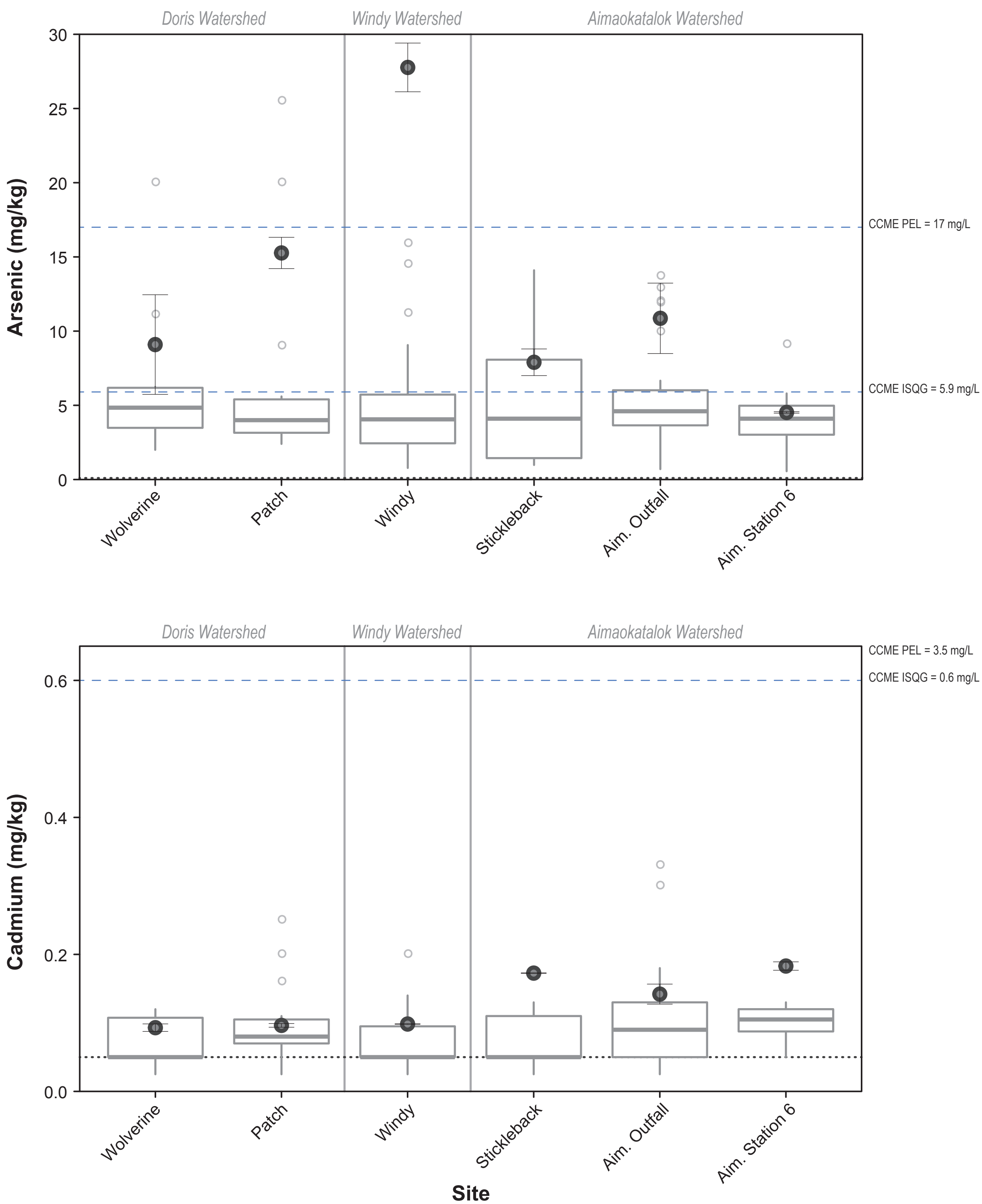
Metals presented in Figure 3.3-1 to 3.3-5 include those with CCME sediment quality guidelines (i.e., arsenic, cadmium, chromium, copper, lead, mercury, and zinc); data are compared to CCME guidelines in Section 3.3.4.

Mean concentrations of sediment cadmium, copper, lead, mercury, and zinc were similar among sites in 2017 likely reflecting their similarities in particle size. Arsenic and chromium were more variable across sites and differences did not reflect patterns in particle size (Figures 3.3-1 to 3.3-5).

Generally, the 2017 sediment metals data were consistent with the historical data (mean of 2017 replicates within 1.5 times the IQR of historical data), though arsenic, cadmium, copper and mercury concentrations in some lakes were higher than 1.5× the IQR and/or any previously measured concentration (Figures 3.3-2 to 3.3-4).

Figure 3.3-2

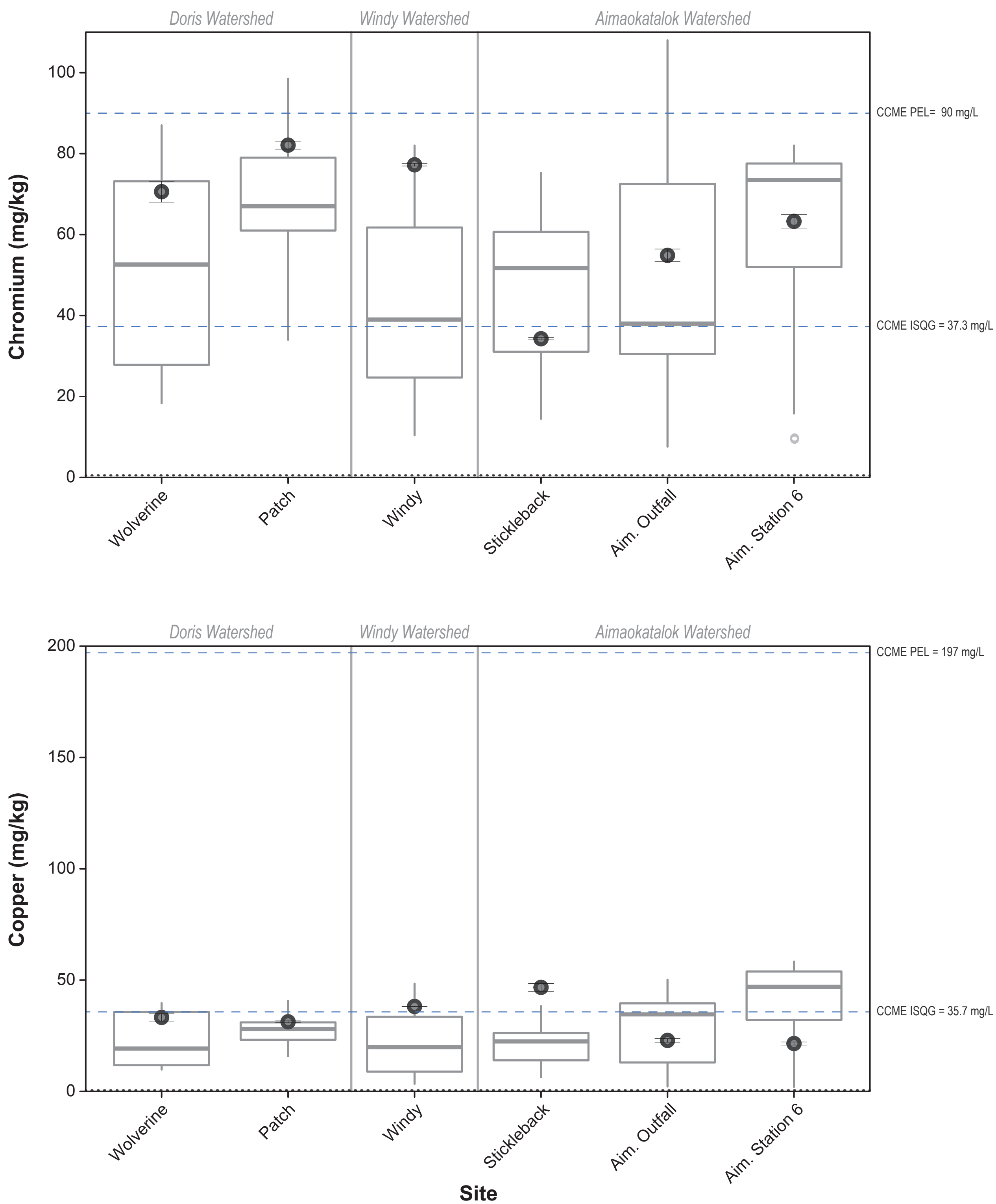
Arsenic and Cadmium Concentrations in Sediments, Madrid-Boston, 1993 to 2017



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.
Error bars on closed circles represent the standard error of the mean of the samples collected in 2017.

Figure 3.3-3

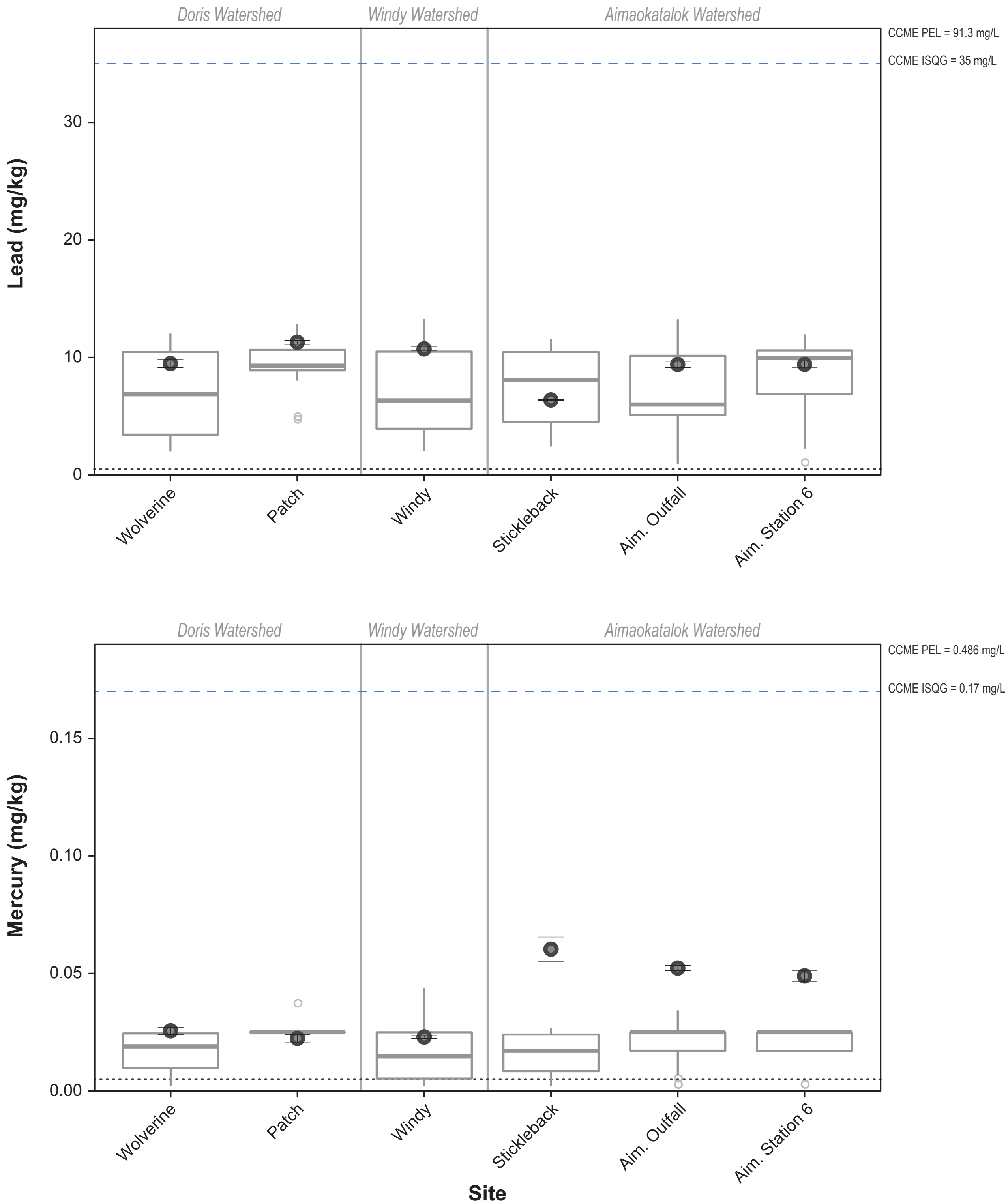
Chromium and Copper Concentrations in Sediments, Madrid-Boston, 1993 to 2017



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.
Error bars on closed circles represent the standard error of the mean of the samples collected in 2017.

Figure 3.3-4

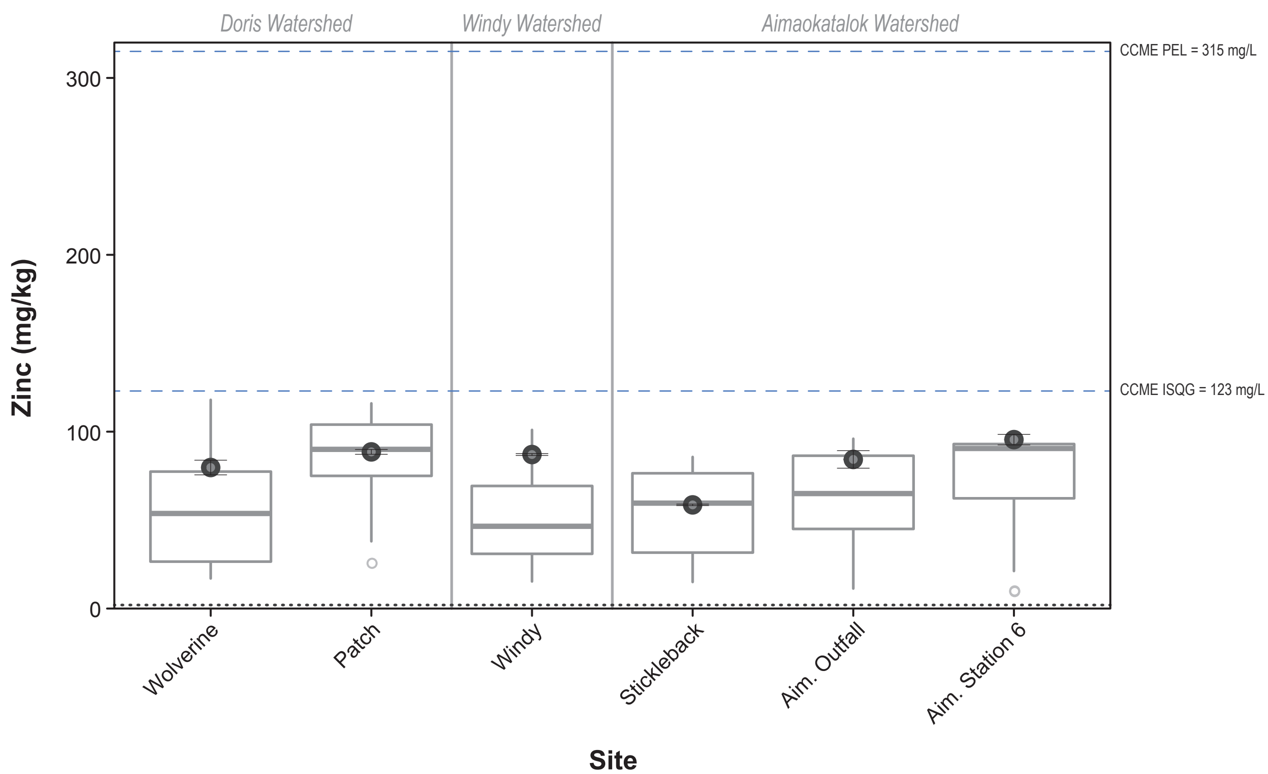
Lead and Mercury Concentrations in Sediments, Madrid-Boston, 1993 to 2017



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.
Error bars on closed circles represent the standard error of the mean of the samples collected in 2017.

Figure 3.3-5

Zinc Concentrations
in Sediments, Madrid-Boston, 1993 to 2017



Notes: Boxplot represents the median with 25th and 75th percentiles.
Whiskers represent the furthest value within 1.5 times of the interquartile range.
Open circles represent outliers in the historical dataset.
Dottled line represents the 2017 median detection limit.
Error bars on closed circles represent the standard error of the mean of the samples collected in 2017.

3.3.4 Comparison with CCME Guidelines

Table 3.3-2 presents the percentage of the 2017 sediment samples in which metal concentrations were higher than their CCME guidelines and the factor by which the mean concentrations exceeded the guidelines. Wolverine and Windy lake sediments tended to exceed the most guidelines. Concentrations of arsenic in sediments ranged from below the ISQG of 5.9 mg/kg to 4.7 times higher. With the exception of Aimaokatalok Station 6, two or three sediment replicates collected from each site contained arsenic concentrations higher than the ISQG. Arsenic concentrations in Windy Lake were greater than the PEL of 17 mg/kg in all samples collected (Figure 3.3-2; Table 3.3-2). Sediment chromium concentrations ranged from below the ISQG of 37.3 mg/kg to 2.2 times higher. With the exception of Stickleback Lake, where chromium concentrations were lower, all sediment samples collected contained chromium concentrations greater than the ISQG but lower than the PEL of 90 mg/kg (Figure 3.3-3; Table 3.3-2). Sediment copper concentrations were slightly higher (factor = ≤1.3) than the ISQG of 35.7 mg/kg in one or more samples collected from Wolverine, Windy, and Patch lakes. Copper concentrations in sediments were lower than the PEL of 197 mg/kg at all sites sampled (Figure 3.3-3; Table 3.3-2). Concentrations of cadmium, lead, mercury, and zinc in sediments were less than the ISQG and PEL at all sites (Figures 3.3-2, 3.3-4, and 3.3-5).

Table 3.3-2. Comparison of Sediment Quality Data against CCME Guidelines, Madrid-Boston, 2017

CCME Guideline		Arsenic (As)				Chromium (Cr)		Copper (Cu)	
		ISQG 5.9 mg/kg		PEL 17 mg/kg		ISQG 37.3 mg/kg		ISQG 35.7 mg/kg	
Site	Replicates	Factor	Percent	Factor	Percent	Factor	Percent	Factor	Percent
Wolverine	3	1.8	67%	-	0%	1.9	100%	1.003	33%
Patch	3	2.6	100%	-	0%	2.2	100%	-	0%
Windy	3	4.7	100%	1.6	100%	2.1	100%	1.1	100%
Stickleback	3	1.3	100%	-	0%	-	0%	1.3	100%
Aimaokatalok Outfall	3	1.8	100%	-	0%	1.5	100%	-	0%
Aimaokatalok Station 6	3	-	0%	-	0%	1.7	100%	-	0%

Notes:
CCME guideline = CCME guideline for the protection of aquatic life; ISQG = interim sediment quality guideline;
PEL = probable effects level
Table includes guidelines that were exceeded in 2017 only.
Factor represents the factor by which average sample concentrations were greater than guideline concentrations.
Percent represents the percentage of replicates collected at each site that were greater than guidelines.

Observations of elevated arsenic, chromium, and copper in sediment are generally consistent with historical data (Figures 3.3-2 to 3.3-5). In general, concentrations of arsenic, chromium and copper higher than the ISQG were observed at the same sites in 2017 as historically. Exceptions include arsenic concentrations at Aimaokatalok Station 6 where one historical sample was higher than the ISQG but no samples were higher in 2017, chromium concentrations in Stickleback Lake which were higher than the ISQG historically but lower than the ISQG in 2017, and copper concentrations in

Stickleback Lake which were higher than the ISQG in 2017 but lower than the ISQG historically (Figures 3.3-2 to 3.3-5). Concentrations of arsenic and chromium higher than the PEL were infrequent both historically and in 2017, with the exception of arsenic in Windy Lake where all samples collected in 2017 were higher than the PEL but no historical samples were higher (Figures 3.3-2 and 3.3-3). Sediment copper concentrations were not higher than the PEL at any site either in 2017 or historically (Figure 3.3-3). Concentrations of sediment cadmium, lead, mercury and zinc lower than ISQG in 2017 are also consistent with historical data (Figures 3.3-2 to 3.3-5).

3.4 PRIMARY PRODUCER BIOMASS

Under-ice and open-water season primary producer biomass samples were collected between April 22 and 25, 2017 and August 16 to 20, 2017 (Table 3.2-1). Results for primary producer biomass samples collected in 2017 are provided in Appendix 3.4-1.

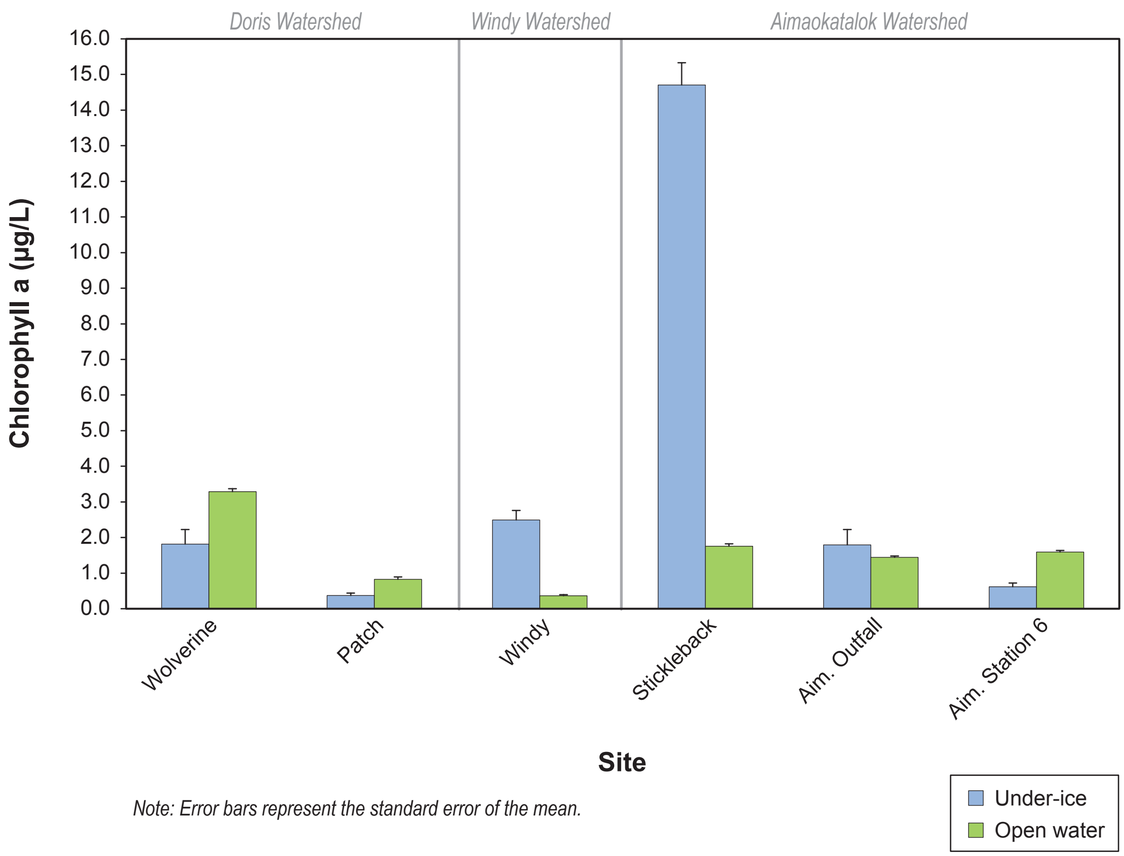
Mean primary producer biomass (as chl *a*) was variable among lakes and across seasons with no consistent patterns (Figure 3.4-1). Mean primary producer biomass was higher in Windy and Stickleback lakes and at the Aimaokatalok Outfall site during the under-ice season, but was greater in open water in Wolverine and Patch lakes and Aimaokatalok Station 6 (Figure 3.4-1). Low to moderate primary producer biomass was observed at all sites during both seasons (mean range = 0.37 to 3.29 µg/L), with one exception: the under-ice mean in Stickleback Lake (mean = 14.7 µg/L). No historical under-ice data exist for primary producer biomass in Stickleback Lake; therefore, it is uncertain whether the 2017 results represent typical under-ice primary producer biomass in this lake. Nutrient concentrations observed in Stickleback Lake during the under-ice season of 2017 were similar to concentrations observed in other lakes with the exception of total phosphorus, which was highest in Stickleback Lake (0.0174 mg/L). The elevated phosphorus levels in Stickleback Lake may have been driving the phytoplankton bloom under-ice in combination with the increasing photoperiod in April, which would increase overall light availability.

3.5 BENTHIC INVERTEBRATES

Benthic invertebrate samples were collected between August 16 and 21, 2017 (Table 3.3-1), with the results provided in Appendix 3.5-1. Figures 3.5-1 to 3.5-3 present benthos density, relative densities of the major taxonomic groups, and richness and diversity metrics calculated for enumerated assemblages from each site.

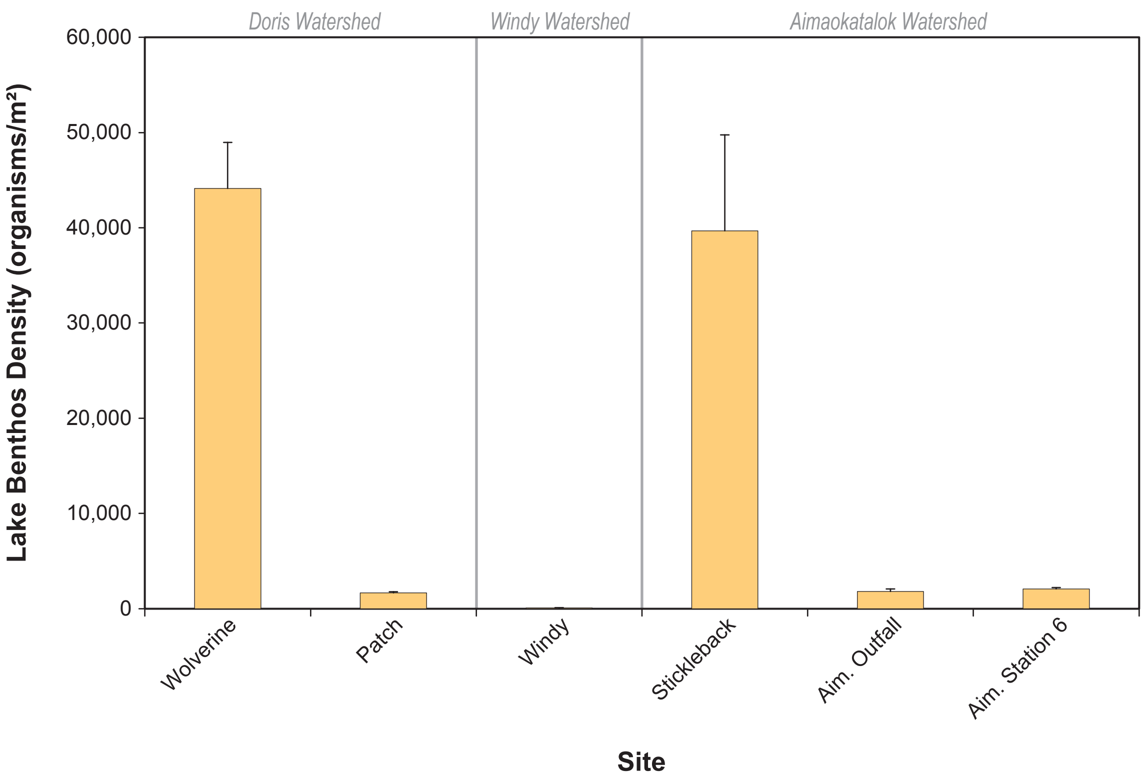
3.5.1 Density and Community Composition

Mean benthos density varied among lakes, ranging from 71 organisms/m^2 (Windy Lake) to 44,122 organisms/m^2 (Wolverine Lake; Figure 3.5-1). Mean benthos densities in the shallow (<5 m) Wolverine and Stickleback lakes (range = 39,668 to 44,122 organisms m^2) were much higher than the deeper lakes (range = 71 to 2,071 organisms m^2). Mean benthos densities were similar among Patch and Aimaokatalok lake sites (Figure 3.5-1).



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

Lake Benthos Density, Madrid-Boston, 2017



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

Figure 3.5-2 presents the taxonomic composition of the benthos assemblages by major taxonomic group. Benthic communities were dominated by dipterans (true flies; 60 to 77% of mean relative abundance) in the sampled lake, except Wolverine Lake and Aimaokatalok Station 6. Wolverine Lake was dominated by oligochaetes (segmented worms; 70% of mean relative abundance), while Aimaokatalok Station 6 was co-dominated by dipterans and pelecypods (bivalves; means of 45 and 49%, respectively). Pelecypods were also common at the Aimaokatalok Outfall site (mean of 21%) and Stickleback Lake (mean of 13%). Ostracods (seed shrimp) were common among sites (4 to 20% of mean relative abundance). Gastropods were only present at the shallow sites.

Overall, there were no clear patterns in benthos community composition among watersheds or sampling depths. Community composition also did not appear to be related to the total density of benthos organisms.

3.5.2 Richness and Diversity

Dipterans were typically the dominant taxonomic group in lake benthos communities (Figure 3.5-3). For this reason, benthic diversity (at the level of genus) was analyzed for both the whole community and the dipteran subset.

3.5.2.1 Community Richness and Diversity

Mean benthos genera richness ranged from three to 12 genera/sample, with a mean of eight genera/sample across sites (Figure 3.5-3). The lowest mean genera richness was in Windy Lake which is also had the lowest density of benthic invertebrates (Figure 3.5-1).

The sampled lakes had moderately diverse to diverse benthic communities, with mean Simpson's diversity indices ranging from 0.45 in Wolverine Lake to 0.80 at Patch, averaging 0.61 across all sites. There were no apparent correlations between benthos diversity and density, watersheds, or site depths (Figure 3.5-3).

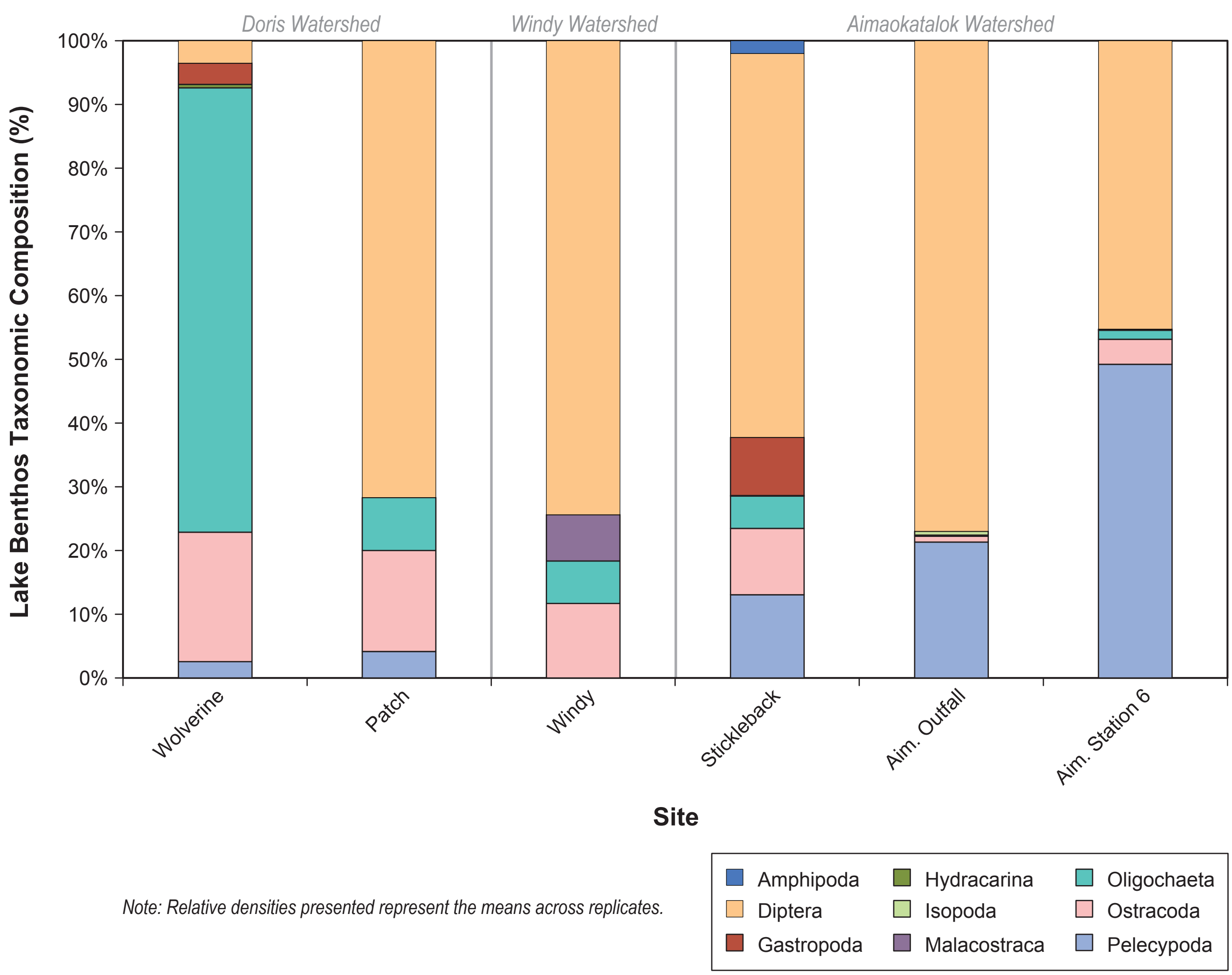
3.5.2.2 Dipteran Richness and Diversity

Mean dipteran genera richness ranged from 2 to 7 genera/sample, averaging 5 genera/sample across sites and accounting 50% or more of total genera richness at any given site (Figure 3.5-2). Although the benthic communities of Wolverine Lake and Aimaokatalok Station 6 were not dominated by dipterans, mean dipteran genera richness at these sites (5 genera/sample) were comparable to sites that were dominated by dipterans. The lowest mean dipteran richness was observed in Windy Lake (2 genera/sample), where the lowest density of benthic invertebrates was observed (Figure 3.5-1). As observed with whole community genera richness, dipteran genera richness was not related to the benthic invertebrate density at other sites.

Dipteran diversity ranged widely from 0.17 at the Aimaokatalok Outfall site to 0.69 in Patch Lake. There were no clear patterns between dipteran richness or diversity and overall benthos density, watersheds, or site depths (Figure 3.5-3).

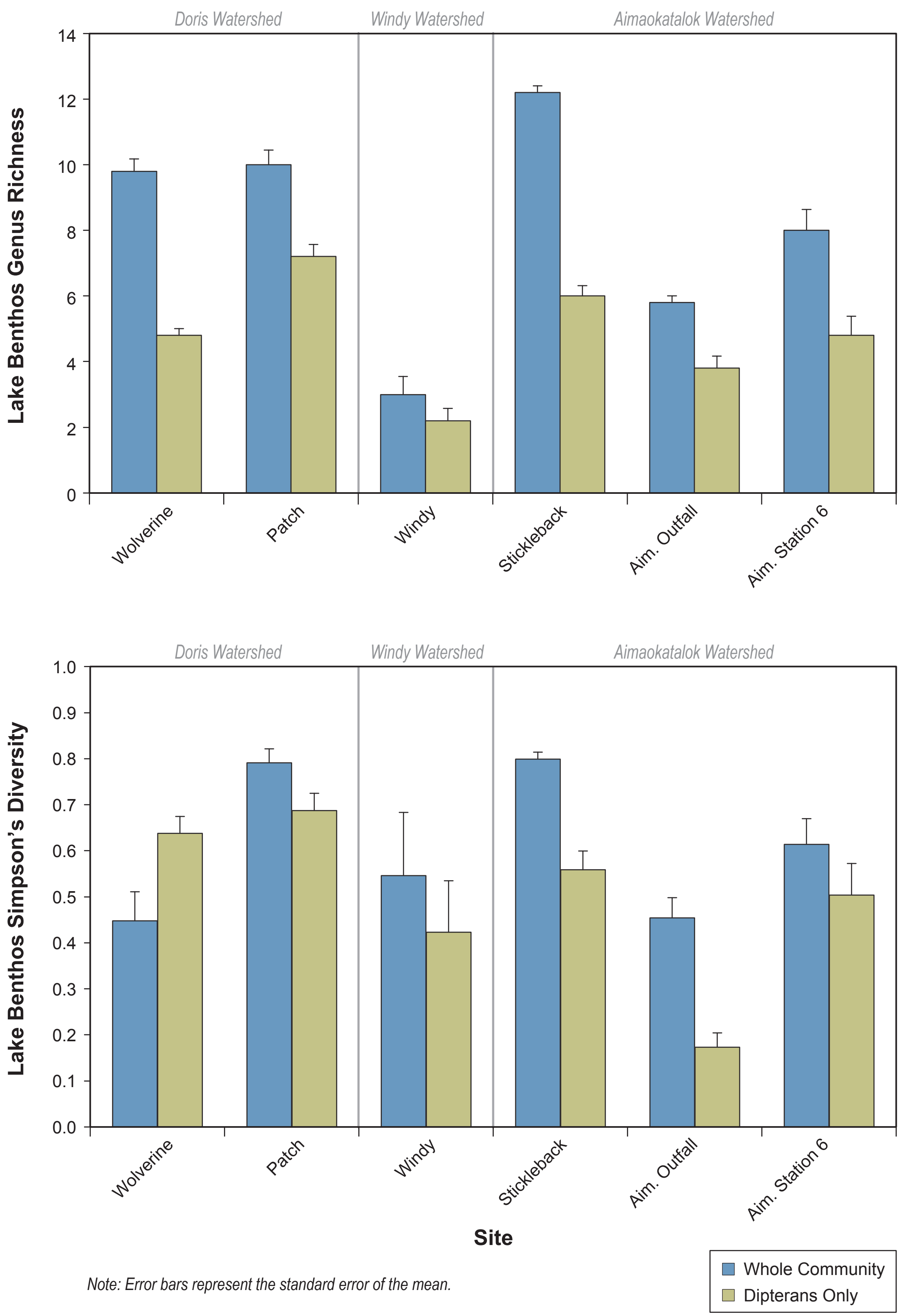
Figure 3.5-2

Relative Densities of Lake Benthos Taxa by Major Groupings, Madrid-Boston, 2017



Note: Relative densities presented represent the means across replicates.

Lake Benthos Richness and Diversity, Madrid-Boston, 2017



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

3.5.3 QA/QC

To meet the sorting efficiency criterion, 10% (n = 3) of the benthos samples were re-sorted. Sorting efficiencies of 90% or greater are considered acceptable under the EEM guidelines (Environment Canada 2012). All assessed samples had sorting efficiencies well exceeding the 90% threshold (mean = 98%), thus no re-sorting of samples were necessary.

4. SUMMARY

The key findings of the 2017 baseline program are summarized in the following sections.

4.1 PHYSICAL LIMNOLOGY

Vertical profiles of temperature and dissolved oxygen (DO) were collected from six sites in the Project area during the under-ice season and 10 sites during the open-water season of 2017. Under-ice water column structure was typical of ice-covered lakes, with the coldest water lying just below the ice and temperatures warming with depth. Under-ice DO concentrations were lower in the shallow lakes (Wolverine and Stickleback) compared to the deeper lakes (Patch, Windy and Aimaokatalok) and declined with depth at all sites. Under-ice DO concentrations were higher than the CCME oxygen guidelines throughout the water column at deeper sites, with the exception of Aimaokatalok Station 6 where DO concentrations were lower than the minimum CCME oxygen guideline of 6.5 mg/L at depth. Under-ice DO concentrations were far below the minimum guideline (<2 mg/L) in the shallow Wolverine and Stickleback lakes, which is common in shallow Arctic lakes during the ice-covered season.

During the open-water season, all lakes except Aimaokatalok Lake were well-mixed and relatively warm. Temperatures in Aimaokatalok Lake were similar to other lakes but weak thermal stratification was observed at all six sites sampled. Open-water DO concentrations were higher than the CCME oxygen guidelines at all sites. Euphotic zone depths ranged from 2.3 to 11.8 m and extended throughout the water column in Stickleback Lake and at The Aimaokatalok Outfall site.

4.2 WATER QUALITY

Water quality samples were collected from six sites in the Project area during both the under-ice and open-water seasons of 2017. Water quality varied among lakes. Wolverine, Patch, Windy, and Stickleback lakes had higher pH, were less sensitive to acid inputs (i.e., higher alkalinity), and contained harder water with higher conductivity and concentrations of TSS, chloride, and fluoride compared to Aimaokatalok Lake. These parameters, as well as most nutrients and metals, tended to be higher during the ice-covered season than the open-water season. The largest seasonal differences were generally observed in the shallow lakes. Total suspended solids concentrations and turbidity were generally low, reflecting the relatively high water clarity observed through euphotic zone estimates from Secchi depth measurements. Concentrations of nutrients and most metals were also generally low. Trophic categorizations based on total phosphorus concentrations ranged from ultra-oligotrophic to mesotrophic with shallow sites tending to have higher concentrations of total phosphorus. Site means for most water quality parameters were lower than CCME guidelines in 2017. Mean chloride concentrations were higher than the CCME guideline of 120 mg/L in Wolverine and Stickleback lakes during the under-ice season. Mean total iron concentrations were also higher than the CCME guideline of 0.3 mg/L during the under-ice season at these two locations.

4.3 SEDIMENT QUALITY

Sediment quality samples were collected from six sites in the Project area during the open-water season of 2017. Sediments at all sites were relatively fine, consisting mainly of silt and clay. Mean concentrations of sediment cadmium, copper, lead, mercury, and zinc were similar among sites likely reflecting their similarities in particle size. Arsenic and chromium were more variable across sites and differences did not reflect patterns in particle size. Compared to CCME guidelines, concentrations of cadmium, lead, mercury, and zinc in sediments were less than the ISQG and PEL at all sites. Sediments had naturally elevated concentrations of arsenic, chromium, and copper, and concentrations of these metals were often higher than the ISQG in 2017. The only sediment parameter with concentrations greater than the PEL in 2017 was arsenic (Windy Lake). Wolverine and Windy lake sediments exceeded the most guidelines.

4.4 PRIMARY PRODUCERS

Primary producer biomass samples (as chl *a*) were collected from six sites in the Project area during both the under-ice and open-water seasons of 2017. Low to moderate primary producer biomass was observed at all lakes during both seasons, with the exception of under-ice in Stickleback Lake where high primary producer biomass was observed.

4.5 BENTHIC INVERTEBRATES

Benthic invertebrate samples were collected from six sites in the Project area during the open-water season of 2017. Shallow sites tended to have higher benthic invertebrate densities than deep sites. Benthic communities were dominated by dipterans (true flies), except at Wolverine Lake where oligochaetes (segmented worms) were dominant, and at Aimaokatalok Station 6 where dipterans and pelecypods (bivalves) were co-dominant. Mean whole community genera richness ranged from three to 12 genera/sample and mean dipteran genera richness accounted for 50% or more of total genera richness at any given site. Mean whole community and dipteran Simpson's diversity were variable across lakes (mean ranges = 0.45 to 0.80 and 0.17 to 0.69, respectively) and there were no apparent correlations between diversity and density, watersheds, or site depths.

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Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

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Appendix 3.1-1

Temperature and Dissolved Oxygen Data, Madrid-Boston, 2017

APPENDIX 3.1-1. TEMPERATURE AND DISSOLVED OXYGEN DATA, MADRID-BOSTON, 2017

Wolverine – April 22, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
1.5	0.4	7.8	1.1
2	0.4	7.7	1.1
2.5	0.9	7.5	1.1
3	1.3	6.7	0.9
3.5	1.7	5.5	0.8
4	1.9	4.5	0.6

Patch – April 22, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
1.5	0.1	95.5	13.9
2	0.3	90.5	13.1
2.5	0.9	90.4	12.9
3	1.3	90.4	12.7
3.5	1.5	88.5	12.4
4	1.6	84.2	11.8
4.5	1.6	81.0	11.3
5	1.6	78.9	11.0
5.5	1.6	77.4	10.8
6	1.6	75.8	10.6
6.5	1.7	75.0	10.5
7	1.6	74.2	10.4
7.5	1.5	73.4	10.3
8	1.5	73.3	10.3
8.5	1.5	73.4	10.3

Windy – April 25, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
2	0.2	102.4	14.9
3	0.6	102.8	14.8
4	0.8	102.2	14.6
5	0.9	101.7	14.5
6	0.9	101.3	14.4
7	1.0	101.1	14.4
8	1.0	100.7	14.3
9	1.1	100.1	14.2
10	1.3	99.2	14.0
11	1.4	98.0	13.8
12	1.5	97.1	13.6
13	1.7	96.2	13.4
14	1.9	95.4	13.2
15	2.1	90.6	12.5
16	2.3	82.2	11.2
17	2.6	75.9	10.3

Stickleback – April 24, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
1.5	0.1	13.5	2.0
2	0.5	10.4	1.5
2.5	0.9	7.8	1.1

Aimaokatalok Outfall – April 24, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
2	0.6	107.6	15.5
2.5	0.6	107.8	15.5
3	0.7	106.3	15.2
3.5	0.8	104.4	14.9
4	0.9	102.2	14.6
4.5	0.9	98.6	14.1
5	1.0	95.8	13.6
5.5	1.0	94.0	13.4
6	1.1	91.7	13.0

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
6.5	1.1	88.4	12.5
7	1.2	85.4	12.1
7.5	1.2	84.1	11.9

Aimaokatalok Station 6 – April 22, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
2	0.4	102.0	14.7
3	0.7	101.2	14.5
4	0.9	96.8	13.8
5	1.0	92.8	13.2
6	1.1	90.2	12.8
7	1.1	88.4	12.5
8	1.2	87.7	12.4
9	1.2	88.0	12.4
10	1.2	88.3	12.5
11	1.3	85.0	12.0
12	1.4	82.7	11.6
13	1.5	79.5	11.2
14	1.5	76.8	10.8
15	1.6	74.3	10.4
16	1.7	71.7	10.0
17	1.7	69.4	9.7
18	1.8	66.3	9.2
19	1.8	62.2	8.7
20	1.8	59.3	8.2
21	1.9	57.4	8.0
22	1.9	56.2	7.8
23	1.9	54.5	7.6
24	2.0	51.3	7.1
25	2.1	47.1	6.5
26	2.2	40.8	5.6

Wolverine – August 20, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
0.5	14.2	117.7	12.0
1	14.2	115.6	11.8
1.5	14.2	114.7	11.7
2	14.2	114.0	11.7
2.5	14.1	113.3	11.6
3	14.1	112.8	11.6
3.5	14.1	112.4	11.5

Patch – August 19, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
0.5	13.9	107.8	11.1
1	13.9	107.7	11.1
1.5	13.9	107.7	11.1
2	13.9	107.7	11.1
2.5	13.9	107.6	11.1
3	13.9	107.6	11.1
3.5	13.9	107.6	11.1
4	13.9	107.6	11.1
4.5	13.9	107.7	11.1
5	13.9	107.7	11.1
5.5	13.9	107.5	11.1
6	13.9	108.1	11.1
6.5	13.9	108.3	11.1
7	13.9	108.1	11.1

Windy – August 19, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
1	12.9	112.8	11.9
2	12.9	112.5	11.9
3	12.8	112.1	11.8
4	12.8	111.8	11.8
5	12.8	111.6	11.8
6	12.8	111.6	11.8
7	12.8	111.9	11.8
8	12.8	111.6	11.8
9	12.8	111.3	11.7
10	12.8	111.0	11.7
11	12.8	110.8	11.7

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
12	12.8	110.8	11.7
13	12.8	110.7	11.7
14	12.8	110.7	11.7
15	12.8	110.5	11.7
16	12.8	110.4	11.7
17	12.8	110.4	11.7

Stickleback – August 16, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
1	13.7	97.7	10.1
1.5	13.7	97.8	10.1
2	13.7	98.1	10.2

Aimaokatalok Outfall – August 18, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
0.5	13.2	112.4	11.8
1	13.2	111.8	11.7
1.5	13.2	111.3	11.7
2	13.1	111.2	11.7
2.5	13.1	111.0	11.6
3	13.1	110.9	11.6
3.5	13.1	110.9	11.6
4	13.1	110.8	11.6
4.5	13.1	110.5	11.6
5	13.0	109.9	11.6
5.5	12.9	109.1	11.5
6	12.9	108.6	11.5
6.5	12.8	107.8	11.4
7	12.8	107.2	11.3

Aimaokatalok Station 6 – August 18, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
1	13.4	112.8	11.8
2	13.4	112.2	11.7
3	13.4	111.6	11.6
4	13.3	110.7	11.6
5	13.1	109.6	11.5
6	13.0	108.7	11.4
7	12.8	107.4	11.3
8	12.8	106.7	11.3
9	12.8	106.3	11.2
10	12.7	105.9	11.2
11	12.7	105.4	11.2
12	12.7	105.1	11.1
13	12.7	105.4	11.2
14	12.7	105.4	11.2
15	12.7	105.4	11.2
16	12.7	105.3	11.2
17	12.6	105.1	11.1
18	12.6	104.5	11.1
19	12.6	103.5	11.0
20	12.5	102.8	10.9
21	12.5	102.6	10.9
22	12.5	102.0	10.9
23	12.3	100.5	10.7
24	12.3	99.2	10.6
25	12.2	98.1	10.5
26	12.2	97.3	10.4

Aimaokatalok 2017-1 – August 18, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
1	14.0	109.9	11.3
2	14.0	110.2	11.3
3	13.6	108.8	11.3
4	13.5	108.5	11.3
5	13.4	108.0	11.2
6	13.3	107.0	11.2
7	13.2	106.2	11.1
8	13.2	105.9	11.1
9	13.1	105.4	11.1
10	13.0	104.7	11.0
11	13.0	104.1	11.0

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
12	12.9	103.6	10.9
13	12.8	102.9	10.9
14	12.8	102.5	10.8
15	12.8	102.1	10.8
16	12.7	101.8	10.8
17	12.7	101.4	10.7
18	12.6	100.8	10.7
19	12.4	99.7	10.6
20	12.1	97.2	10.4
21	11.7	94.3	10.2
22	11.5	90.9	9.9
23	11.4	89.8	9.8
24	11.3	89.3	9.8
25	11.3	89.1	9.7

Aimaokatalok 2017-2 – August 18, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
1	13.7	109.9	11.4
2	13.7	109.9	11.4
3	13.7	109.8	11.4
4	13.6	109.3	11.3
5	13.2	107.7	11.3
6	13.1	107.3	11.3
7	13.0	106.5	11.2
8	12.9	105.7	11.2
9	12.8	105.3	11.1
10	12.8	105.0	11.1
11	12.8	104.7	11.1
12	12.7	104.4	11.0
13	12.7	104.0	11.0
14	12.7	103.4	11.0
15	12.7	102.5	10.9

Aimaokatalok 2017-3 – August 18, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
1	13.4	109.4	11.4
2	13.4	109.8	11.5
3	13.3	109.7	11.5
4	13.3	109.6	11.5
5	13.2	109.1	11.4
6	13.1	108.2	11.4
7	12.9	106.5	11.2
8	12.9	106.1	11.2
9	12.8	105.5	11.2
10	12.7	104.5	11.1
11	12.7	103.8	11.0
12	12.7	104.0	11.0
13	12.7	103.6	11.0
14	12.7	103.1	10.9
15	12.6	102.3	10.8
16	12.6	102.2	10.8

Aimaokatalok 2017-4 – August 18, 2017

Depth (m)	Temperature (°C)	Oxygen (% saturation)	Oxygen (mg/L)
1	13.2	109.4	11.4
2	13.2	110.2	11.5
3	13.2	110.0	11.5
4	13.2	109.8	11.5
5	13.1	109.5	11.5
6	12.9	108.1	11.4
7	12.8	106.9	11.3
8	12.8	106.1	11.2
9	12.7	105.3	11.1
10	12.6	103.5	11.0
11	12.5	101.0	10.8
12	12.4	98.3	10.5
13	12.3	96.5	10.3

Appendix 3.2-1

Water Quality Data, Madrid-Boston, 2017

Appendix 3.2-1. Water Quality Data, Madrid-Boston, 2017

Site ID:				Wolverine	Patch	Patch	Patch	Windy	Windy	Stickleback	Aimaokatalok Outfall	Aimaokatalok Outfall	Aimaokatalok Station 6	Aimaokatalok Station 6	Wolverine
Depth Zone:				Surface	Surface	Surface	Deep	Surface	Deep	Surface	Surface	Deep	Surface	Deep	Surface
Depth Sampled (m):				2	2.5	2.5	6.5	2.5	14	1.4	2.5	5.5	2.5	24	1
Replicate:				1	1	2	1	1	1	1	1	1	1	1	1
Date Sampled:				22-Apr-2017	22-Apr-2017	22-Apr-2017	22-Apr-2017	25-Apr-2017	25-Apr-2017	22-Apr-2017	22-Apr-2017	22-Apr-2017	22-Apr-2017	22-Apr-2017	20-Aug-2017
ALS Sample ID:	**Units**	**CCME Guideline for the Protection of Aquatic Life[a]**	**Realized Detection Limits**	L1920252-1	L1920252-2	L1920252-4	L1920252-3	L1918949-1	L1918949-2	L1920252-9	L1920252-7	L1920252-8	L1920252-5	L1920252-6	L1979286-7
Physical Tests															
Conductivity	uS/cm		2.0	733	425	429	449	496	477	640	83.2	80.9	81.0	80.5	348
Hardness (as $CaCO_3$)	mg/L		0.50	126	81.4	77.6	80.7	78.7	76.6	208	19.9	19.4	19.4	18.6	59.5
pH	pH	6.5 - 9	0.10	7.60	7.78	7.78	7.75	7.89	7.89	8.08	7.28	7.24	7.26	7.20	7.72
Salinity	psu		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
Total Suspended Solids	mg/L	Increase from background[b]	1.0	<1.0	<1.0	<1.0	<1.0	4.8	1.9	5.7	<1.0	<1.0	<1.0	<1.0	2.3
Total Dissolved Solids	mg/L		13 - 20	445	243	237	256	262	256	436	55	53	53	55	226
Turbidity	NTU	Increase from background[c]	0.10	1.51	0.83	0.79	1.26	0.20	0.16	5.48	0.32	0.40	0.30	0.84	1.93
Anions and Nutrients															
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0	83.1	51.3	51.1	52.4	56.1	52.7	125	12.8	12.4	11.8	11.8	39.2
Ammonia, Total (as N)	mg/L	pH and temperature dependent[d]	0.005 - 0.25	0.216	0.0187	0.0142	0.0222	<0.0050	0.0070	0.193	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L		0.05 - 2.5	0.45	0.290	0.285	0.299	0.405	0.391	0.217	<0.050	<0.050	<0.050	<0.050	0.211
Chloride (Cl)	mg/L	120	0.5 - 2.5	170	94.2	94.6	99.8	109	104	124	13.7	13.1	13.3	13.7	82.2
Fluoride (F)	mg/L	0.12	0.02 - 0.1	0.10	0.083	0.084	0.085	0.083	0.080	0.095	0.036	0.032	0.031	0.031	0.061
Nitrate (as N)	mg/L	3	0.005 - 0.025	0.057	0.0520	0.0542	0.0562	<0.0050	0.0105	<0.0050	0.0513	0.0748	0.0519	0.120	<0.0050
Nitrite (as N)	mg/L	0.06	0.001 - 0.005	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	0.0015	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Orthophosphate-Dissolved (as P)	mg/L		0.0010	0.0018	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	0.0010	0.0014	0.0032	<0.0010
Phosphorus (P)-Total	mg/L		0.0020	0.0129	0.0053	0.0031	0.0030	0.0032	0.0024	0.0174	0.0035	0.0028	0.0037	0.0051	0.0112
Sulfate (SO_4)	mg/L		0.3 - 1.5	<1.5	3.38	3.40	3.50	9.52	9.14	2.13	2.48	2.57	2.13	2.01	0.33
Cyanides															
Cyanide, Total	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
Cyanide, Free	mg/L	0.005	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 / Inorganic Carbon															
Total Organic Carbon	mg/L		0.50	13.4	7.33	7.20	7.28	2.71	2.21	13.7	7.33	7.06	6.90	6.05	6.78
Total Metals															
Aluminum (Al)	mg/L	0.005 at pH <6.5; 0.1 at pH ≥ 6.5	0.0030	0.0126	0.0417	0.0393	0.0516	0.0051	0.0054	0.0034	0.0189	0.0267	0.0215	0.0577	0.0384
Antimony (Sb)	mg/L		0.000030	0.000039	0.000033	0.000031	0.000030	0.000085	0.000079	<0.000030	<0.000030	<0.000030	<0.000030	<0.000030	<0.000030
Arsenic (As)	mg/L	0.005	0.000050	0.000650	0.000316	0.000301	0.000317	0.000236	0.000212	0.000889	0.000179	0.000165	0.000165	0.000151	0.000380
Barium (Ba)	mg/L		0.00010	0.0120	0.00380	0.00391	0.00422	0.00257	0.00250	0.0367	0.00247	0.00255	0.00225	0.00240	0.00471
Beryllium (Be)	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
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
Boron (B)	mg/L	1.5	0.010	0.041	0.038	0.039	0.043	0.052	0.052	0.045	<0.010	<0.010	<0.010	<0.010	0.026
Cadmium (Cd)	mg/L	hardness dependent[e]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	0.0000130	<0.0000050	0.0000079	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050

Notes:

Shaded cells indicate values that exceed CCME guidelines for the protection of aquatic life.

[a] *Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Accessed November 27, 2017.*

[b] *Clear flow = maximum average increase of 5 mg/L from background levels; high flow = maximum increase of 25 mg/L from background levels at any time when background levels are betweeen 25 and 250 mg/L. Should not increase more than 10% of background levels when background is ≥ 250 mg/L.*

[c] *Clear flow = maximum average increase of 2 nephelometric turbidity units (NTU) from background levels for longer term exposures (e.g., 30 day period); high flow or turbid waters = maximum increase of 8 NTU from background levels at any one time when background levels are between 8 and 80 NTUs. Should not increase more than 10% of background levels when background is > 80 NTUs.*

[d] *Maximum of 190 mg/L at temperature of 0 ℃ and pH of 6; minimum of 0.017 mg/L at temperature of 30 ℃ and pH of 10.*

[e] *10(0.83[log10(hardness)]-2.46)/1000, minimum of 0.00004 mg/L applicable to hardness 0-16 mg/L, maximum of 0.00037 mg/L applicable to hardness greater than 280 mg/L.*

[f] *0.2*e(0.8545[ln(hardness)]-1.465)/1000, minimum 0.002 mg/L applicable to hardness 0-82 mg/L, maximum of 0.004 mg/L applicable to hardness greater than 180 mg/L.*

[g] *e(1.273[ln(hardness)]-4.705)/1000, minimum of 0.001 mg/L applicable to hardness 0-60 mg/L, maximum of 0.007 mg/L applicable at hardness greater than 180 mg/L.*

[h] *e(0.76[ln(hardness)]+1.06)/1000, minimum of 0.025 mg/L applicable to hardness 0-60 mg/L, maximum of 0.15 mg/L at hardness greater than 180 mg/L.*

Appendix 3.2-1. Water Quality Data, Madrid-Boston, 2017

Site ID:				Wolverine	Patch	Patch	Patch	Windy	Windy	Stickleback	Aimaokatalok Outfall	Aimaokatalok Outfall	Aimaokatalok Station 6	Aimaokatalok Station 6	Wolverine
Depth Zone:				Surface	Surface	Surface	Deep	Surface	Deep	Surface	Surface	Deep	Surface	Deep	Surface
Depth Sampled (m):				2	2.5	2.5	6.5	2.5	14	1.4	2.5	5.5	2.5	24	1
Replicate:				1	1	2	1	1	1	1	1	1	1	1	1
Date Sampled:		CCME Guideline for the	Realized Detection	22-Apr-2017	22-Apr-2017	22-Apr-2017	22-Apr-2017	25-Apr-2017	25-Apr-2017	22-Apr-2017	22-Apr-2017	22-Apr-2017	22-Apr-2017	22-Apr-2017	20-Aug-2017
ALS Sample ID:	Units	Protection of Aquatic Life[a]	Limits	L1920252-1	L1920252-2	L1920252-4	L1920252-3	L1918949-1	L1918949-2	L1920252-9	L1920252-7	L1920252-8	L1920252-5	L1920252-6	L1979286-7
Calcium (Ca)	mg/L		0.050	19.4	14.5	13.8	14.3	13.8	13.4	53.5	4.03	3.89	3.90	3.76	8.81
Cesium (Cs)	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
Chromium (Cr)	mg/L	0.0089 (III), 0.001 (VI)	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	0.000164	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000633	<0.000050	<0.000050	<0.000050	<0.000050	0.000054
Copper (Cu)	mg/L	hardness dependent[f]	0.00050	0.00094	0.00179	0.00182	0.00173	0.00092	0.00103	0.00057	0.00147	0.00136	0.00137	0.00121	0.00074
Gallium (Ga)	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
Iron (Fe)	mg/L	0.3	0.030	0.622	0.061	0.052	0.114	<0.030	<0.030	1.26	0.030	0.041	0.036	0.067	0.148
Lead (Pb)	mg/L	hardness dependent[g]	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
Lithium (Li)	mg/L		0.00040	0.00953	0.00643	0.00670	0.00681	0.00325	0.00319	0.0121	0.00116	0.00107	0.00114	0.00104	0.00559
Magnesium (Mg)	mg/L		0.10	19.0	11.0	10.5	10.9	10.7	10.5	18.1	2.40	2.35	2.36	2.24	9.10
Manganese (Mn)	mg/L		0.00020	0.264	0.00536	0.00459	0.0159	0.00063	0.00056	0.753	0.00121	0.00212	0.00138	0.0176	0.0336
Mercury (Hg)	mg/L	0.000026	0.00000050	0.00000061	<0.00000050	<0.00000050	<0.00000050	<0.00000050	<0.00000050	0.00000054	0.00000075	0.00000072	0.00000076	0.00000087	<0.00000050
Molybdenum (Mo)	mg/L	0.073	0.000050	0.000146	0.000290	0.000281	0.000272	0.000706	0.000673	0.000160	0.000068	0.000057	0.000077	<0.000050	0.000104
Nickel (Ni)	mg/L	hardness dependent[h]	0.00020	0.00125	0.00088	0.00089	0.00091	0.00025	0.00025	0.00064	0.00062	0.00060	0.00057	0.00049	0.00056
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
Potassium (K)	mg/L		2.0	4.3	3.8	3.5	3.7	4.2	4.0	4.8	<2.0	<2.0	<2.0	<2.0	2.2
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
Rubidium (Rb)	mg/L		0.000020	0.00150	0.00200	0.00209	0.00214	0.00236	0.00225	0.00333	0.00190	0.00189	0.00174	0.00172	0.000975
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
Silicon (Si)	mg/L		0.10	0.98	0.81	0.77	0.90	0.38	0.40	1.72	0.35	0.44	0.37	1.02	0.15
Silver (Ag)	mg/L	0.00025	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	90.8	52.5	50.3	52.4	60.8	58.6	48.4	7.6	7.2	7.9	7.8	45.0
Strontium (Sr)	mg/L		0.00020	0.0939	0.0701	0.0718	0.0788	0.0676	0.0676	0.226	0.0189	0.0184	0.0195	0.0188	0.0490
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
Thallium (Tl)	mg/L	0.0008	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
Thorium (Th)	mg/L		0.0000050	0.0000179	0.0000174	0.0000167	0.0000200	<0.0000050	<0.0000050	<0.0000050	0.0000321	0.0000319	0.0000314	0.0000323	0.0000119
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
Titanium (Ti)	mg/L		0.00020	<0.00020	0.00064	0.00055	0.00105	<0.00020	<0.00020	<0.00020	0.00028	0.00046	0.00024	0.00093	0.00145
Tungsten (W)	mg/L		0.000010	<0.000010	0.000012	0.000013	0.000019	<0.000010	<0.000010	0.000014	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	0.015	0.0000020	0.0000413	0.0000688	0.0000707	0.0000638	0.000202	0.000199	0.0000381	0.0000397	0.0000374	0.0000381	0.0000310	0.0000336
Vanadium (V)	mg/L		0.000050	0.000137	0.000103	0.000101	0.000144	0.000074	0.000071	0.000068	0.000068	0.000074	0.000066	0.000103	0.000141
Yttrium (Y)	mg/L		0.0000050	0.0000289	0.0000292	0.0000295	0.0000340	0.0000052	0.0000055	0.0000103	0.0000538	0.0000560	0.0000528	0.0000530	0.0000154
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	0.0032	<0.0030	<0.0030
Zirconium (Zr)	mg/L		0.000050	0.000058	0.000052	<0.000050	0.000060	<0.000050	<0.000050	<0.000050	0.000081	0.000075	0.000082	0.000074	<0.000050

Notes:

Shaded cells indicate values that exceed CCME guidelines for the protection of aquatic life.

[a] *Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Accessed November 27, 2017.*

[b] *Clear flow = maximum average increase of 5 mg/L from background levels; high flow = maximum increase of 25 mg/L from background levels at any time when background levels are betweeen 25 and 250 mg/L. Should not increase more than 10% of background levels when background is ≥ 250 mg/L.*

[c] *Clear flow = maximum average increase of 2 nephelometric turbidity units (NTU) from background levels for longer term exposures (e.g., 30 day period); high flow or turbid waters = maximum increase of 8 NTU from background levels at any one time when background levels are between 8 and 80 NTUs. Should not increase more than 10% of background levels when background is > 80 NTUs.*

[d] *Maximum of 190 mg/L at temperature of 0 ℃ and pH of 6; minimum of 0.017 mg/L at temperature of 30 ℃ and pH of 10.*

[e] *10(0.83[log10(hardness)]-2.46)/1000, minimum of 0.00004 mg/L applicable to hardness 0-16 mg/L, maximum of 0.00037 mg/L applicable to hardness greater than 280 mg/L.*

[f] *0.2*e(0.8545[ln(hardness)]-1.465)/1000, minimum 0.002 mg/L applicable to hardness 0-82 mg/L, maximum of 0.004 mg/L applicable to hardness greater than 180 mg/L.*

[g] *e(1.273[ln(hardness)]-4.705)/1000, minimum of 0.001 mg/L applicable to hardness 0-60 mg/L, maximum of 0.007 mg/L applicable at hardness greater than 180 mg/L.*

[h] *e(0.76[ln(hardness)]+1.06)/1000, minimum of 0.025 mg/L applicable to hardness 0-60 mg/L, maximum of 0.15 mg/L at hardness greater than 180 mg/L.*

Appendix 3.2-1. Water Quality Data, Madrid-Boston, 2017

Site ID:				**Patch**	**Patch**	**Windy**	**Windy**	**Stickleback**	**Stickleback**	**Aimaokatalok Outfall**	**Aimaokatalok Outfall**	**Aimaokatalok Station 6**	**Aimaokatalok Station 6**
Depth Zone:				**Surface**	**Deep**	**Surface**	**Deep**	**Surface**	**Surface**	**Surface**	**Deep**	**Surface**	**Deep**
Depth Sampled (m):				**1**	**6**	**1**	**16**	**1**	**1**	**1**	**7**	**1**	**25**
Replicate:				**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**
Date Sampled:		**CCME Guideline for the**	**Realized Detection**	**19-Aug-2017**	**19-Aug-2017**	**19-Aug-2017**	**19-Aug-2017**	**16-Aug-2017**	**16-Aug-2017**	**18-Aug-2017**	**18-Aug-2017**	**18-Aug-2017**	**18-Aug-2017**
ALS Sample ID:	**Units**	**Protection of Aquatic Life[a]**	**Limits**	**L1979286-3**	**L1979286-4**	**L1979286-1**	**L1979286-2**	**L1977620-1**	**L1977620-2**	**L1979286-8**	**L1979286-9**	**L1979286-10**	**L1979286-11**
Physical Tests													
Conductivity	uS/cm		2.0	292	292	424	430	239	229	58.6	58.8	58.5	59.0
Hardness (as $CaCO_3$)	mg/L		0.50	52.1	52.6	70.4	67.4	68.5	69.2	14.1	13.9	13.9	14
pH	pH	6.5 - 9	0.10	7.76	7.76	7.93	7.93	7.77	7.66	7.21	7.21	7.21	7.20
Salinity	psu		1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Suspended Solids	mg/L	Increase from background[b]	1.0	1.1	1.9	<1.0	<1.0	1.1	<1.0	<1.0	<1.0	1.1	<1.0
Total Dissolved Solids	mg/L		13 - 20	166	171	227	228	178	160	39	38	42	40
Turbidity	NTU	Increase from background[c]	0.10	1.44	1.25	0.65	0.79	0.67	0.67	1.19	1.08	1.02	1.40
Anions and Nutrients													
Alkalinity, Total (as $CaCO_3$)	mg/L		1.0	36.7	35.5	49.6	50.6	40.6	40.0	9.5	9.6	9.7	9.7
Ammonia, Total (as N)	mg/L	pH and temperature dependent[d]	0.005 - 0.25	<0.0050	<0.0050	<0.0050	<0.0050	0.0111	0.0078	<0.0050	<0.0050	<0.0050	0.0102
Bromide (Br)	mg/L		0.05 - 2.5	0.206	0.213	0.401	0.393	0.083	0.083	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	120	0.5 - 2.5	67.2	67.1	97.0	96.8	45.7	45.7	10.1	10.1	10.1	10.1
Fluoride (F)	mg/L	0.12	0.02 - 0.1	0.062	0.063	0.077	0.077	0.043	0.044	0.026	0.026	0.026	0.025
Nitrate (as N)	mg/L	3	0.005 - 0.025	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0052
Nitrite (as N)	mg/L	0.06	0.001 - 0.005	<0.0010	<0.0010	<0.0010	<0.0010	0.0018	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Orthophosphate-Dissolved (as P)	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)-Total	mg/L		0.0020	0.0034	0.0050	<0.0020	0.0033	0.0085	0.0078	0.0056	0.0051	0.0042	0.0057
Sulfate (SO_4)	mg/L		0.3 - 1.5	2.45	2.46	8.57	8.57	0.91	0.91	1.61	1.61	1.61	1.61
Cyanides													
Cyanide, Total	mg/L		0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Free	mg/L	0.005	0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon													
Total Organic Carbon	mg/L		0.50	4.75	<0.50	1.95	1.92	5.27	5.29	5.11	4.92	4.93	4.86
Total Metals													
Aluminum (Al)	mg/L	0.005 at pH <6.5; 0.1 at pH ≥ 6.5	0.0030	0.0547	0.0578	0.0328	0.0390	0.0046	0.0037	0.0388	0.0386	0.0371	0.0528
Antimony (Sb)	mg/L		0.000030	<0.000030	<0.000030	0.000070	0.000067	<0.000030	<0.000030	<0.000030	<0.000030	<0.000030	<0.000030
Arsenic (As)	mg/L	0.005	0.000050	0.000277	0.000261	0.000234	0.000246	0.000324	0.000384	0.000156	0.000158	0.000146	0.000150
Barium (Ba)	mg/L		0.00010	0.00262	0.00275	0.00268	0.00281	0.00560	0.00581	0.00208	0.00209	0.00203	0.00218
Beryllium (Be)	mg/L		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
Boron (B)	mg/L	1.5	0.010	0.033	0.036	0.068	0.063	0.021	0.023	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)	mg/L	hardness dependent[e]	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050

Notes:

Shaded cells indicate values that exceed CCME guidelines for the protection of aquatic life.

[a] *Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Accessed November 27, 2017.*

[b] *Clear flow = maximum average increase of 5 mg/L from background levels; high flow = maximum increase of 25 mg/L from background levels at any time when background levels are betweeen 25 and 250 mg/L. Should not increase more than 10% of background levels when background is ≥ 250 mg/L.*

[c] *Clear flow = maximum average increase of 2 nephelometric turbidity units (NTU) from background levels for longer term exposures (e.g., 30 day period); high flow or turbid waters = maximum increase of 8 NTU from background levels at any one time when background levels are between 8 and 80 NTUs. Should not increase more than 10% of background levels when background is > 80 NTUs.*

[d] *Maximum of 190 mg/L at temperature of 0 ℃ and pH of 6; minimum of 0.017 mg/L at temperature of 30 ℃ and pH of 10.*

[e] *10(0.83[log10(hardness)]-2.46)/1000, minimum of 0.00004 mg/L applicable to hardness 0-16 mg/L, maximum of 0.00037 mg/L applicable to hardness greater than 280 mg/L.*

[f] *0.2*e(0.8545[ln(hardness)]-1.465)/1000, minimum 0.002 mg/L applicable to hardness 0-82 mg/L, maximum of 0.004 mg/L applicable to hardness greater than 180 mg/L.*

[g] *e(1.273[ln(hardness)]-4.705)/1000, minimum of 0.001 mg/L applicable to hardness 0-60 mg/L, maximum of 0.007 mg/L applicable at hardness greater than 180 mg/L.*

[h] *e(0.76[ln(hardness)]+1.06)/1000, minimum of 0.025 mg/L applicable to hardness 0-60 mg/L, maximum of 0.15 mg/L at hardness greater than 180 mg/L.*

Appendix 3.2-1. Water Quality Data, Madrid-Boston, 2017

Site ID:				**Patch**	**Patch**	**Windy**	**Windy**	**Stickleback**	**Stickleback**	**Aimaokatalok Outfall**	**Aimaokatalok Outfall**	**Aimaokatalok Station 6**	**Aimaokatalok Station 6**
Depth Zone:				**Surface**	**Deep**	**Surface**	**Deep**	**Surface**	**Surface**	**Surface**	**Deep**	**Surface**	**Deep**
Depth Sampled (m):				**1**	**6**	**1**	**16**	**1**	**1**	**1**	**7**	**1**	**25**
Replicate:				**1**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**
Date Sampled:		**CCME Guideline for the**	**Realized Detection**	**19-Aug-2017**	**19-Aug-2017**	**19-Aug-2017**	**19-Aug-2017**	**16-Aug-2017**	**16-Aug-2017**	**18-Aug-2017**	**18-Aug-2017**	**18-Aug-2017**	**18-Aug-2017**
ALS Sample ID:	**Units**	**Protection of Aquatic Life[a]**	**Limits**	**L1979286-3**	**L1979286-4**	**L1979286-1**	**L1979286-2**	**L1977620-1**	**L1977620-2**	**L1979286-8**	**L1979286-9**	**L1979286-10**	**L1979286-11**
Calcium (Ca)	mg/L		0.050	9.11	9.18	12.2	11.7	17.1	17.3	2.80	2.80	2.77	2.79
Cesium (Cs)	mg/L		0.0000050	<0.0000050	0.0000052	<0.0000050	0.0000052	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)	mg/L	0.0089 (III), 0.001 (VI)	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	0.000052	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)	mg/L	hardness dependent[f]	0.00050	0.00121	0.00109	0.00090	0.00087	0.00056	<0.00050	0.00093	0.00083	0.00125	0.00086
Gallium (Ga)	mg/L		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	0.054	0.058	0.033	0.034	0.105	0.105	0.118	0.117	0.115	0.134
Lead (Pb)	mg/L	hardness dependent[g]	0.000050	<0.000050	0.000136	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)	mg/L		0.00040	0.00545	0.00541	0.00377	0.00346	0.00445	0.00463	0.00108	0.00108	0.00105	0.00100
Magnesium (Mg)	mg/L		0.10	7.12	7.20	9.71	9.27	6.26	6.31	1.72	1.69	1.70	1.71
Manganese (Mn)	mg/L		0.00020	0.00968	0.00902	0.00169	0.00179	0.0232	0.0254	0.00496	0.00513	0.00466	0.00713
Mercury (Hg)	mg/L	0.000026	0.00000050	<0.00000050	<0.00000050	<0.00000050	<0.00000050	<0.00000050	<0.00000050	0.00000074	0.00000076	0.00000073	0.00000079
Molybdenum (Mo)	mg/L	0.073	0.000050	0.000202	0.000247	0.000677	0.000636	0.000260	0.000208	0.000056	0.000053	0.000056	<0.000050
Nickel (Ni)	mg/L	hardness dependent[h]	0.00020	0.00057	0.00056	0.00029	0.00029	0.00059	0.00031	0.00043	0.00039	0.00053	0.00042
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
Potassium (K)	mg/L		2.0	2.5	2.5	4.0	3.8	<2.0	<2.0	<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
Rubidium (Rb)	mg/L		0.000020	0.00170	0.00185	0.00240	0.00247	0.00115	0.00122	0.00164	0.00165	0.00162	0.00163
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
Silicon (Si)	mg/L		0.10	0.34	0.35	0.38	0.38	0.28	0.28	0.32	0.32	0.31	0.38
Silver (Ag)	mg/L	0.00025	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	34.3	34.8	56.0	50.4	16.9	17.0	5.5	5.4	5.4	5.4
Strontium (Sr)	mg/L		0.00020	0.0518	0.0584	0.0622	0.0640	0.0817	0.0813	0.0135	0.0133	0.0135	0.0134
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
Thallium (Tl)	mg/L	0.0008	0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Thorium (Th)	mg/L		0.0000050	0.0000159	0.0000158	0.0000107	0.0000131	<0.0000050	<0.0000050	0.0000228	0.0000245	0.0000243	0.0000291
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
Titanium (Ti)	mg/L		0.00020	0.00183	0.00202	0.00157	0.00172	<0.00020	<0.00020	0.00094	0.00096	0.00092	0.00136
Tungsten (W)	mg/L		0.000010	<0.000020	<0.000020	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)	mg/L	0.015	0.0000020	0.0000554	0.0000534	0.000163	0.000164	0.0000119	0.0000095	0.0000211	0.0000211	0.0000214	0.0000233
Vanadium (V)	mg/L		0.000050	0.000154	0.000155	0.000111	0.000145	<0.000050	<0.000050	0.000110	0.000115	0.000105	0.000132
Yttrium (Y)	mg/L		0.0000050	0.0000209	0.0000221	0.0000122	0.0000135	<0.0000050	<0.0000050	0.0000350	0.0000345	0.0000360	0.0000392
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
Zirconium (Zr)	mg/L		0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.000051	<0.000050	0.000051	0.000055

Notes:

Shaded cells indicate values that exceed CCME guidelines for the protection of aquatic life.

[a] *Canadian water quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Accessed November 27, 2017.*

[b] *Clear flow = maximum average increase of 5 mg/L from background levels; high flow = maximum increase of 25 mg/L from background levels at any time when background levels are betweeen 25 and 250 mg/L. Should not increase more than 10% of background levels when background is ≥ 250 mg/L.*

[c] *Clear flow = maximum average increase of 2 nephelometric turbidity units (NTU) from background levels for longer term exposures (e.g., 30 day period); high flow or turbid waters = maximum increase of 8 NTU from background levels at any one time when background levels are between 8 and 80 NTUs. Should not increase more than 10% of background levels when background is > 80 NTUs.*

[d] *Maximum of 190 mg/L at temperature of 0 ℃ and pH of 6; minimum of 0.017 mg/L at temperature of 30 ℃ and pH of 10.*

[e] *10(0.83[log10(hardness)]-2.46)/1000, minimum of 0.00004 mg/L applicable to hardness 0-16 mg/L, maximum of 0.00037 mg/L applicable to hardness greater than 280 mg/L.*

[f] *0.2*e(0.8545[ln(hardness)]-1.465)/1000, minimum 0.002 mg/L applicable to hardness 0-82 mg/L, maximum of 0.004 mg/L applicable to hardness greater than 180 mg/L.*

[g] *e(1.273[ln(hardness)]-4.705)/1000, minimum of 0.001 mg/L applicable to hardness 0-60 mg/L, maximum of 0.007 mg/L applicable at hardness greater than 180 mg/L.*

[h] *e(0.76[ln(hardness)]+1.06)/1000, minimum of 0.025 mg/L applicable to hardness 0-60 mg/L, maximum of 0.15 mg/L at hardness greater than 180 mg/L.*

Appendix 3.2-2

Water Quality QA/QC Data, Madrid-Boston, 2017

Appendix 3.2-2. Water Quality QA/QC Data, Madrid-Boston, 2017

Sample Type:		**Equipment Blank**	**Field Blank**	**Travel Blank**	**Equipment Blank**	**Field Blank**	**Travel Blank**
Date Sampled:		**22-Apr-2017**	**27-Apr-2017**	**27-Apr-2017**	**16-Aug-2017**	**19-Aug-2017**	**19-Aug-2017**
ALS Sample ID:	**Units**	**L1920252-10**	**L1918949-5**	**L1918949-6**	**L1977620-3**	**L1979286-6**	**L1979286-5**
Physical Tests (Water)							
Conductivity	uS/cm	<2.0	-	-	<2.0	<2.0	<2.0
Hardness (as $CaCO_3$)	mg/L	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
pH	pH	5.30	5.41	5.34	5.26	5.35	5.38
Salinity	psu	<1.0	-	-	<1.0	<1.0	<1.0
Total Suspended Solids	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Dissolved Solids	mg/L	<10	-	-	<10	<10	<10
Turbidity	NTU	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Anions and Nutrients (Water)							
Alkalinity, Total (as $CaCO_3$)	mg/L	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Ammonia, Total (as N)	mg/L	<0.0050	<0.0050	**0.0076**	<0.0050	<0.0050	<0.0050
Bromide (Br)	mg/L	<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
Fluoride (F)	mg/L	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
Nitrate (as N)	mg/L	**0.0103**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nitrite (as N)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Orthophosphate-Dissolved (as P)	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)-Total	mg/L	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Sulphate (SO_4)	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Cyanides (Water)							
Cyanide, Total	mg/L	<0.0010	-	-	<0.0010	<0.0010	<0.0010
Cyanide, Free	mg/L	<0.0010	-	-	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon (Water)							
Total Organic Carbon	mg/L	<0.50	-	-	<0.50	<0.50	<0.50
Total Metals (Water)							
Aluminum (Al)-Total	mg/L	<0.0030	<0.0030	<0.0030	**0.0036**	<0.0030	<0.0030
Antimony (Sb)-Total	mg/L	<0.000030	<0.000030	<0.000030	<0.000030	<0.000030	<0.000030
Arsenic (As)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Barium (Ba)-Total	mg/L	<0.00010	<0.00010	<0.00010	**0.00013**	<0.00010	<0.00010
Beryllium (Be)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Bismuth (Bi)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Total	mg/L	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Cesium (Cs)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Chromium (Cr)-Total	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Cobalt (Co)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Copper (Cu)-Total	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Gallium (Ga)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Iron (Fe)-Total	mg/L	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Lead (Pb)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Total	mg/L	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040	<0.00040
Magnesium (Mg)-Total	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Manganese (Mn)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Mercury (Hg)-Total	ug/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050

Note:

Bold values represent concentrations that are higher than analytical detection limits.

Appendix 3.2-2. Water Quality QA/QC Data, Madrid-Boston, 2017

Sample Type:		**Equipment Blank**	**Field Blank**	**Travel Blank**	**Equipment Blank**	**Field Blank**	**Travel Blank**
Date Sampled:		**22-Apr-2017**	**27-Apr-2017**	**27-Apr-2017**	**16-Aug-2017**	**19-Aug-2017**	**19-Aug-2017**
ALS Sample ID:	**Units**	**L1920252-10**	**L1918949-5**	**L1918949-6**	**L1977620-3**	**L1979286-6**	**L1979286-5**
Molybdenum (Mo)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Nickel (Ni)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Phosphorus (P)-Total	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Total	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Rhenium (Re)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Rubidium (Rb)-Total	mg/L	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Selenium (Se)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Silicon (Si)-Total	mg/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Silver (Ag)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Sodium (Na)-Total	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Strontium (Sr)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Tellurium (Te)-Total	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Thallium (Tl)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Thorium (Th)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Tin (Sn)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)-Total	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Tungsten (W)-Total	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Uranium (U)-Total	mg/L	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020	<0.0000020
Vanadium (V)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Yttrium (Y)-Total	mg/L	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Zinc (Zn)-Total	mg/L	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Zirconium (Zr)-Total	mg/L	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050

Note:
Bold values represent concentrations that are higher than analytical detection limits.

Appendix 3.3-1

Sediment Quality Data, Madrid-Boston, 2017

Appendix 3.3-1. Sediment Quality Data, Madrid-Boston, 2017

Site ID:					Wolverine		
Depth Zone:					Shallow	Shallow	Shallow
Depth (m):					3.8	4	3.8
Replicate:					1	2	3
Date Sampled:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	20-Aug-2017	20-Aug-2017	20-Aug-2017
ALS Sample ID:					L1980002-1	L1980002-2	L1980002-3
Parameter	Units	ISQG[b]	PEL[c]				
Physical Tests (Soil)							
Moisture	%			0.25	85.4	84.8	85.1
pH (1:2 soil:water)	pH			0.10	5.93	6.03	5.90
Particle Size (Soil)							
% Gravel (>2mm)	%			1.0	<1.0	<1.0	<1.0
% Sand (2.0mm - 0.063mm)	%			1.0	<1.0	<1.0	<1.0
% Silt (0.063mm - 4um)	%			1.0	67.9	70.3	73.4
% Clay (<4um)	%			1.0	32.0	29.6	26.5
Texture	-				Silt loam	Silt loam	Silt loam
Organic / Inorganic Carbon (Soil)							
Total Organic Carbon	%			0.050	6.96	7.42	7.33
Metals (Soil)							
Aluminum (Al)	mg/kg			50	26000	23300	21400
Antimony (Sb)	mg/kg			0.10	0.16	0.14	0.14
Arsenic (As)	mg/kg	5.9	17	0.10	5.95	5.53	15.8
Barium (Ba)	mg/kg			0.50	148	136	141
Beryllium (Be)	mg/kg			0.10	0.85	0.79	0.77
Bismuth (Bi)	mg/kg			0.20	0.24	0.22	0.22
Boron (B)	mg/kg			5.0	23.5	18.5	23.4
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.102	0.094	0.083
Calcium (Ca)	mg/kg			50	6310	5990	6370
Chromium (Cr)	mg/kg	37.3	90	0.50	75.4	69.8	66.6
Cobalt (Co)	mg/kg			0.10	14.7	13.4	13.2
Copper (Cu)	mg/kg	35.7	197	0.50	35.8	33.7	30.2
Iron (Fe)	mg/kg			50	37300	36500	73600
Lead (Pb)	mg/kg	35	91.3	0.50	10.1	9.45	8.90
Lithium (Li)	mg/kg			2.0	45.5	41.8	39.0
Magnesium (Mg)	mg/kg			20	15500	14100	12600
Manganese (Mn)	mg/kg			1.0	472	429	481
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0275	0.0267	0.0226
Molybdenum (Mo)	mg/kg			0.10	1.49	1.31	0.99
Nickel (Ni)	mg/kg			0.50	42.3	38.7	36.2
Phosphorus (P)	mg/kg			50	1330	1200	2010
Potassium (K)	mg/kg			100	7100	6030	5660
Selenium (Se)	mg/kg			0.20	0.34	0.29	0.34
Silver (Ag)	mg/kg			0.10	0.11	0.10	<0.10
Sodium (Na)	mg/kg			50	1460	1290	1250
Strontium (Sr)	mg/kg			0.50	41.3	36.8	37.7
Thallium (Tl)	mg/kg			0.050	0.297	0.264	0.263
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	1570	1370	1320
Uranium (U)	mg/kg			0.050	2.33	2.11	2.00
Vanadium (V)	mg/kg			0.20	79.4	72.2	69.9
Zinc (Zn)	mg/kg	123	315	2.0	86.6	80.3	72.3

Notes:

Shaded cells indicate values that exceed CCME guidelines (light grey, ISQG; dark grey, PEL).

[a] *Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Accessed November 27, 2017.*

[b] *ISQG = Interim Sediment Quality Guideline.*

[c] *PEL = Probable Effects Level.*

Appendix 3.3-1. Sediment Quality Data, Madrid-Boston, 2017

Site ID:					Patch		
Depth Zone:					Mid	Mid	Mid
Depth (m):					7.7	8.3	8.4
Replicate:					1	2	3
Date Sampled:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	19-Aug-2017	20-Aug-2017	20-Aug-2017
ALS Sample ID:					L1980002-10	L1980002-11	L1980002-12
Parameter	Units	ISQG[b]	PEL[c]				
Physical Tests (Soil)							
Moisture	%			0.25	81.0	75.6	78.3
pH (1:2 soil:water)	pH			0.10	6.31	6.26	6.08
Particle Size (Soil)							
% Gravel (>2mm)	%			1.0	<1.0	<1.0	<1.0
% Sand (2.0mm - 0.063mm)	%			1.0	1.6	1.8	1.3
% Silt (0.063mm - 4um)	%			1.0	53.4	56.6	53.8
% Clay (<4um)	%			1.0	45.1	41.6	44.9
Texture	-				Silty clay loam	Silty clay loam	Silty clay loam
Organic / Inorganic Carbon (Soil)							
Total Organic Carbon	%			0.050	2.18	2.03	2.15
Metals (Soil)							
Aluminum (Al)	mg/kg			50	25800	26400	26900
Antimony (Sb)	mg/kg			0.10	0.18	0.18	0.18
Arsenic (As)	mg/kg	5.9	17	0.10	13.3	15.6	16.9
Barium (Ba)	mg/kg			0.50	158	163	164
Beryllium (Be)	mg/kg			0.10	0.89	0.88	0.89
Bismuth (Bi)	mg/kg			0.20	0.24	0.25	0.26
Boron (B)	mg/kg			5.0	23.6	22.6	23.5
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.091	0.099	0.099
Calcium (Ca)	mg/kg			50	6500	6420	6400
Chromium (Cr)	mg/kg	37.3	90	0.50	80.3	82.3	83.7
Cobalt (Co)	mg/kg			0.10	16.4	16.5	17.0
Copper (Cu)	mg/kg	35.7	197	0.50	30.8	30.9	32.1
Iron (Fe)	mg/kg			50	46400	49500	49600
Lead (Pb)	mg/kg	35	91.3	0.50	11.0	11.5	11.4
Lithium (Li)	mg/kg			2.0	50.7	50.0	50.2
Magnesium (Mg)	mg/kg			20	15800	16200	16400
Manganese (Mn)	mg/kg			1.0	1470	1360	1540
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0196	0.0225	0.0251
Molybdenum (Mo)	mg/kg			0.10	1.99	1.80	2.00
Nickel (Ni)	mg/kg			0.50	46.2	46.7	48.5
Phosphorus (P)	mg/kg			50	1170	1280	1240
Potassium (K)	mg/kg			100	6880	7050	7210
Selenium (Se)	mg/kg			0.20	0.32	0.33	0.37
Silver (Ag)	mg/kg			0.10	0.29	0.31	0.31
Sodium (Na)	mg/kg			50	1370	1360	1410
Strontium (Sr)	mg/kg			0.50	45.2	44.5	44.9
Thallium (Tl)	mg/kg			0.050	0.305	0.321	0.317
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	1680	1650	1690
Uranium (U)	mg/kg			0.050	2.07	2.15	2.16
Vanadium (V)	mg/kg			0.20	84.2	85.6	86.6
Zinc (Zn)	mg/kg	123	315	2.0	86.0	89.1	90.6

Notes:

Shaded cells indicate values that exceed CCME guidelines (light grey, ISQG; dark grey, PEL).

[a] *Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Accessed November 27, 2017.*

[b] *ISQG = Interim Sediment Quality Guideline.*

[c] *PEL = Probable Effects Level.*

Appendix 3.3-1. Sediment Quality Data, Madrid-Boston, 2017

Site ID:					Windy		
Depth Zone:					Deep	Deep	Deep
Depth (m):					17.7	17.6	17.6
Replicate:					1	2	3
Date Sampled:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	19-Aug-2017	21-Aug-2017	21-Aug-2017
ALS Sample ID:					L1980002-7	L1980002-8	L1980002-9
Parameter	Units	ISQG[b]	PEL[c]				
Physical Tests (Soil)							
Moisture	%			0.25	73.8	73.4	74.6
pH (1:2 soil:water)	pH			0.10	6.78	6.85	6.91
Particle Size (Soil)							
% Gravel (>2mm)	%			1.0	<1.0	<1.0	<1.0
% Sand (2.0mm - 0.063mm)	%			1.0	<1.0	<1.0	<1.0
% Silt (0.063mm - 4um)	%			1.0	55.9	54.2	54.7
% Clay (<4um)	%			1.0	43.8	45.5	44.8
Texture	-				Silty clay loam	Silty clay loam	Silty clay loam
Organic / Inorganic Carbon (Soil)							
Total Organic Carbon	%			0.050	1.3	1.28	1.36
Metals (Soil)							
Aluminum (Al)	mg/kg			50	25600	25900	25800
Antimony (Sb)	mg/kg			0.10	0.24	0.25	0.24
Arsenic (As)	mg/kg	5.9	17	0.10	24.6	28.6	30.1
Barium (Ba)	mg/kg			0.50	157	154	157
Beryllium (Be)	mg/kg			0.10	0.89	0.90	0.91
Bismuth (Bi)	mg/kg			0.20	0.27	0.27	0.25
Boron (B)	mg/kg			5.0	21.0	21.4	21.6
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.098	0.099	0.098
Calcium (Ca)	mg/kg			50	6620	6770	6730
Chromium (Cr)	mg/kg	37.3	90	0.50	77.8	76.8	77.1
Cobalt (Co)	mg/kg			0.10	16.4	16.9	16.9
Copper (Cu)	mg/kg	35.7	197	0.50	38.4	38.1	38.0
Iron (Fe)	mg/kg			50	47600	50400	50700
Lead (Pb)	mg/kg	35	91.3	0.50	10.9	10.9	10.4
Lithium (Li)	mg/kg			2.0	50.2	50.8	49.5
Magnesium (Mg)	mg/kg			20	16500	16700	16400
Manganese (Mn)	mg/kg			1.0	1210	1520	1840
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0243	0.0226	0.0221
Molybdenum (Mo)	mg/kg			0.10	3.24	3.96	4.31
Nickel (Ni)	mg/kg			0.50	41.5	41.6	41.6
Phosphorus (P)	mg/kg			50	1350	1430	1420
Potassium (K)	mg/kg			100	7140	7260	7190
Selenium (Se)	mg/kg			0.20	0.41	0.41	0.42
Silver (Ag)	mg/kg			0.10	0.10	<0.10	<0.10
Sodium (Na)	mg/kg			50	1540	1540	1540
Strontium (Sr)	mg/kg			0.50	45.2	46.8	45.3
Thallium (Tl)	mg/kg			0.050	0.319	0.319	0.303
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	1700	1690	1660
Uranium (U)	mg/kg			0.050	2.54	2.49	2.44
Vanadium (V)	mg/kg			0.20	81.3	82.7	81.0
Zinc (Zn)	mg/kg	123	315	2.0	86.2	88.0	87.0

Notes:

Shaded cells indicate values that exceed CCME guidelines (light grey, ISQG; dark grey, PEL).

[a] *Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Accessed November 27, 2017.*

[b] *ISQG = Interim Sediment Quality Guideline.*

[c] *PEL = Probable Effects Level.*

Appendix 3.3-1. Sediment Quality Data, Madrid-Boston, 2017

Site ID:					Stickleback		
Depth Zone:					Shallow	Shallow	Shallow
Depth (m):					2.3	2.4	2.3
Replicate:					1	2	3
Date Sampled:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	16-Aug-2017	16-Aug-2017	16-Aug-2017
ALS Sample ID:					L1980002-4	L1980002-5	L1980002-6
Parameter	Units	ISQG[b]	PEL[c]				
Physical Tests (Soil)							
Moisture	%			0.25	92.4	92.8	93.6
pH (1:2 soil:water)	pH			0.10	6.36	5.91	5.76
Particle Size (Soil)							
% Gravel (>2mm)	%			1.0	<1.0	<1.0	<1.0
% Sand (2.0mm - 0.063mm)	%			1.0	<1.0	<1.0	<1.0
% Silt (0.063mm - 4um)	%			1.0	92.6	93.5	93.7
% Clay (<4um)	%			1.0	7.3	6.3	6.2
Texture	-				Silt	Silt	Silt
Organic / Inorganic Carbon (Soil)							
Total Organic Carbon	%			0.050	22.5	22.1	22.3
Metals (Soil)							
Aluminum (Al)	mg/kg			50	11000	11100	10900
Antimony (Sb)	mg/kg			0.10	0.22	0.23	0.22
Arsenic (As)	mg/kg	5.9	17	0.10	6.40	7.80	9.50
Barium (Ba)	mg/kg			0.50	71.6	68.9	65.5
Beryllium (Be)	mg/kg			0.10	0.45	0.45	0.47
Bismuth (Bi)	mg/kg			0.20	<0.20	<0.20	<0.20
Boron (B)	mg/kg			5.0	27.3	26.4	21.5
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.173	0.173	0.172
Calcium (Ca)	mg/kg			50	9270	8510	8060
Chromium (Cr)	mg/kg	37.3	90	0.50	33.8	34.2	34.8
Cobalt (Co)	mg/kg			0.10	10.6	11.4	11.3
Copper (Cu)	mg/kg	35.7	197	0.50	44.5	45.5	50.2
Iron (Fe)	mg/kg			50	19800	21700	20900
Lead (Pb)	mg/kg	35	91.3	0.50	6.41	6.43	6.32
Lithium (Li)	mg/kg			2.0	17.6	18.0	17.6
Magnesium (Mg)	mg/kg			20	6260	6110	6100
Manganese (Mn)	mg/kg			1.0	346	228	232
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0671	0.0637	0.0502
Molybdenum (Mo)	mg/kg			0.10	1.21	1.60	1.90
Nickel (Ni)	mg/kg			0.50	31.2	32.8	33.4
Phosphorus (P)	mg/kg			50	1310	1130	821
Potassium (K)	mg/kg			100	2680	2570	2420
Selenium (Se)	mg/kg			0.20	0.70	0.85	0.70
Silver (Ag)	mg/kg			0.10	<0.10	<0.10	<0.10
Sodium (Na)	mg/kg			50	744	735	770
Strontium (Sr)	mg/kg			0.50	50.7	48.5	44.2
Thallium (Tl)	mg/kg			0.050	0.152	0.151	0.146
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	589	601	511
Uranium (U)	mg/kg			0.050	1.70	1.69	1.86
Vanadium (V)	mg/kg			0.20	40.1	41.8	43.1
Zinc (Zn)	mg/kg	123	315	2.0	57.8	58.8	59.2

Notes:

Shaded cells indicate values that exceed CCME guidelines (light grey, ISQG; dark grey, PEL).

[a] *Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Accessed November 27, 2017.*

[b] *ISQG = Interim Sediment Quality Guideline.*

[c] *PEL = Probable Effects Level.*

Appendix 3.3-1. Sediment Quality Data, Madrid-Boston, 2017

Site ID:					Aimaokatalok Outfall		
Depth Zone:					Mid	Mid	Mid
Depth (m):					8.3	8.4	8.5
Replicate:					1	2	3
Date Sampled:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	18-Aug-2017	18-Aug-2017	18-Aug-2017
ALS Sample ID:					L1980002-16	L1980002-17	L1980002-18
Parameter	Units	ISQG[b]	PEL[c]				
Physical Tests (Soil)							
Moisture	%			0.25	71.7	72.6	71.5
pH (1:2 soil:water)	pH			0.10	6.08	5.98	6.19
Particle Size (Soil)							
% Gravel (>2mm)	%			1.0	<1.0	<1.0	<1.0
% Sand (2.0mm - 0.063mm)	%			1.0	5.9	3.5	6.5
% Silt (0.063mm - 4um)	%			1.0	65.2	69.2	64.6
% Clay (<4um)	%			1.0	28.9	27.3	29.0
Texture	-				Silt loam	Silt loam	Silt loam
Organic / Inorganic Carbon (Soil)							
Total Organic Carbon	%			0.050	2.21	2.17	2.18
Metals (Soil)							
Aluminum (Al)	mg/kg			50	18000	20000	18800
Antimony (Sb)	mg/kg			0.10	0.14	0.15	0.13
Arsenic (As)	mg/kg	5.9	17	0.10	8.74	15.6	8.25
Barium (Ba)	mg/kg			0.50	109	157	110
Beryllium (Be)	mg/kg			0.10	0.64	0.73	0.67
Bismuth (Bi)	mg/kg			0.20	0.20	0.22	<0.20
Boron (B)	mg/kg			5.0	14.3	16.9	14.6
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.124	0.171	0.131
Calcium (Ca)	mg/kg			50	4710	5000	4380
Chromium (Cr)	mg/kg	37.3	90	0.50	51.9	57.1	55.6
Cobalt (Co)	mg/kg			0.10	18.6	23.4	17.3
Copper (Cu)	mg/kg	35.7	197	0.50	21.9	24.5	22.3
Iron (Fe)	mg/kg			50	41200	53400	40100
Lead (Pb)	mg/kg	35	91.3	0.50	9.13	9.94	9.16
Lithium (Li)	mg/kg			2.0	30.1	32.4	30.8
Magnesium (Mg)	mg/kg			20	9050	9850	9460
Manganese (Mn)	mg/kg			1.0	4010	11300	2750
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0544	0.0517	0.0508
Molybdenum (Mo)	mg/kg			0.10	1.87	3.39	1.75
Nickel (Ni)	mg/kg			0.50	28.2	35.0	29.3
Phosphorus (P)	mg/kg			50	997	1300	996
Potassium (K)	mg/kg			100	4010	4570	4040
Selenium (Se)	mg/kg			0.20	0.36	0.41	0.33
Silver (Ag)	mg/kg			0.10	0.10	0.11	0.11
Sodium (Na)	mg/kg			50	581	625	617
Strontium (Sr)	mg/kg			0.50	35.4	43.7	35.8
Thallium (Tl)	mg/kg			0.050	0.239	0.281	0.230
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	1010	1150	1040
Uranium (U)	mg/kg			0.050	1.70	1.87	1.70
Vanadium (V)	mg/kg			0.20	61.1	68.6	63.9
Zinc (Zn)	mg/kg	123	315	2.0	78.9	94.2	79.8

Notes:

Shaded cells indicate values that exceed CCME guidelines (light grey, ISQG; dark grey, PEL).

[a] *Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Accessed November 27, 2017.*

[b] *ISQG = Interim Sediment Quality Guideline.*

[c] *PEL = Probable Effects Level.*

Appendix 3.3-1. Sediment Quality Data, Madrid-Boston, 2017

Site ID:					Aimaokatalok Station 6		
Depth Zone:					Deep	Deep	Deep
Depth (m):					27.3	24.4	27.5
Replicate:					1	2	3
Date Sampled:		CCME Guidelines for the Protection of Aquatic Life[a]		Realized Detection Limit	18-Aug-2017	18-Aug-2017	18-Aug-2017
ALS Sample ID:					L1980002-13	L1980002-14	L1980002-15
Parameter	Units	ISQG[b]	PEL[c]				
Physical Tests (Soil)							
Moisture	%			0.25	66.5	63.2	68.5
pH (1:2 soil:water)	pH			0.10	6.18	6.11	6.13
Particle Size (Soil)							
% Gravel (>2mm)	%			1.0	<1.0	<1.0	<1.0
% Sand (2.0mm - 0.063mm)	%			1.0	12.2	10.7	10.1
% Silt (0.063mm - 4um)	%			1.0	51.3	50.3	59.9
% Clay (<4um)	%			1.0	36.5	38.9	30.0
Texture	-				Silty clay loam	Silty clay loam	Silt loam
Organic / Inorganic Carbon (Soil)							
Total Organic Carbon	%			0.050	1.92	1.59	1.83
Metals (Soil)							
Aluminum (Al)	mg/kg			50	21100	22700	21800
Antimony (Sb)	mg/kg			0.10	0.13	0.13	0.13
Arsenic (As)	mg/kg	5.9	17	0.10	4.58	4.42	4.56
Barium (Ba)	mg/kg			0.50	130	140	131
Beryllium (Be)	mg/kg			0.10	0.77	0.82	0.78
Bismuth (Bi)	mg/kg			0.20	<0.20	0.22	<0.20
Boron (B)	mg/kg			5.0	17.3	17.1	18.2
Cadmium (Cd)	mg/kg	0.6	3.5	0.050	0.175	0.195	0.179
Calcium (Ca)	mg/kg			50	4710	4760	4850
Chromium (Cr)	mg/kg	37.3	90	0.50	60.4	66.1	63.3
Cobalt (Co)	mg/kg			0.10	13.2	13.5	13.4
Copper (Cu)	mg/kg	35.7	197	0.50	20.8	22.8	20.9
Iron (Fe)	mg/kg			50	30100	29600	30000
Lead (Pb)	mg/kg	35	91.3	0.50	8.98	9.97	9.30
Lithium (Li)	mg/kg			2.0	35.5	41.5	38.6
Magnesium (Mg)	mg/kg			20	11000	12000	11400
Manganese (Mn)	mg/kg			1.0	782	670	721
Mercury (Hg)	mg/kg	0.17	0.486	0.0050	0.0509	0.0443	0.0517
Molybdenum (Mo)	mg/kg			0.10	1.05	1.13	1.09
Nickel (Ni)	mg/kg			0.50	29.5	32.0	30.7
Phosphorus (P)	mg/kg			50	838	811	817
Potassium (K)	mg/kg			100	5020	5250	5190
Selenium (Se)	mg/kg			0.20	0.28	0.23	0.24
Silver (Ag)	mg/kg			0.10	0.11	0.12	0.12
Sodium (Na)	mg/kg			50	827	790	769
Strontium (Sr)	mg/kg			0.50	41.2	41.7	42.4
Thallium (Tl)	mg/kg			0.050	0.269	0.290	0.280
Tin (Sn)	mg/kg			2.0	<2.0	<2.0	<2.0
Titanium (Ti)	mg/kg			1.0	1230	1280	1260
Uranium (U)	mg/kg			0.050	1.69	1.79	1.71
Vanadium (V)	mg/kg			0.20	66.4	71.9	68.2
Zinc (Zn)	mg/kg	123	315	2.0	90.7	101	94.8

Notes:

Shaded cells indicate values that exceed CCME guidelines (light grey, ISQG; dark grey, PEL).

[a] *Canadian sediment quality guidelines for the protection of freshwater aquatic life, Canadian Council of Ministers of the Environment, Accessed November 27, 2017.*

[b] *ISQG = Interim Sediment Quality Guideline.*

[c] *PEL = Probable Effects Level.*

Appendix 3.3-2

Sediment Sample Descriptions, Madrid-Boston, 2017

Appendix 3.3-2. Sediment Sample Descriptions, Madrid-Boston, 2017

Site ID:	Wolverine			Patch		
Date Sampled:	20-Aug-17	20-Aug-17	20-Aug-17	19-Aug-17	20-Aug-17	20-Aug-17
Replicate:	1	2	3	1	2	3
Grab Depth (m)	3.8	4.0	3.8	7.7	8.3	8.4
Grab Thickness (mm)	54	56	67	85	71	59
Phsical Description	loose surface seds with organic plant materials over clays	loose surface seds with organic plant materials over clays	loose surface seds with organic plant materials over clays	loose silt over clay	fine silt over silty-clay	fine silt over clay
Musell Colour Classification	top - 10 YR 4/1	top - 10YR 4/3 remaining - 2.5Y 4/1, 2.5Y 5/1	top - 10YR 3/6 remaining - 10YR 4/1, 5Y 3/1	top - 10 YR 4/4 remaining - 5Y 5/1, 5Y 3/1	top - 7.5YR 4/4 remaining - 5Y 5/1, GLEY 1 4/N	top - 7.5YR 4/4 remaining - 5Y 5/1, GLEY 1 4/N
Biological Materal	macrophytes (various stages of degredation), algal mats (filamentous), small round gelatinous spheres, gastropod shells	some macrophytes (various stages of degredation), algal mats (filamentous), small round gelatinous spheres, gastropod shells	macrophtyes, sparse algae mats	algal mats (filamentous)	algal mats (filamentous)	algal mats (filamentous)
Debris	none	none	none	none	none	none
Photograph (Y/N)	Y	Y	Y	Y	Y	Y
Notes:	-	-	-	-	-	-

Appendix 3.3-2. Sediment Sample Descriptions, Madrid-Boston, 2017

Site ID:	Windy			Stickleback		
Date Sampled:	19-Aug-17	21-Aug-17	21-Aug-17	16-Aug-17	16-Aug-17	16-Aug-17
Replicate:	1	2	3	1	2	3
Grab Depth (m)	17.7	17.6	17.6	2.3	2.4	2.3
Grab Thickness (mm)	47	78	66	44	23	35
Phsical Description	very fine clay/sand on top, clay below	fine sand over smooth clay	fine sand over smooth clay	fine, loose, silt over homgenous clay	fine, loose, silt over homgenous clay	fine, loose, silt /sand over homgenous clay
Musell Colour Classification	top - 2.5YR 5/4 remaining - 5Y 5/1	top - 2.5YR 5/4 remaining - 5Y 5/1	top - 2.5YR 5/4 remaining - 5Y 5/1	top - 10 YR 3/2 remaining - 10YR 3/4	top - 2.5YR 3/1, 2.5YR 3/2 remaining - 10YR 3/1	top - 10 YR 3/2 remaining - 10YR 4/3
Biological Materal	none	none	none	small gastropod shells, many macrophytes (varying degredation)	many macrophytes (varying degredation), gastropod/mollusc shells	many macrophytes (varying degredation), gastropod/mollusc shells
Debris	none	none	none	none	none	none
Photograph (Y/N)	Y	Y	Y	Y	Y	Y
Notes:	-	-	-	-	-	-

Appendix 3.3-2. Sediment Sample Descriptions, Madrid-Boston, 2017

Site ID:	**Aimaokatalok Outfall**			**Aimaokatalok Station 6**		
Date Sampled:	**18-Aug-17**	**18-Aug-17**	**18-Aug-17**	**18-Aug-17**	**18-Aug-17**	**18-Aug-17**
Replicate:	**1**	**2**	**3**	**1**	**2**	**3**
Grab Depth (m)	8.3	8.4	8.5	27.3	24.4	27.5
Grab Thickness (mm)	53	48	56	76	-	59
Phsical Description	silt/fine sand	loose fine silt mixed with silt/fine sand	fine silt/sand over mixed clay	fine sand over dense clay	fine sand over dense clay	fine sand over dense clay
Musell Colour Classification	top - 7.5YR 4/3 remaining - 10YR5/3, 5Y 5/1	top - 5YR 3/3, 7.5YR 3/3 remaining - 2.5Y 5/2, 2.5Y 25/1	top - 105YR 3/6, 10YR 5/1 remaining - 2.5R 6/3	top - 7.5YR 4/4 remaining- GLEY 1 5/10Y	top - 7.5YR 4/4 remaining- GLEY 1 5/10Y	top - 7.5YR 4/4 remaining- GLEY 1 5/10Y
Biological Materal	none	none	none	none	none	none
Debris	none	dense gravel patches mixed in deeper layers	none	none	none	none
Photograph (Y/N)	Y	Y	Y	Y	none	Y
Notes:	a lot of coarse material (gravel) in benthos sieve	a lot of coarse material (gravel) in benthos sieve	a lot of coarse material (gravel) in benthos sieve	floating macrophyte clump removed from grab	-	-

Appendix 3.3-3

Sediment Sample Photos, Madrid-Boston, 2017

Appendix 3.3-3. Sediment Sample Photos, Madrid-Boston, 2017

Plate 1. Wolverine Rep 1.

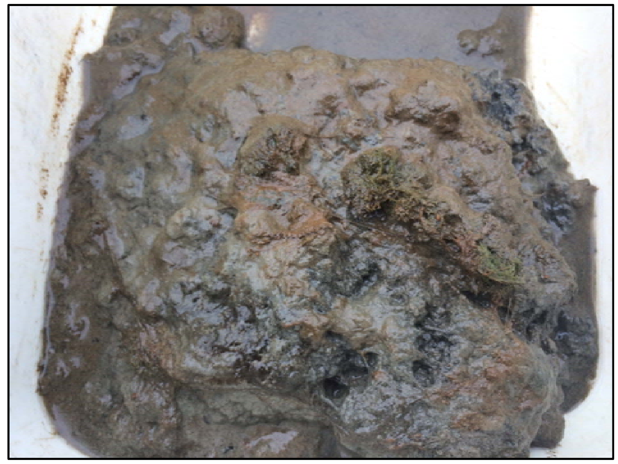

Plate 2. Wolverine Rep 2.

Plate 3. Wolverine Rep 3.

Plate 4. Patch Rep 1.

Plate 5. Patch Rep 2.

Plate 6. Patch Rep 3.


Plate 7. Windy Rep 2.


Plate 8. Windy Rep 2.


Plate 9. Windy Rep 3.

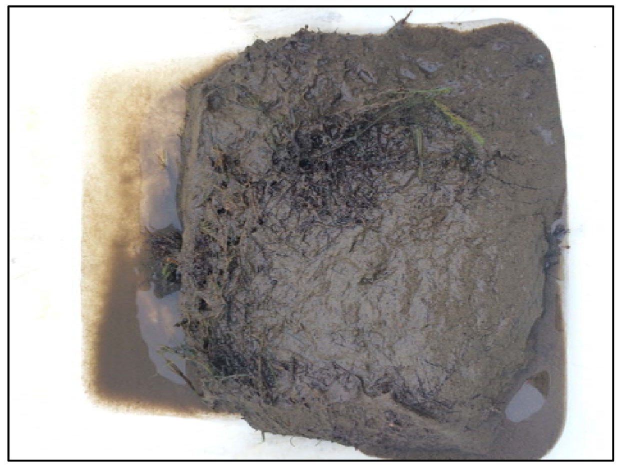
Plate 10. Stickleback Rep 1.


Plate 11. Stickleback Rep 2.


Plate 12. Stickleback Rep 3.

Plate 13. Aimaokatalok Outfall Rep 1.

Plate 14. Aimaokatalok Outfall Rep 2.

Plate 15. Aimaokatalok Outfall Rep 3.

Plate 16. Aimaokatalok Station 6 Rep 1.

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Plate 17. Aimaokatalok Station 6 Rep 2.

Plate 18. Aimaokatalok Station 6 Rep 3.

Appendix 3.4-1

Primary Producer Biomass Data, Madrid-Boston, 2017

Appendix 3.4-1. Primary Producer Biomass Data, Madrid-Boston, 2017

Site ID	Replicate	Date Sampled	ALS Sample ID	Chlorophyll α (µg/L)	Mean	Standard Error
Wolverine	1	22-Apr-17	L1919326-7	1.12	1.82	0.41
	2	22-Apr-17	L1919326-8	2.53		
	3	22-Apr-17	L1919326-9	1.80		
Patch	1	22-Apr-17	L1919326-4	0.51	0.37	0.07
	2	22-Apr-17	L1919326-5	0.29		
	3	22-Apr-17	L1919326-6	0.32		
Windy	1	25-Apr-17	L1919326-1	2.00	2.50	0.27
	2	25-Apr-17	L1919326-2	2.57		
	3	25-Apr-17	L1919326-3	2.92		
Stickleback	1	24-Apr-17	L1919326-10	14.8	14.7	0.62
	2	24-Apr-17	L1919326-11	13.6		
	3	24-Apr-17	L1919326-12	15.8		
Aimaokatalok Outfall	1	24-Apr-17	L1919326-13	0.95	1.79	0.44
	2	24-Apr-17	L1919326-14	2.01		
	3	24-Apr-17	L1919326-15	2.41		
Aimaokatalok Station 6	1	24-Apr-17	L1919326-16	0.42	0.62	0.10
	2	24-Apr-17	L1919326-17	0.66		
	3	24-Apr-17	L1919326-18	0.78		
Wolverine	1	20-Aug-17	L1979141-1	3.17	3.29	0.08
	2	20-Aug-17	L1979141-2	3.27		
	3	20-Aug-17	L1979141-3	3.43		
Patch	1	19-Aug-17	L1979141-7	0.96	0.83	0.07
	2	19-Aug-17	L1979141-8	0.74		
	3	19-Aug-17	L1979141-9	0.79		
Windy	1	19-Aug-17	L1979141-10	0.31	0.37	0.03
	2	19-Aug-17	L1979141-11	0.39		
	3	19-Aug-17	L1979141-12	0.41		
Stickleback	1	16-Aug-17	L1979141-4	1.87	1.75	0.07
	2	16-Aug-17	L1979141-5	1.77		
	3	16-Aug-17	L1979141-6	1.62		
Aimaokatalok Outfall	1	18-Aug-17	L1979141-16	1.44	1.44	0.04
	2	18-Aug-17	L1979141-17	1.37		
	3	18-Aug-17	L1979141-18	1.52		
Aimaokatalok Station 6	1	18-Aug-17	L1979141-13	1.54	1.59	0.05
	2	18-Aug-17	L1979141-14	1.69		
	3	18-Aug-17	L1979141-15	1.56		

Note: all samples collected at 1 m depth except in Stickleback Lake on April 24. The water beneath the ice was too shallow to use the Niskin sampling bottle, instead, the sampling bottle was affixed to a pole and filled from just below the bottom of the ice layer.

Appendix 3.5-1

Lake Benthos Data, Madrid-Boston, 2017

Appendix 3.5-1. Lake Benthos Data, Madrid-Boston, 2017

				Site ID:	**Wolverine Lake**					**Patch Lake**					**Windy Lake**				
				Depth Zone:	Shallow	Shallow	Shallow	Shallow	Shallow	Mid	Mid	Mid	Mid	Mid	Deep	Deep	Deep	Deep	Deep
				Depth (m):	3.8	4	3.8	3.9	4	7.7	8.3	8.4	8.3	8.4	17.7	17.6	17.6	17.7	17.6
				Replicate:	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
				Date Sampled:	20-Aug-17	20-Aug-17	20-Aug-17	20-Aug-17	20-Aug-17	19-Aug-17	20-Aug-17	20-Aug-17	20-Aug-17	20-Aug-17	19-Aug-17	21-Aug-17	21-Aug-17	21-Aug-17	21-Aug-17
Major Group	**Family**	**Subfamily**	**Tribe**	**Genus**															
Oligochaeta – cocoon*	-	-	-	-	0	0	0	0	0	0	0	0	0	0	15	0	0	0	0
Oligochaeta	Lumbriculidae	-	-	-	0	0	0	237	0	0	0	0	0	0	0	0	0	0	0
	Naididae	Naidinae	-	-	13985	26904	33363	38874	39230	0	0	0	0	0	0	0	0	0	0
	Naididae	Tubificinae	-	-	0	0	119	0	0	0	222	119	74	193	15	0	0	0	0
Gastropoda	Valvatidae	-	-	*Valvata sincera*	948	1185	2193	2015	830	0	0	0	0	0	0	0	0	0	0
Pelecypoda	Pisidiidae	-	-	(i/d)*	830	1778	1007	2133	474	59	89	89	0	15	0	0	0	0	0
		-	-	*Sphaerium*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		-	-	*Pisidium*	874	889	830	1422	1304	44	44	15	148	89	0	0	0	0	0
Hydracarina	-	-	-	(i/d)*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lebertiidae	-	-	*Lebertia*	0	59	0	0	0	0	0	0	0	0	0	0	0	0	0
	Pionidae	-	-	*Piona*	119	237	237	593	0	0	0	0	0	0	0	0	0	0	0
Ostracoda	-	-	-	-	8237	12800	8770	8889	2074	222	148	252	296	341	0	0	15	15	0
Amphipoda	Gammaridae	-	-	*Gammarus lacustris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malacostraca	Mysidae	-	-	*Mysis relicta*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	59
Isopoda	Chaetiliidae	-	-	*Saduria entomon*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	Chironomidae	-	-	(pupa)*	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
		Tanypodinae	Pentaneurini	*Thienemannimyia* group	0	0	0	0	0	237	30	44	44	15	0	0	0	0	0
			Procladiini	*Procladius*	119	0	59	0	59	15	222	193	119	163	15	30	15	15	74
		Diamesinae	Protanypini	*Protanypus*	0	0	0	0	0	0	0	0	0	0	0	0	15	15	0
		Prodiamesinae	-	*Monodiamesa*	0	0	0	0	0	15	44	119	44	89	0	0	0	0	15
		Orthocladiinae	Orthocladiini	*Cricotopus / Orthocladius*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				Heterotrissocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				Nanocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				Psectrocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				Zalutschia	0	59	237	296	59	0	0	0	0	0	0	0	15	0	0
		Chironominae	Chironomini	*Chironomus*	207	296	593	415	178	0	0	0	0	0	15	0	0	0	15
				Cladopelma	119	237	0	0	0	0	0	0	0	0	0	0	0	0	0
				Sergenta	963	711	356	1007	474	948	89	370	800	163	0	0	0	0	0
				Stictochironomus	0	0	0	0	0	0	148	30	0	0	0	0	0	0	0
			Tanytarsini	*Cladotanytarsus*	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0
				Corynocera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				Micropsectra	0	0	0	0	0	207	370	296	281	356	0	0	0	0	0
				Paratanytarsus	0	0	0	0	0	148	15	59	74	15	0	0	0	0	0
				Tanytarsus	15	119	119	119	356	15	0	0	0	15	0	0	0	0	0
Terrestrial**	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nematoda**	-	-	-	-	356	1600	1304	2133	415	0	0	0	0	0	0	0	0	0	0
Copepoda – Calanoida**	-	-	-	-	0	0	0	0	0	0	74	0	0	74	0	15	30	0	15
Copepoda – Cyclopoida**	-	-	-	-	59	948	0	296	0	252	222	311	281	148	0	0	0	0	0
Cladocera**	Daphnidae	-	-	*Daphnia*	0	0	0	0	0	15	15	15	74	74	0	0	0	0	0
				Total	26415	45274	47881	56000	45037	1911	1437	1585	1881	1467	59	30	59	44	163

Notes:

Data presented as organisms/m².

i/d = immature or damaged inviduals; NA = not available.

**Taxa were included in the total abundance calculation but excluded from community composition analyses.*

***Taxa were excluded from all data analyses.*

Appendix 3.5-1. Lake Benthos Data, Madrid-Boston, 2017

				Site ID:	**Stickleback Lake**					**Aimaokatalok Outfall**					**Aimaokatalok Station 6**				
				Depth Zone:	Shallow	Shallow	Shallow	Shallow	Shallow	Mid	Mid	Mid	Mid	Mid	Deep	Deep	Deep	Deep	Deep
				Depth (m):	2.3	2.4	2.3	NA	2.3	8.3	8.4	8.5	8.5	8.8	27.3	24.4	27.5	27.3	27.4
				Replicate:	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
				Date Sampled:	16-Aug-17	16-Aug-17	16-Aug-17	16-Aug-17	16-Aug-17	18-Aug-17	18-Aug-17	18-Aug-17	18-Aug-17	18-Aug-17	18-Aug-17	18-Aug-17	18-Aug-17	18-Aug-17	18-Aug-17
Major Group	**Family**	**Subfamily**	**Tribe**	**Genus**															
Oligochaeta – cocoon*	-	-	-	-	0	0	0	59	0	0	0	0	0	0	0	15	59	0	0
Oligochaeta	Lumbriculidae	-	-	-	356	0	0	59	474	0	0	0	0	0	0	0	0	0	0
	Naididae	Naidinae	-	-	0	0	0	296	0	0	0	0	0	0	15	0	0	0	0
	Naididae	Tubificinae	-	-	1541	1126	770	1896	2133	0	0	0	0	0	30	15	15	15	15
Gastropoda	Valvatidae	-	-	*Valvata sincera*	2015	1422	2785	4741	6044	0	0	0	0	0	0	0	0	0	0
Pelecypoda	Pisidiidae	-	-	(i/d)*	1481	178	2726	3437	3674	859	430	163	281	533	104	400	785	667	711
		-	-	*Sphaerium*	1956	1541	889	1126	2844	0	0	0	0	0	0	0	0	0	0
		-	-	*Pisidium*	3259	830	2311	2963	3911	474	385	311	74	281	104	1170	637	770	1052
Hydracarina	-	-	-	(i/d)*	0	0	237	0	0	0	0	0	0	0	59	30	0	30	30
	Lebertiidae	-	-	*Lebertia*	0	119	0	0	0	0	0	0	0	0	0	0	0	0	0
	Pionidae	-	-	*Piona*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ostracoda	-	-	-	-	830	1659	2252	11615	3793	15	0	0	0	44	74	74	30	89	30
Amphipoda	Gammaridae	-	-	*Gammarus lacustris*	919	281	104	770	1837	0	0	0	0	0	0	0	0	0	0
Malacostraca	Mysidae	-	-	*Mysis relicta*	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0
Isopoda	Chaetiliidae	-	-	*Saduria entomon*	0	0	0	0	0	0	15	0	15	0	0	15	0	0	0
Diptera	Chironomidae	-	-	(pupa)*	0	0	0	0	0	0	0	0	15	0	15	0	0	0	0
		Tanypodinae	Pentaneurini	*Thienemannimyia* group	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Procladiini	*Procladius*	0	474	296	711	1896	1185	1007	1081	637	711	178	281	356	489	400
		Diamesinae	Protanypini	*Protanypus*	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
		Prodiamesinae	-	*Monodiamesa*	0	0	0	0	0	0	15	15	0	0	15	0	15	30	0
		Orthocladiinae	Orthocladiini	*Cricotopus / Orthocladius*	830	1007	119	1185	4030	0	0	0	0	0	0	0	0	0	0
				Heterotrissocladius	0	0	0	0	0	44	0	0	0	0	0	0	0	0	0
				Nanocladius	119	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				Psectrocladius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				Zalutschia	474	1067	356	0	830	0	0	15	0	0	0	0	0	0	0
		Chironominae	Chironomini	*Chironomus*	4622	7704	10489	13985	17304	0	0	0	0	0	0	30	0	0	30
				Cladopelma	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
				Sergenta	119	0	356	0	0	0	0	0	0	0	430	15	0	0	0
				Stictochironomus	0	0	0	0	0	44	0	44	0	15	59	89	59	74	44
			Tanytarsini	*Cladotanytarsus*	0	0	0	59	0	0	0	0	0	0	0	0	0	0	0
				Corynocera	0	0	0	533	1185	0	0	0	0	0	0	0	0	0	0
				Micropsectra	0	0	0	0	0	15	0	0	15	0	119	0	0	0	0
				Paratanytarsus	5096	7111	3793	2785	26074	0	0	0	0	0	341	0	0	0	0
				Tanytarsus	0	0	0	0	474	0	74	15	30	119	74	15	44	30	89
Terrestrial**	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0
Nematoda**	-	-	-	-	1067	119	1126	1896	11141	0	0	15	15	0	15	0	0	0	0
Copepoda – Calanoida**	-	-	-	-	0	0	0	0	0	15	15	15	44	15	30	0	44	0	15
Copepoda – Cyclopoida**	-	-	-	-	0	0	0	237	0	0	0	15	15	0	15	0	0	15	15
Cladocera**	Daphnidae	-	-	*Daphnia*	0	0	0	0	0	0	0	0	0	15	0	0	0	0	0
				Total	23615	24519	27481	46222	76504	2637	1941	1644	1067	1719	1615	2148	2000	2193	2400

Notes:

Data presented as organisms/m².

i/d = immature or damaged inviduals; NA = not available.

**Taxa were included in the total abundance calculation but excluded from community composition analyses.*

***Taxa were excluded from all data analyses.*