Appendix E

Evaluation of Reference Lakes

Mary River Project

June 2014

Candidate Reference Lakes:

Preliminary Survey 2013

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Aquatic Environment Specialists

Candidate Reference Lakes: Preliminary Survey 2013

June, 2014

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AEMP	Aquatic Effects Monitoring Program
BMI	Benthic macroinvertebrate(s)
CCME	Council of Ministers of the Environment
CCREM	Canadian Council of Resource and Environment Ministers
COV	Coefficient of variation
CREMP	Core Receiving Environment Monitoring Program
DO	Dissolved oxygen
NSC	North/South Consultants Inc.
PAL	Protection of aquatic life
PRSD	Percent relative standard deviation
PSA	Particle size analysis
RPMD	Relative percent mean difference
SD	Standard deviation
SE	Standard error of the mean
TDS	Total dissolved solids
TN	Total nitrogen
TP	Total phosphorus
TOC	Total organic carbon

1.0 INTRODUCTION AND OVERVIEW

The Core Receiving Environment Monitoring Program (CREMP) of the aquatic effects monitoring program (AEMP) for the Mary River Project incorporates monitoring in reference waterbodies. The AEMP identifies that a minimum of one reference lake would be monitored for chemical and biological parameters in parallel with the CREMP which will be conducted in the Mine Area.

Preliminary identification of candidate reference lakes for the CREMP and AEMP was completed through a series of desktop screening exercises completed in 2013. This exercise, which is described in North/South Consultants Inc. (NSC) and Knight Piésold (2013), identified 12 potential reference lakes for Camp and/or Sheardown lakes within an 80 km radius of the Mary River Mine Site (Figure 1).

This interim report provides a description of reconnaissance surveys conducted in the open-water season of 2013 to identify reference lakes for Camp and Sheardown lakes at the mine site. Reconnaissance surveys were planned for the open-water season of 2013, with the objective of collecting information on the biota, physical habitat, and chemical conditions (i.e., water quality) at the three most suitable lakes as identified through an initial survey. Ultimately, the objective was to determine presence/absence of land-locked resident Arctic Char (*Salvelinus alpinus*), conduct a coarse aquatic habitat survey, and collect water quality, phytoplankton, zooplankton, and benthic macroinvertebrate (BMI) samples (all from a single site) in each of three lakes to assist with selecting the final reference lake(s).

The first reconnaissance survey conducted in summer (i.e., early August 2013) identified two potentially suitable reference lakes and these lakes were surveyed as indicated above. As the overall objective was to identify three candidate lakes, a second reconnaissance survey was completed in fall 2013 with the intent to identify additional lakes for consideration.

The following provides a description of the aerial and ground reconnaissance surveys completed for candidate reference lakes in the open-water season of 2013, a description of results of the field programs, and qualitative comparisons to Mine Area lakes.

2.0 SUMMER RECONNAISSANCE SURVEY

The first reconnaissance survey was undertaken in early August and included an initial aerial survey to identify the most suitable lakes of the 12 candidates identified through the desktop screening exercise, followed by ground surveys of the these lakes.

2.1 AERIAL SURVEYS

Twelve potential reference lakes for Camp and/or Sheardown lakes were initially identified within an 80 km radius of the Mary River Mine Site through the desktop screening exercise (Figure 1, NSC and Knight Piésold 2013). On August 3, 2013, these 12 lakes were surveyed by helicopter to identify basic suitability characteristics such as general depth, shoreline substrate and connectivity to other waterbodies. Lakes that were identified as unsuitable during the aerial survey were eliminated as potential references. Depth was the primary limiting factor identified during aerial surveys. Based on several ground-truthed surveys of other lakes in the study area, depths < 3.0 m, which are insufficient for overwintering, can be identified reliably from aerial surveys.

Table 1 provides a summary of reconnaissance survey information for the 12 candidate reference lakes surveyed in early August. Five of the lakes were eliminated as potential references due to shallow depths observed during aerial surveys. An additional three lakes remained largely frozen in early August . These three lakes are located in a mountain range to the north of the Mine Area at significantly higher altitudes than Camp and Sheardown lakes and may remain at least partially ice-covered during most summers. For this reason, these lakes were disregarded from further consideration. Aerial surveys indicated four of the 12 lakes may be suitable candidates as reference lakes.

2.2 DETAILED GROUND SURVEYS

Of the four lakes identified as potentially suitable candidates through the aerial reconnaissance survey, detailed ground surveys were conducted at lakes CR-P3-11, CR-P3-09, and CL-P2-13. Lake CR-P3-12 appeared to have nearly identical physical characteristics to the adjacent Lake CR-P3-11, including a largely sandy shoreline, and only one (Lake CR-P3-11) of these two lakes was chosen for a detailed ground survey.

Ground surveys included collection of information on shoreline characteristics (qualitative observations), an aquatic habitat reconnaissance survey (collection of bathymetric and substrate information), determination of fish presence/absence (specifically identification of land-locked resident Arctic Char), collection of water quality information (*in situ* and laboratory measurements) and collection of phytoplankton and zooplankton samples (Table 2).

3.0 FALL RECONNAISSANCE SURVEY

The second round of the reconnaissance surveys was conducted in late August and included revisiting and sampling two of the candidate lakes visited in early August (CR-P3-11 and CL-P2-13), as well as conduct of a second aerial reconnaissance survey to identify additional potential candidate lakes for consideration. The third lake (Lake CR-P3-09) that was surveyed in early August was subsequently dropped from further consideration and was not sampled in late August due to the suspected presence of a population of dwarf Arctic Char (see Section 4.1.3 for a detailed description of results).

3.1 AERIAL SURVEY

Results from aerial and ground surveys conducted on potential reference lakes in early August confirmed only two lakes as likely suitable candidates. Both lakes are smaller than Sheardown and Camp lakes and one has primarily sandy substrate (less preferred by Arctic Char for spawning and rearing). As a result, 11 alternate lakes to the south of the mine site (ALT-1 to ALT-11) were surveyed aerially in late August for general depth, shoreline substrate and connectivity to other waterbodies to expand the list of potential suitable candidates (Figure 1).

Table 1 provides a summary of reconnaissance survey information for these 11 lakes. Several lakes appeared potentially suitable as references, but four have a combination of abundant, ideal nearshore habitat (cobble), sufficient depths (estimated to be > 10 m), and sufficient size when compared with Camp and/or Sheardown NW lakes.

3.2 DETAILED GROUND SURVEYS

Detailed sampling was completed in fall at lakes CR-P3-11 and CL-P2-13 and included collection of information on water quality, phytoplankton, zooplankton and BMIs (Table 2). Detailed ground surveys of the four alternate lakes identified during the aerial reconnaissance in late August could not be completed due to inclement weather conditions and time constraints.

4.0 SUMMARY OF RESULTS

The following sections provide a brief summary of the results of the ground reconnaissance surveys completed in 2013 and qualitative comparisons to Mine Area lakes to provide an initial screening of the suitability of the lakes as reference waterbodies.

4.1 LAKE CR-P3-09

4.1.1 WATER QUALITY

In situ water quality measurements are presented in Appendix 1 and the sampling site is indicated in Figure 2. As this lake was subsequently eliminated as a candidate reference lake, detailed review of water quality for this lake was not undertaken.

4.1.2 LOWER TROPHIC LEVEL BIOTA

Samples for taxonomic analysis of phytoplankton and zooplankton were collected from Lake CR-P3-09 in summer and have been archived at the laboratory at NSC in Winnipeg, MB. BMIs were not sampled in Lake CR-P3-09 as the lake was eliminated as a candidate following the summer sampling period. Metadata associated with the summer sampling period are presented in Appendix 2 and sampling sites are presented in Figure 2.

4.1.3 FISH AND FISH HABITAT

Lake CR-P3-09 is isolated from all nearby waterbodies. Both the inflow and outflow provide insufficient depth or flows for adult or juvenile Arctic Char use. Any fish in the lake are, therefore, resident and non-migratory. The shoreline of this lake is typically cobble/boulder with a relatively steep gradient (Photo 1). Nearshore substrate (to about 5-6 m depth) is a continuation of the cobble/boulder shoreline (Photo 2). As depth increases, cobble is replaced with increasing amounts of sand and silt (Figure 3). Silt is the dominant substrate at depths greater than 10 m. Maximum observed depth in this lake was 29.81 m with a mean of 11.92 m (Figure 2).

Juvenile Arctic Char (30-70 mm fork length) were observed in nearshore rocky habitat. Five Arctic Char were captured in two standard gang index gill nets set for short duration in the lake. The captured fish ranged in size from 191-332 mm. One fish (193 mm) died in the net and was frozen and transported to the laboratory at NSC in Winnipeg for further examination of sex, maturity, diet, parasite load and age. Laboratory examination indicated this fish was a sexually mature male aged 11 years with a diet of chironomids and a parasite infracommunity that included cestode cysts (probably *Diphyllobothrium* sp.) along the exterior surface of the digestive tract. The presence of a sexually mature 11-year-old male at that size, and the lack of

Photo 1. Typical shoreline of reference lake CR-P3-09.

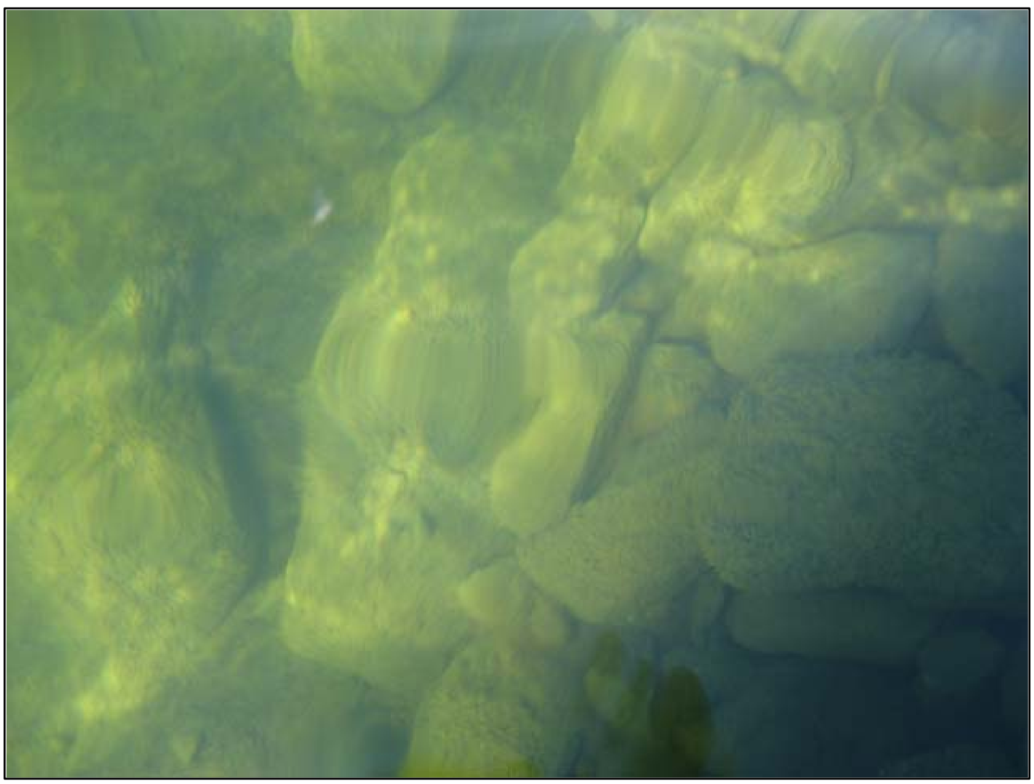

Photo 2. Typical nearshore substrate in reference lake CR-P3-09.

any fish larger than about 330 mm in the gill nets, suggest that this lake likely contains a stunted population of Arctic Char. On this basis Lake CR-P3-09 is likely not a suitable reference for Camp or Sheardown lakes. As previously noted, this lake was subsequently dropped from further consideration as a candidate reference lake based on this observation. Therefore, fall sampling was not undertaken in this lake.

4.2 LAKE CR-P3-11

4.2.1 WATER QUALITY

Laboratory and *in situ* water quality results collected in summer and fall at Lake CR-P3-11 are provided in Appendix 1 and the sampling site is indicated in Figure 4. Qualitative comparison of water quality conditions in Lake CR-P3-11 to Mine Area lakes (2013 data) indicates similarities for some parameters but differences for others (Table 3 and Figures 5-9).

Like Mine Area lakes, Lake CR-P3-11 was well-oxygenated and had a relatively high clarity. Nutrient concentrations were also relatively similar between this candidate reference lake and the Mine Area lakes (Figure 5) and the lake ranked as oligotrophic on the basis of total phosphorus (TP). Total nitrogen (TN) to TP ratios indicate this lake is strongly phosphorus limited, like Mine Area lakes (Table 3). Concentrations of many metals were also similar to Mine Area lakes, with a number of metals below detection (on average) in all of the lakes including antimony, beryllium, bismuth, boron, cadmium, cobalt, mercury, selenium, thallium, tin, titanium, and vanadium. Aluminum, iron, and copper were also similar to Mine Area lakes (Figure 6).

The primary difference between Lake CR-P3-11 and the Mine Area lakes relates to total dissolved solids (TDS)/conductivity, major cations, alkalinity, and hardness, all of which were lower in Lake CR-P3-11 (Table 3, Figure 7). Conductivity was less than half the levels measured in Sheardown Lake NW and SE and Camp Lake, but more similar to the more dilute Mary Lake (Figure 7). Lake CR-P3-11 ranked as very soft, whereas Mine Area lakes ranked as soft to moderately soft based on the Canadian Council of Resource and Environment Ministers (CCREM 1987) water hardness categories. These differences likely reflect differences in local geology.

Lake CR-P3-11 contains lower concentrations of calcium, magnesium, and potassium, but similar concentrations of sodium, than Mine Area lakes (Figure 8). Although concentrations of a number of metals were lower in Lake CR-P3-11, chromium, nickel, zinc (Figure 9) and manganese (Figure 6) were higher. Lake CR-P3-11 was not thermally stratified during the two sampling periods in 2013, whereas Mine Area lakes stratify during some sampling periods.

All water quality parameters measured in Lake CR-P3-11 in 2013 were within the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of aquatic life (PAL; CCME 1999; updated to 2014).

4.2.1 LOWER TROPHIC LEVEL BIOTA

Samples of phytoplankton, zooplankton, and BMIs were collected during summer and/or fall from Lake CR-P3-11. Metadata associated with this sampling are presented in Appendix 2 and sampling sites are presented in Figure 4.

Phytoplankton

Chlorophyll *a* concentrations measured in Lake CR-P3-11 were similar to those measured in Mine Area lakes in the open-water season of 2013 (Table 3, Figure 10), indicating similar levels of primary productivity.

Detailed phytoplankton results for samples collected in summer and fall at Lake CR-P3-11 are provided in Appendix 3. Qualitative comparisons of the phytoplankton community in Lake CR-P3-11 measured in the open-water season of 2013 to data collected in the open-water seasons of 2007 and 2008 from Mine Area lakes indicated that the community composition differs (Table 4; Figure 11). Unlike Mine Area lakes where diatoms dominated the phytoplankton community, dinoflagellates dominated the phytoplankton community and diatoms formed a small portion of the phytoplankton biomass in Lake CR-P3-11 (Figure 11). However, the dominant taxa (*Gymnodinium* and *Peridinium* sp.) were also present in Mine Area lakes in 2007 and 2008. Species diversity and richness were also higher in Lake CR-P3-11 in 2013 than in the Mine Area lakes in 2007 and 2008 (Table 4). Three phytoplankton not identified in the Mine Area lakes were observed in CR-P3-11, including: *Rhoicosphenia* sp. (Diatom), *Staurodesmus* sp. (Charophyta), and *Bitrichia* sp. (Charophyta).

During the summer, three phytoplankton replicates were collected and two of these were analysed for phytoplankton composition and biomass to assess variability (Appendix 3). The relative percent mean difference (RPMD) for biomass was high (63%) indicating that there is a high degree in variation in the phytoplankton. Variability of replicates of this order of magnitude is not uncommon for environmental monitoring programs (e.g., Coordinated Aquatic Monitoring Program 2014).

Zooplankton

Detailed zooplankton results for samples collected in summer and fall at Lake CR-P3-11 are provided in Appendix 4. Qualitative comparisons of the zooplankton community in CR-P3-11 to

Mine Area lakes (2007 and 2008 data) indicated that the communities were generally comparable (Table 5, Figure 12). A total of five crustacean zooplankton taxa were identified from vertical tows in Lake CR-P3-11, within the range of the number of taxa observed in the Mine Area lakes. As observed in Mine Area lakes, copepods, particularly cyclopoids, dominated the community and consisted of two species, *Cyclops scutifer* and *Diaptomus minutus*. The cladoceran community was primarily composed of two small-bodied taxa, *Bosmina longirostris* and *Daphnia longiremis*. The other cladoceran observed, *Holopedium gibberum*, was rare in comparison. As is typical, cladoceran density increased through the growing season and these organisms contributed to a greater proportion of the community sampled in the fall in comparison to the summer. Cyclopoid copepods and smaller-bodied cladocerans are more likely to be present in lakes with fish predators (i.e., Arctic char).

During the summer sampling period, three replicate samples of zooplankton were collected in Lake CR-P3-11 (Appendix 4). Percent relative standard deviation (PRSD) of zooplankton density for the three replicates was low (9%). Higher levels of variability were observed for individual taxa.

Benthic Macroinvertebrates

The objective of the BMI program was to sample aquatic habitat type 14 for comparison to Mine Area lakes. Habitat type 14 is characterized by water depths greater than 12 m, fine sand, silt, clay substrate, and an absence of macrophytes. While mean water depth in CR-P3-11 was only 8.8 m, it was decided that the samples represented the offshore profundal habitat based on its maximum depth of 11.65 m. Supporting variables for the BMI program (i.e., sediment total organic carbon [TOC] and particle size analysis [PSA]) were measured at each replicate station.

Detailed taxonomic results for BMI samples collected in the fall at Lake CR-P3-11 are provided in Appendix 5. Qualitative comparisons of BMI metrics in CR-P3-11 (2013; n=1) were made to the same habitat type within the Mine Area lakes using available data as follows: Sheardown Lake NW (2007, 2008, 2011, 2013; n=17); Sheardown Lake SE (2007; n=6); Camp Lake (2007; n=12); and Mary Lake (2006, 2007; n=11). Statistics for six community metrics: total density, proportion of Chironomidae, Shannon's evenness index, Simpson's diversity index, taxa richness (total number of genera), and Hill's effective richness, were graphically compared using summary statistics. Reference lake values were visually comparable to the mine site lake values for most of the metrics (Figures 13 and 14).

A total of 3,861 individuals/m^2 were collected in Lake CR-P3-11 which was in the range of BMI densities measured in all Mine Area lakes (Table 6). Chironomidae comprised 98% of the total abundance, and was compositionally similar to the Mine Area lakes. Evenness and diversity indices were also similar amongst all lake sites. Mean taxa richness and Hill's effective richness values for Lake CR-P3-11 were both within the ranges for all Mine Area lakes.

Supporting sediment analysis results for Lake CR-P3-11 (n=1) are provided in Figure 15. The benthic sediment was predominantly silt (47.8%), loam in texture; and TOC was 3.17%.

4.2.1 FISH AND FISH HABITAT

The shoreline of Lake CR-P3-11 is predominantly sandy with occasional small patches of rocks and a gradient ranging from low to high (Photos 3 and 4). Nearshore substrate (to about 5-6 m depth) is largely sand with occasional gravel or cobble (Figure 16). Silt and sand are dominant at depths greater than 5 m with occasional patches of coarser material. The most predominant substrate type in this lake is fines (i.e., fine sand, silt, and clay) but hard substrates are present at depths greater than 2 m, indicating the lake provides suitable spawning habitat for Arctic Char (Table 8). Maximum observed depth in this lake was 11.65 m with a mean of 6.10 m (Figure 4). The greatest depths were located in the northern third of the lake. There are several shallow shoals in the southern two thirds of the lake.

Lake CR-P3-11 has tributaries suitable for use by juvenile Arctic Char, but of insufficient depth for adult use. Any fish in the lake are, therefore, likely resident and non-migratory. Juvenile Arctic Char (30-70 mm fork length) were observed in tributary streams and in pools along the lake margin that had become isolated as water levels decreased. Fifteen Arctic Char were captured in two standard gang index gill nets set for short duration in the lake. The captured fish ranged in size from 313-431 mm. There were five mortalities, which were frozen and returned to the laboratory at NSC in Winnipeg for further examination of sex, maturity, diet, parasite load and age. Of the five mortalities, four were immature males (FL = 318-334 mm) and one was a resting female (FL = 355 mm). These fish were aged 10-13 years. Stomachs from all five mortalities contained chironomids and cestode cysts (probably *Diphyllobothrium* sp.) were present along the exterior surface of the digestive tracts. One fish was also infected with adult nematodes (likely *Cystidicola* sp.) in the body cavity, which may have been in the swim bladder before it was punctured during the necropsy.

Although the largely sandy nearshore substrate differs from the nearshore substrate of Camp or Sheardown lakes, which contain greater amounts of coarser substrate, and the lake is smaller and shallower than Camp or Sheardown lakes (Table 8), preliminary analysis of the fish population shows that basic meristics, growth rates, diet and parasite load are similar to populations in the Mine Area lakes. As previously noted, the lake also contains habitat that could support Arctic Char spawning.

Photo 3. Low-relief shoreline in reference lake CR-P3-11.

Photo 4. High-relief shoreline in reference lake CR-P3-11.

4.3 LAKE CL-P2-13

4.3.1 WATER QUALITY

Laboratory and *in situ* water quality results collected in summer and fall at Lake CL-P2-13 are provided in Appendix 1 and the sampling site is indicated in Figure 17. Qualitative comparison of water quality conditions in Lake CL-P2-13 to Mine Area lakes (2013 data) indicates some similarities but also a number of differences (Table 3 and Figures 5-9).

Like Mine Area lakes, Lake CL-P2-13 was well-oxygenated and had a relatively high clarity. Secchi disk depth was within the range measured at the Mine Area lakes, though was most similar to the less clear Mary Lake (Table 3). TP concentrations were also relatively similar between this candidate reference lake and the Mine Area lakes (Figure 5) and the lake ranked as oligotrophic on the basis of TP. TN to TP ratios indicate this lake is strongly phosphorus limited, like Mine Area lakes (Table 3). Concentrations of many metals were similar to Mine Area lakes, with a number of metals below detection (on average) in all of the lakes including antimony, beryllium, bismuth, boron, cadmium, cobalt, mercury, selenium, thallium, tin, titanium, and vanadium. Aluminum, iron, and copper were similar to Mine Area lakes, though the mean iron concentration was slightly higher than Mine Area lakes or Lake CR-P3-11 (Figure 6).

Like Lake CR-P3-11, the primary difference between Lake CL-P2-13 and the Mine Area lakes relates to TDS/conductivity, major cations, alkalinity, and hardness, all of which are lower in Lake CL-P2-13 (Table 3). Conductivity was less than half the levels measured in Sheardown Lake NW and SE and Camp Lake, but more similar to the more dilute Mary Lake (Figure 7). Lake CL-P2-13 ranked as very soft, whereas Mine Area lakes ranked as soft to moderately soft based on the CCREM (1987) water hardness categories. These differences likely reflect differences in local geology. Lake CL-P2-13 contains lower concentrations of calcium, magnesium, potassium, and sodium than Mine Area lakes (Figure 8). Although concentrations of a number of metals were lower in Lake CL-P2-13 than Mine Area lakes, like Lake CR-P3-11, chromium and nickel were higher (Figure 9). Lake CL-P2-13 was not thermally stratified during the two sampling periods in 2013, whereas Mine Area lakes stratify during some sampling periods.

All water quality parameters measured in Lake CL-P2-13 in 2013 were within the CCME PAL guidelines (CCME 1999; updated to 2014).

4.3.2 LOWER TROPHIC LEVEL BIOTA

Samples of phytoplankton, zooplankton, and BMIs were collected during summer and/or fall from Lake CL-P2-13. Metadata associated with this sampling are presented in Appendix 2 and sampling sites are presented in Figure 17.

Phytoplankton

Chlorophyll *a* concentrations measured in Lake CL-P2-13 were similar to those measured in Mine Area lakes and Lake CR-P3-11 in the open-water season of 2013 (Table 3, Figure 10), indicating similar levels of primary productivity.

Detailed results of phytoplankton biomass and community composition analyses of samples collected in summer and fall at Lake CR-P3-13 are provided in Appendix 3. Qualitative comparisons of the phytoplankton community in Lake CR-P3-13 to Mine Area lakes (2007 and 2008 data) indicates that the communities are different, but compared to Lake CR-P3-11, the phytoplankton community of Lake CR-P3-13 is more similar to the Mine Area lakes (Table 4; Figure 11). Unlike Mine Area lakes where diatoms dominated, dinoflagellates dominated the phytoplankton community in Lake CR-P3-13 (Figure 11).

In general, species diversity was similar to Mine Area lakes, but a greater number of species (i.e., richness) was observed in Lake CR-P3-13 in 2013 than in the Mine Area lakes in 2007 and 2008 (Table 4). The phytoplankton *Bitrichia* sp. (Charophyta) was observed in CR-P3-13, but was not identified in the Mine Area lakes.

During the fall, three phytoplankton replicates were collected and two of these were analysed for phytoplankton composition and biomass to evaluate variability (Appendix 3). The RPMD for biomass was low (8%) indicating good precision in the estimate of phytoplankton biomass.

Zooplankton

Detailed zooplankton results for samples collected in summer and fall at Lake CL-P2-13 are provided in Appendix 3. Qualitative comparisons of the zooplankton community in CL-P2-13 to Mine Area lakes (2007 and 2008 data) indicate that the communities are generally comparable (Table 5, Figure 12). Total zooplankton density in CL-P2-13 was somewhat lower than in Mine Area lakes and Lake CR-P3-11, but within the range of densities observed in the Mine Area lakes throughout the open-water season. The distribution of zooplankton is inherently patchy (i.e., these organisms are often highly aggregated). Spatial (e.g., within a lake or among lakes in the same area) and temporal (e.g., seasonal) variation in lake zooplankton density is typical and may be related to a variety of factors such as water depth, prevailing wind direction, water temperature regimes, and fish predation pressure.

A total of five crustacean zooplankton taxa were identified from vertical tows in Lake CL-P2-13, which is within the range of the number of taxa observed in the Mine Area lakes. As observed in Mine Area lakes and Lake CR-P3-11, copepods, particularly cyclopoids, dominated the community and consisted of two species, *Cyclops scutifer* and *Diaptomus minutus*. The cladoceran community was primarily composed of two small-bodied taxa, *Bosmina longirostris* and *Daphnia longiremis*. The other cladoceran observed, *Holopedium gibberum*, was rare in comparison.

During the summer, three zooplankton replicate samples were collected in CL-P2-13 (Appendix 4). PRSD for total zooplankton density was relatively low (26%) but higher variability was observed among the replicates for the various taxa.

Benthic Macroinvertebrates

BMIs were sampled in the profundal zone of Lake CL-P2-13 (i.e., aquatic habitat type 14) in the fall of 2013. Detailed taxonomic results for BMI samples are provided in Appendix 5. Qualitative comparisons of BMI metrics measured in Lake CL-P2-13 (2013; n=1) were made to the data collected from the same habitat type within the Mine Area lakes as follows: Sheardown Lake NW (2007, 2008, 2011, 2013; n=17); Sheardown Lake SE (2007; n=6); Camp Lake (2007; n=12); and Mary Lake (2006, 2007; n=11). Statistics for six community metrics: total density, proportion of Chironomidae, Shannon’s evenness index, Simpson’s diversity index, taxa richness (total number of genera), and Hill’s effective richness, were graphically compared using summary statistics. Reference lake values were visually comparable to the mine site lake values for most of the metrics (Figures 13 and 14).

A total of 1,593 individuals/m^2 were collected in CL-P2-13 which was in the range of BMI densities for Mine Area lakes, except for Sheardown Lake SE (Table 6). Chironomidae comprised 100% of the total abundance, and was compositionally similar to the Mine Area lakes, except for Sheardown Lake NW. Evenness and diversity indices were also similar amongst all lake sites. Mean taxa richness and Hill’s effective richness values for Lake CL-P2-13 were both within the ranges for all Mine Area lake sites.

Supporting sediment analysis results for Lake CL-P2-13 (n=1) are provided in Figure 15. The sediment was predominantly silt (73.0%), silt loam in texture; and TOC was 2.02%.

4.3.3 FISH AND FISH HABITAT

Lake CL-P2-13 has the smallest surface area of the three lakes that were surveyed in detail in 2013 (Figure 17). There are tributaries suitable for use by juvenile Arctic Char, but of insufficient depth for adult use. Any fish in the lake are, therefore, likely resident and non-migratory. The shoreline of this lake is predominantly rocky with a gradient ranging from low to high (Photo 5). Nearshore substrate (to about 5-6 m depth) ranged from almost 100% sand in some areas to almost 100% cobble/boulder in others (Photo 6, Figure 18). Silt and sand were dominant at depths greater than 5 m, however, the northwest section of the lake consisted of large amounts of cobble to at least 12 m depth. The predominant substrate type in this lake is fines (i.e., fine sand, silt, and clay) but hard substrates are present at depths greater than 2 m, indicating the lake provides suitable spawning habitat for Arctic Char (Table 9).The lake is characterized by steep shorelines typically reaching depths of 8-10 m within 50 m of shore tapering to a broad basin ranging from 10-15 m deep (Figure 17). Maximum observed depth in this lake was 15.34 m with a mean of 9.40 m.

Juvenile Arctic Char (30-70 mm fork length) were observed in tributary streams and in rocky nearshore areas. Two Arctic Char were captured in two standard gang index gill nets set for short duration in the lake. The captured fish ranged in size from 395-558 mm. One mortality (FL = 395 mm) was frozen and returned to the NSC laboratory in Winnipeg for further examination of sex, maturity, diet, parasite load and age. The fish was an immature male aged 17 years with chironomids in the stomach and larval cestode (likely *Diphyllobothrium* sp.) cysts along the gut and adult cestodes (possibly *Proteocephalus* sp.) in the stomach. Although this fish is older than most similarly-sized fish from Mine Area lakes, it is immature and may not necessarily be indicative of an overall slower growth rate for fish in this lake. Additional data are required to more thoroughly assess the fish population compatibility with Mine Area lakes.

Despite a smaller surface area, a higher proportion of fines, and a shallower basin than the Mine Area lakes (Table 8), preliminary surveys indicate Lake CL-P2-13 may be suitable as a reference lake.

Photo 5. Typical shoreline of reference lake CL-P2-13.

Photo 6. Typical nearshore substrate in reference lake CL-P2-13.

5.0 SUMMARY AND RECOMMENDATIONS

5.1 WATER QUALITY

Some water quality variables, notably water clarity, dissolved oxygen (DO), nutrients, and numerous metals, were similar between candidate reference lakes and Mine Area lakes. The primary differences observed relate to hardness, TDS/conductivity, and major cations – all of which were lower in candidate reference lakes than Mine Area lakes, notably Camp Lake and Sheardown Lake NW. These parameters were more similar to Mary Lake, which is softer and more dilute than other Mine Area lakes.

5.2 LOWER TROPHIC LEVEL BIOTA

5.2.1 PHYTOPLANKTON

The key findings of the phytoplankton analyses are:

- Primary productivity was similar between the candidate reference lakes and Mine Area lakes based on chlorophyll *a* concentrations; and
- Phytoplankton community composition varied between the candidate reference lakes and Mine Area lakes. The former were dominated by dinoflagellates (Dinophyceae) whereas the latter were typically dominated by diatoms.

While the differences in community composition are not ideal, the community composition of all the lakes (candidate reference lakes and Mine Area lakes) is consistent with nutrient-poor Arctic lakes. Other studies have reported high abundance of dinoflagellates, and specifically the Genus *Gymnodinium*, in other Arctic lakes (e.g., Snap Lake and a reference lake; De Beers 2002; Golder Associates 2012).

5.2.2 ZOOPLANKTON

Densities and composition of the zooplankton communities were similar between Mine Area lakes (as measured in 2007 and 2008) and the candidate reference lakes CR-P3-11 and CL-P2-13 (as measured in 2013).

5.2.3 BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrate abundance and composition metrics were similar between Mine Area lakes (as measured in 2006, 2007, 2008, 2011, and 2013) and the candidate reference lakes CR-P3-11 and CL-P2-13 (as measured in 2013).

5.3 FISH AND FISH HABITAT

Available information regarding Arctic Char populations and aquatic habitat in the two candidate reference lakes indicate both lakes support what are likely land-locked resident populations and both are supplied by tributary streams that appear to provide juvenile rearing habitat (similar to Mine Area lakes). Also like Mine Area lakes, Lakes CR-P3-11 and CL-P21-13 likely provide overwintering and spawning habitat. Of the two lakes, growth rates of Arctic Char in Lake CL-P2-13 may be slower than Mine Area lakes. However, due to limited sample size this suggestion requires further investigation.

5.4 RECOMMENDATIONS

Although some differences in aquatic habitat, water quality, and lower trophic level biota were noted between the candidate reference lakes and Mine Area lakes based on the results of the 2013 survey and comparison to existing data for Mine Area lakes, it is recommended to retain one or both of these lakes for further consideration as reference lakes. However, additional sampling is required to confirm the suitability of these lakes as reference systems, in particular in relation to the Arctic Char populations.

Should additional reference lakes be desired, lakes ALT-06, ALT-07, ALT-09 and ALT-10 (Figure 1) were deemed to be the most likely suitable candidates based on aerial surveys conducted in fall 2013. These lakes have suspected depths, nearshore substrates and, in particular, surface areas that appear to suitably match Camp and Sheardown NW lakes. Surface areas of these lakes area greater than lakes CR-P3-11 and CL-P2-13 and more comparable to the surface areas of Camp and Sheardown NW lakes. If additional reference lakes are to be identified, these lakes could be subject to a ground level screening comparable to that conducted in lakes CR-P3-11 and CL-P2-13 in 2013 to evaluate physical, chemical, and biological conditions.

6.0 LITERATURE CITED

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TABLES AND FIGURES

Table 1. Summary of information collected during preliminary surveys of potential reference lakes, August 2013. Lakes highlighted in bold, blue lettering have been identified as the best possible candidates.

Lake	Date	Survey Type	Maximum Depth (m)	Dominant Substrate (0-5 m depth)	Dominant Substrate (> 5 m depth)	Fish Community	Potential Reference Lake Status	Comments
CR-P3-07	03-Aug-13	Ground	3.0	Cobble	NA	Small juveniles observed along shore	Not Suitable	Too shallow for overwintering or large adult fish use
CL-P2-05	03-Aug-13	Aerial	< 3.0	NA	NA	Unknown	Not Suitable	Too shallow for overwintering or large adult fish use
CL-P2-01	03-Aug-13	Aerial	> 5.0	Appears to be cobble	NA	Unknown	Potentially Suitable	Lake was still ~80% covered in ice and could not be surveyed in detail
CR-P3-29	03-Aug-13	Aerial	> 5.0	Appears to be cobble	NA	Unknown	Potentially Suitable	Lake was still ~90% covered in ice and could not be surveyed in detail
CL-P2-04	03-Aug-13	Aerial	> 5.0	Appears to be cobble	NA	Unknown	Potentially Suitable	Lake was still ~80% covered in ice and could not be surveyed in detail
CL-P2-13	**07-Aug-13**	**Ground**	**13.0-15.0**	**Cobble/boulder**	**Sand/silt with rocky patches**	**Small juveniles along shore and in tributary streams; large adults captured in lake**	**Potentially Suitable**	**Lake is small, but substrate is ideal and there are large, resident Arctic Char**
CL-P2-07	03-Aug-13	Aerial	~ 5.0	Appears to be cobble	NA	Unknown	Not Suitable	80-90% of the lake is < 3.0 m deep

Table 1. - continued -

Lake	Date	Survey Type	Maximum Depth (m)	Dominant Substrate (0-5 m depth)	Dominant Substrate (> 5 m depth)	Fish Community	Potential Reference Lake Status	Comments
CR-P3-09	05-Aug-13	Ground	28.0-30.0	Cobble/ boulder	Sand/silt with rocky patches	Probable isolated stunted Arctic Char population	Not Suitable if resident char are stunted	May need more studies to confirm lack of large fish, but seems unlikely as a reference
CR-P3-01	03-Aug-13	Aerial	~ 5.0-10.0	Appeared to be cobble	NA	Unknown	Not Suitable	50% of the lake is < 3.0 m deep and lake is isolated from other waterbodies
CL-03	03-Aug-13	Aerial	< 2.0	NA	NA	Unknown	Not Suitable	Too shallow for overwintering or large adult fish use
CR-P3-11	**06-Aug-13**	**Ground**	**10.0-12.0**	**Sand**	**Sand/silt**	**Small juveniles along shore and in tributary streams; large adults captured in lake**	**Potentially Suitable**	**Substrate not ideal, but resident fish population present**
CR-P3-12	03-Aug-13	Aerial	~10.0-15.0	Sand	Sand/silt	Probable juvenile and adult use	Potentially Suitable	Very similar to CR-P3-11, so only one of the two was surveyed in detail
ALT-01	31-Aug-13	Aerial	> 10	Sand	NA	Probable juvenile and adult use	Potentially Suitable	Does not have ideal nearshore habitat (larger cobble), but may qualify for more detailed survey
ALT-02	31-Aug-13	Aerial	> 10	Cobble/sand	NA	Probable juvenile and adult use	Potentially Suitable	Nearshore habitat more suitable than ALT-1

Table 1. - continued -

Lake	Date	Survey Type	Maximum Depth (m)	Dominant Substrate (0-5 m depth)	Dominant Substrate (> 5 m depth)	Fish Community	Potential Reference Lake Status	Comments
ALT-03	31-Aug-13	Aerial	~ 5.0-10.0	Cobble/sand	NA	Unknown	Not Likely Suitable	Substrate decent, but depths a little shallow
ALT-04	31-Aug-13	Aerial	> 10	Cobble/sand	NA	Probable juvenile and adult use	Not Suitable	Essentially a bay in Nina Bang Lake
ALT-05	31-Aug-13	Aerial	> 10	Mainly Cobble	NA	Probable juvenile and adult use	Potentially Suitable	Excellent nearshore habitat and depths, but lake is a little small
ALT-06	**31-Aug-13**	**Aerial**	**> 10**	**Mainly Cobble**	**NA**	**Probable juvenile and adult use**	**Potentially Suitable**	**Excellent nearshore habitat and depths and lake is larger than other reference sites**
ALT-07	**31-Aug-13**	**Aerial**	**> 10**	**Mainly Cobble**	**NA**	**Probable juvenile and adult use**	**Potentially Suitable**	**Connected to ALT-06, but even better suited as reference**
ALT-08	31-Aug-13	Aerial	> 10	Sand/Cobble	NA	Unknown	Potentially Suitable	Low shoreline slope and lower quality habitat means this is likely less suitable than others in the area
ALT-09	**31-Aug-13**	**Aerial**	**> 10**	**Mainly Cobble**	**NA**	**Probable juvenile and adult use**	**Potentially Suitable**	**Among the best nearshore habitat and depth of any ALT lakes**
ALT-10	**31-Aug-13**	**Aerial**	**> 10**	**Mainly Cobble**	**NA**	**Probable juvenile and adult use**	**Potentially Suitable**	**Shallow connection to ALT-09 with similar habitat**
ALT-11	31-Aug-13	Aerial	> 10	Sand/Cobble	NA	Probable juvenile and adult use	Potentially Suitable	Good size and depth, but nearshore habitat not as ideal as ALT-06 or ALT-09/10)

Table 2. Sampling programs completed in candidate reference lakes, summer and fall 2013.

Lake	Season	Bathymetry & Substrate	Water Quality			Phytoplankton	Zooplankton	Benthic Macroinvertebrates	Fish
			in situ	Surface Sample	Bottom Sample				
CR-P3-09	Summer	+	+	+[1]		+	+		+
	Fall								
CR-P3-11	Summer	+	+	+	+	+	+		+
	Fall		+	+	+	+	+	+	
CL-P2-13	Summer	+	+	+	+	+	+		+
	Fall		+	+	+	+	+	+	

[1] Sample was collected by not analysed.

Table 3. Water quality measured in candidate reference lakes CR-P3-11 and CL-P2-13 and Mine Area lakes in the open-water season of 2013. Values represent means of surface samples. SDL NW = Sheardown Lake northwest and SDL SE = Sheardown Lake southeast.

Parameter	Unit	Reference Lakes		Mine Area Lakes			
		CR-P3-11	CR-P2-13	SDL NW	SDL SE	Camp L.	Mary L.
In situ							
Temperature	°C	Summer: 9.6 Fall: 4.4	Summer: 6.9 Fall: 3.8	Summer: 8.6 Fall: 6.9	Summer: 10.0 Fall: 6.3	Summer: 4.6 Fall: 6.9	Summer: 6.2 Fall: 5.9
Dissolved oxygen	mg/L	11.54	11.55	12.20	12.09	12.20	12.37
pH	pH units	8.01	7.83	7.87	7.62	7.54	7.53
Specific conductance	µS/cm	40.1	42.0	120	100	122	64.3
Secchi Disk Depth	m	6.13	4.30	7.48	4.17	7.15	4.56
Laboratory Routine							
Lab pH	pH units	6.70	6.73	7.44	7.35	7.42	7.02
Lab Conductivity	µS/cm	41	42	121	106	124	67
Lab Turbidity	NTU	0.60	0.90	0.43	0.65	0.27	1.30
Total Alkalinity (as $CaCO_3$)	mg/L	17	22	57	50	59	33
Bromide	mg/L	<0.25	<0.25	<0.25	<0.25	0.25	<0.25
Chloride	mg/L	2.0	<1	3.0	2.5	3.2	2.0
Dissolved Hardness	mg/L	16.0	18.8	58.7	48.7	59.1	31.0
Total Hardness	mg/L	16.7	18.7	61.1	51.2	61.2	31.7
Ammonia	mg N/L	0.03	0.52	0.08	<0.02	0.28	0.14
Nitrite	mg N/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrite/nitrate	mg N/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrate	mg N/L	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Sulphate	mg/L	3	<3	4	4	<3	<3
Total Dissolved Solids	mg/L	26.7	27.5	79	68.5	80.7	43.6
Total Suspended Solids	mg/L	<2	<2	<2	<2	<2	<2
Total Phosphorus	mg/L	0.005	0.005	0.005	0.006	0.004	0.005
Total Kjeldahl Nitrogen	mg/L	0.75	0.80	0.20	<0.10	0.60	0.22
Total Nitrogen	mg/L	0.85	0.90	0.30	<0.2	0.70	0.32
TN:TP Molar Ratios	-	533	556	163	101	493	144
Phenols	mg/L	<0.001	0.009	<0.001	<0.001	<0.001	<0.001
Total Organic Carbon	mg/L	2.0	1.2	1.8	1.6	1.9	1.4
Dissolved Organic Carbon	mg/L	1.9	1.1	1.7	1.4	1.8	1.3
Chlorophyll *a*	µg/L	0.45	0.90	0.59	1.90	0.73	1.70
Pheophytin *a*	µg/L	0.72	0.80	0.75	0.20	2.22	0.42

Table 3. - continued -

Parameter	Unit	Reference Lakes		Mine Area Lakes			
		CR-P3-11	CR-P2-13	SDL NW	SDL SE	Camp L.	Mary L.
Total Metals							
Al	mg/L	0.0164	0.0346	0.0090	0.0356	0.0060	0.0425
Sb	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
As	mg/L	<0.00010	0.00012	<0.00010	<0.00010	<0.00010	<0.00010
Ba	mg/L	0.00276	0.00243	0.00502	0.00462	0.00548	0.00372
Be	mg/L	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Bi	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
B	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
Cd	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Ca	mg/L	3.6	3.8	12.2	10.4	12.3	6.5
Cr	mg/L	0.00077	0.00175	0.00038	0.00019	0.00014	0.00023
Cu	mg/L	0.00046	0.00179	0.00312	0.00076	0.00087	0.00066
Co	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Fe	mg/L	0.03	0.08	0.02	0.04	0.01	0.05
Pb	mg/L	0.00007	0.00009	<0.00005	<0.00005	<0.00005	0.00007
Li	mg/L	<0.00005	<0.00005	0.00034	<0.00005	0.00082	<0.00005
Mg	mg/L	1.89	2.24	7.42	6.15	7.39	3.77
Mn	mg/L	0.00402	0.00232	0.00203	0.00276	0.00230	0.00168
Hg	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Mo	mg/L	0.00006	0.00042	0.00077	0.00047	0.00022	0.00011
Ni	mg/L	0.0008	0.0010	0.0007	0.0006	0.0006	<0.00050
K	mg/L	0.355	0.310	0.873	0.706	0.881	0.471
Se	mg/L	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Si	mg/L	0.27	0.37	0.61	0.57	0.40	0.47
Ag	mg/L	<0.000001	0.0000085	<0.000001	<0.000001	<0.000001	<0.000001
Na	mg/L	1.09	0.70	1.06	1.06	1.04	0.94
Sr	mg/L	0.00492	0.00368	0.00795	0.00706	0.00919	0.00513
Tl	mg/L	<0.000001	<0.000001	<0.000001	<0.000001	<0.000001	<0.000001
Sn	mg/L	<0.00010	0.00050	<0.00010	<0.00010	<0.00010	<0.00010
Ti	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
U	mg/L	0.000074	0.000136	0.000931	0.000695	0.000584	0.000498
V	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zn	mg/L	0.013	0.004	<0.0030	<0.0030	<0.0030	<0.0030

Table 3. - continued -

Paramaeter	Unit	Reference Lakes		Mine Area Lakes			
		CR-P3-11	CR-P2-13	SDL NW	SDL SE	Camp L.	Mary L.
Dissolved Metals							
Al	mg/L	0.0043	0.0039	<0.00100	0.0022	<0.00100	0.0073
Sb	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
As	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Ba	mg/L	0.00274	0.00220	0.00494	0.00439	0.00546	0.00349
Be	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Bi	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
B	mg/L	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100	<0.0100
Cd	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Ca	mg/L	3.44	3.83	11.73	9.81	11.97	6.38
Cr	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Cr(VI)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cr(III)	mg/L	-	-	<0.005	<0.005	<0.005	<0.005
Co	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Cu	mg/L	0.00036	0.00041	0.00074	0.00059	0.00279	0.00049
Fe	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pb	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Li	mg/L	<0.00005	<0.00005	0.00090	0.00095	0.00113	0.00117
Mg	mg/L	1.81	2.24	7.16	5.85	7.08	3.66
Mn	mg/L	0.00116	0.00084	0.00041	0.00032	0.00063	0.00072
Hg	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Mo	mg/L	<0.00005	0.00012	0.00072	0.00045	0.00021	0.00015
Ni	mg/L	0.00050	0.00109	0.00060	<0.00050	0.00054	<0.00050
K	mg/L	0.349	0.288	0.852	0.694	0.876	0.458
Se	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Si	mg/L	0.23	0.32	0.59	0.49	0.36	0.36
Ag	mg/L	<0.0000010	<0.0000010	<0.0000010	<0.0000010	<0.0000010	<0.0000010
Na	mg/L	1.11	0.670	1.05	0.92	1.05	0.959
Sr	mg/L	0.00475	0.00352	0.00756	0.00667	0.00857	0.00480
Tl	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sn	mg/L	<0.00010	0.00082	<0.00010	<0.00010	<0.00010	<0.00010
Ti	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.02
U	mg/L	0.000063	0.000118	0.000897	0.000666	0.000552	0.000455
V	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Zn	mg/L	0.00139	0.00255	0.00133	0.00092	0.00217	0.00199

Table 4. Mean, standard deviation (SD), coefficient of variation (COV), and 95th percentiles for phytoplankton species diversity, evenness, and richness metrics measured in reference lakes (summer and fall 2013) and Mine Area lakes (summer and late summer/fall, 2007 and 2008).

	MEANS					
	Simpson's Diversity Index	Simpson's Evenness	Species Richness	Shannon's Evenness	Hill's Effective Richness	Hill's Evenness
CR-P3-11	0.82	0.24	24	0.70	9.20	0.39
CL-P2-13	0.69	0.18	22	0.59	6.41	0.30
Camp Lake	0.72	0.22	17	0.60	5.55	0.33
Sheardown Lake NW	0.71	0.22	18	0.61	6.19	0.34
Sheardown Lake SE	0.71	0.29	16	0.61	6.1	0.37
Mary Lake	0.52	0.2	15	0.47	3.84	0.28
	SD					
	Simpson's Diversity Index	Simpson's Evenness	Species Richness	Shannon's Evenness	Hill's Effective Richness	Hill's Evenness
CR-P3-11	0.00	0.00	1	0.02	0.44	0.03
CL-P2-13	0.17	0.09	1	0.14	2.81	0.12
Camp Lake	0.07	0.05	3	0.04	1.18	0.04
Sheardown Lake NW	0.12	0.08	3	0.10	1.94	0.08
Sheardown Lake SE	0.88	0.43	20	0.77	9.31	0.54
Mary Lake	0.19	0.15	4	0.17	2.00	0.15
	COV					
	Simpson's Diversity Index	Simpson's Evenness	Species Richness	Shannon's Evenness	Hill's Effective Richness	Hill's Evenness
CR-P3-11	1	1	3	3	5	8
CL-P2-13	25	53	3	24	44	41
Camp Lake	9	25	20	7	21	13
Sheardown Lake NW	17	34	16	16	31	25
Sheardown Lake SE	27	42	18	26	41	34
Mary Lake	36	75	28	36	52	55
	95TH PERCENTILE					
	Simpson's Diversity Index	Simpson's Evenness	Species Richness	Shannon's Evenness	Hill's Effective Richness	Hill's Evenness
CR-P3-11	0.83	0.24	24	0.72	9.5	0.41
CL-P2-13	0.80	0.24	22	0.68	8.2	0.37
Camp Lake	0.81	0.28	23	0.66	7.5	0.37
Sheardown Lake NW	0.84	0.34	22	0.74	8.9	0.46
Sheardown Lake SE	0.87	0.42	19	0.76	9.2	0.51
Mary Lake	0.84	0.52	21	0.78	7.5	0.56

Table 5. Summary statistics for total crustacean zooplankton density (individuals/m^3) by waterbody (seasonally) for the candidate reference (2013) and Mine Area (2007 and 2008) lakes.

Waterbody	Season	n [1]	Mean	SD	Min	Max	Taxonomic Richness [2]
Lake CR-P3-11							
	Summer	3	7,942	741	7,153	8,623	5
	Fall	1	7,920	-	-	-	4
Lake CL-P2-13							
	Summer	1	1,163	-	-	-	5
	Fall	3	1,619	414	1,354	2,096	5
Camp Lake							
	Summer	6	11,772	8,442	3,244	22,619	4
	Fall	3	9,829	6,269	5,561	17,027	5
Sheardown Lake NW							
	Summer	10	11,878	8,335	2,637	26,211	7
	Fall	10	19,966	17,352	3,753	53,307	6
Sheardown Lake SE							
	Summer	6	13,127	10,132	3,303	31,074	6
	Fall	6	10,578	5,707	4,776	16,854	6
Mary Lake							
	Summer	9	2,713	2,246	750	7,811	9
	Fall	5	6,147	5,159	1,528	13,832	5

[1] number of samples collected

[2] total number of taxa observed to species-level, not the average number of taxa

Table 6. Mean, median, standard deviation (SD), standard error (SE), minimum (Min), maximum (Max), precision (20%), 95th percentile, and coefficient of variation (%COV) for BMI composition and richness metrics measured from the offshore profundal habitat of candidate reference lakes and Mine Area lakes.

Metric	**Total Macroinvertebrate Density (individuals/m²)**					
Habitat Type	**Offshore Profundal (14)**					
Lake	**CL-P2-13**	**CR-P3-11**	**SDL NW**	**SDL SE**	**Camp**	**Mary**
Sample Year(s)	2013	2013	2007, 2008, 2011, 2013	2007	2007	2006, 2007
n (rep. stn.)	1	1	17	6	12	11
Mean	1593	3861	1871	5042	2649	2668
Median	--	--	1783	4674	1978	2670
SD	--	--	1143.36	1350.49	1496.51	2057.11
SE	--	--	277.31	551.34	432.01	620.24
Min	--	--	102	3548	730	609
Max	--	--	4652	6730	6226	7017
Sub-samples (20% precision)	--	--	9.33	1.79	7.98	14.86
95th Percentile	--	--	3603.56	6700.00	5250.43	5917.00
COV (%)	--	--	61.10	26.78	56.50	77.10

Metric	**Chironomidae Proportion (% of total density)**					
Habitat Type	**Offshore Profundal (14)**					
Lake	**CL-P2-13**	**CR-P3-11**	**SDL NW**	**SDL SE**	**Camp**	**Mary**
Sample Year(s)	2013	2013	2007, 2008, 2011, 2013	2007	2007	2006, 2007
n (rep. stn.)	1	1	17	6	12	11
Mean	100	98	91	97	95	96
Median	--	--	94	98	96	99
SD	--	--	7.68	2.85	4.32	4.54
SE	--	--	1.86	1.16	1.25	1.37
Min	--	--	70	92	88	89
Max	--	--	98	100	100	100
Sub-samples (20% precision)	--	--	0.18	0.02	0.05	0.06
95th Percentile	--	--	97.08	99.74	100.00	100.00
COV (%)	--	--	8.46	2.94	4.55	4.71

Metric	**Shannon's Evenness Index**					
Habitat Type	**Offshore Profundal (14)**					
Lake	**CL-P2-13**	**CR-P3-11**	**SDL NW**	**SDL SE**	**Camp**	**Mary**
Sample Year(s)	2013	2013	2007, 2008, 2011, 2013	2007	2007	2006, 2007
n (rep. stn.)	1	1	17	6	12	11
Mean	0.63	0.67	0.45	0.59	0.56	0.52
Median	--	--	0.43	0.59	0.57	0.56
SD	--	--	0.14	0.09	0.13	0.21
SE	--	--	0.03	0.04	0.04	0.06
Min	--	--	0.23	0.46	0.33	0.00
Max	--	--	0.68	0.68	0.82	0.81
Sub-samples (20% precision)	--	--	2.53	0.54	1.41	4.09
95th Percentile	--	--	0.66	0.68	0.75	0.73
COV (%)	--	--	31.80	14.65	23.75	40.42

Table 6. - continued -

Metric	Simpson's Diversity Index					
Habitat Type	Offshore Profundal (14)					
Lake	CL-P2-13	CR-P3-11	SDL NW	SDL SE	Camp	Mary
Sample Year(s)	2013	2013	2007, 2008, 2011, 2013	2007	2007	2006, 2007
n (rep. stn.)	1	1	17	6	12	11
Mean	0.51	0.67	0.41	0.61	0.60	0.50
Median	--	--	0.44	0.65	0.61	0.58
SD	--	--	0.16	0.15	0.12	0.23
SE	--	--	0.04	0.06	0.03	0.07
Min	--	--	0.15	0.35	0.39	0.00
Max	--	--	0.63	0.75	0.76	0.69
Sub-samples (20% precision)	--	--	4.06	1.46	0.94	5.38
95th Percentile	--	--	0.61	0.74	0.76	0.68
COV (%)	--	--	40.30	24.13	19.41	46.38

Metric	Total Taxa Richness (genus-level)					
Habitat Type	Offshore Profundal (14)					
Lake	CL-P2-13	CR-P3-11	SDL NW	SDL SE	Camp	Mary
Sample Year(s)	2013	2013	2007, 2008, 2011, 2013	2007	2007	2006, 2007
n (rep. stn.)	1	1	17	6	12	11
Mean	9 [1]	17 [1]	9	9	9	9
Median	--	--	9	10	9	8
SD	--	--	2.27	2.83	2.76	5.66
SE	--	--	0.55	1.15	0.80	1.71
Min	--	--	4	4	6	1
Max	--	--	12	12	14	18
Sub-samples (20% precision)	--	--	1.77	2.47	2.36	10.11
95th Percentile	--	--	12.00	11.75	13.45	16.50
COV (%)	--	--	26.58	31.43	30.70	63.59

[1] Total number of taxa observed to genus-level, not the average number of taxa

Metric	Hill's Effective Richness					
Habitat Type	Offshore Profundal (14)					
Lake	CL-P2-13	CR-P3-11	SDL NW	SDL SE	Camp	Mary
Sample Year(s)	2013	2013	2007, 2008, 2011, 2013	2007	2007	2006, 2007
n (rep. stn.)	1	1	17	6	12	11
Mean	3	5	3	4	4	3
Median	--	--	2	4	3	4
SD	--	--	0.88	1.15	1.24	1.31
SE	--	--	0.21	0.47	0.36	0.40
Min	--	--	1	2	2	1
Max	--	--	4	5	6	5
Sub-samples (20% precision)	--	--	2.82	2.39	3.04	3.85
95th Percentile	--	--	3.94	5.03	5.52	4.90
COV (%)	--	--	33.60	30.89	34.85	39.27

Table 7. Substrate types in Lake CR-P3-11.

Substrate Type	Shoreline Zone (0-2 m)		Euphotic Zone (2-12 m)		Total	
	(m^2)	%	(m^2)	%	(m^2)	%
Boulder / Cobble	6,687	17	36,976	8	43,663	9
Gravel/Pebble	5,843	15	2,241	0.5	8,084	2
Sand	9,623	25	167,909	37	177,532	36
Fine Sand, Silt/Clay	16,504	43	250,251	55	266,754	54
Grand Total	38,657	100	457,376	100	496,033	100

Table 8. Comparison of aquatic habitat and lake characteristics.

Lake	Drainage Basin Area (km^2)	Lake Area (km^2)	Lake Area (km^2)	Drainage Basin: Lake Area Ratio	Mean Depth (m)	Maximum Depth (m)	Volume (1,000,000 m^3)	Substrate			
								Cobble/ Boulder (%)	Gravel/ Pebble (%)	Sand (%)	Fine Sand and Silt/Clay (%)
Camp Lake	26.47	2.21	2.21	11.98	13.03	35.08	27.5	5.1	28.2	61.1	5.6
Sheardown Lake NW	6.55	0.678	0.678	9.66	12.11	30.1	8.18	10.1	41.8	46.0	2.0
CR-P3-11	2.35	0.496	0.484	4.86	6.1	11.65	3.01	8.8	1.6	35.8	53.8
CL-P2-13	3.39	0.241	0.228	14.9	9.4	15.34	2.27	18.1	12.6	8.4	60.9

Table 9. Substrate types in Lake CL-P2-13.

Substrate Type	Shoreline Zone (0-2 m)		Euphotic Zone (2-12 m)		Profundal Zone (>12 m)		Total	
	(m^2)	%	(m^2)	%	(m^2)	%	(m^2)	%
Boulder / Cobble	3,128	30.4	35,752	19.5	4,547	9.8	43,427	18.1
Gravel/Pebble	1,031	10.0	23,035	12.6	6,102	13.2	30,169	12.6
Sand	5,164	50.1	14,918	8.1	157	0.3	20,238	8.4
Fine Sand, Silt/Clay	982	9.5	109,761	59.8	35,443	76.6	146,186	60.9
Grand Total	10,305	100.0	183,466	100.0	46,250	100.0	240,021	100.0

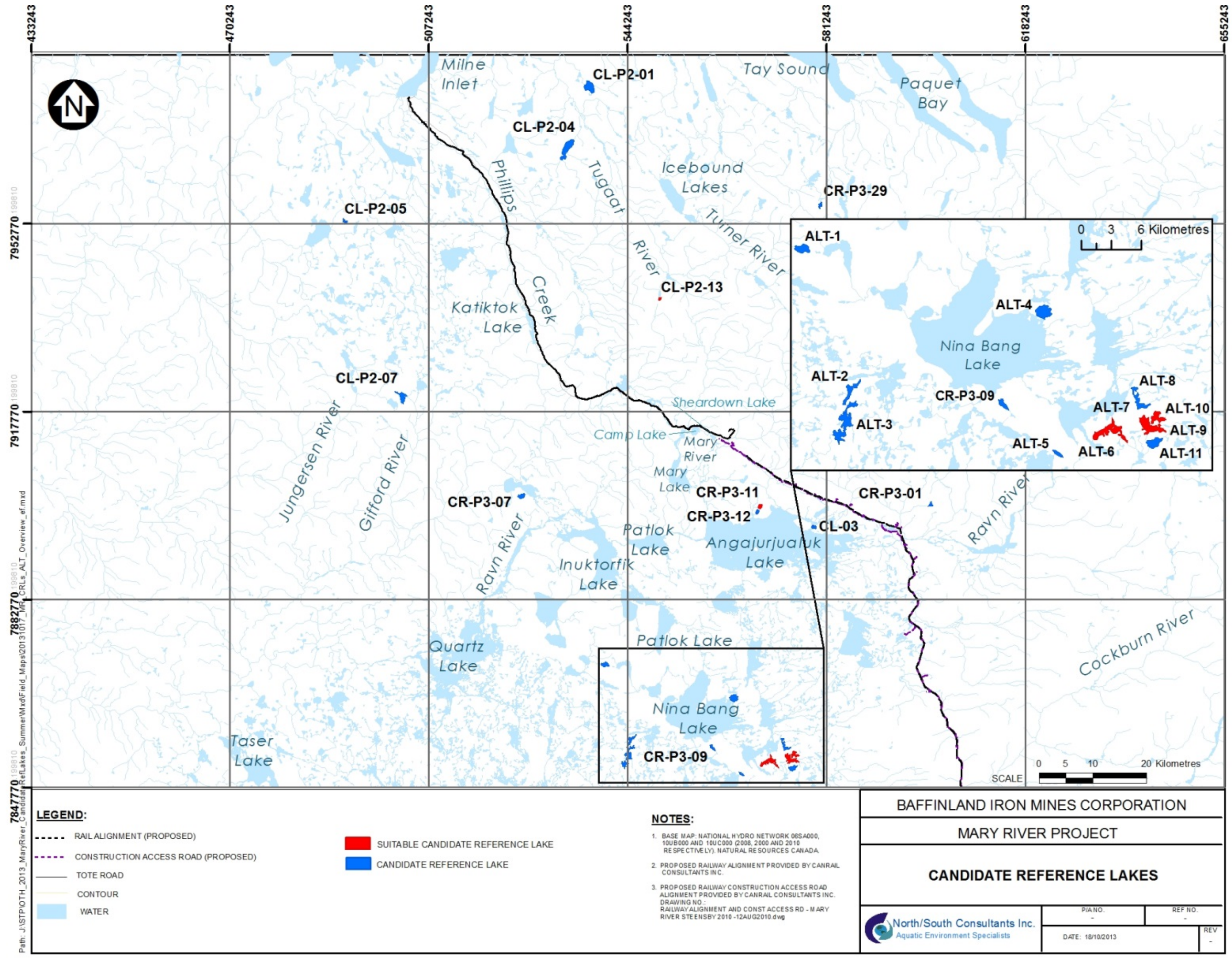

Figure 1. Proposed candidate reference lakes surveyed during summer and fall 2013. Lakes highlighted in red were identified as those most likely to be suitable as references for Camp and/or Sheardown NW lakes.

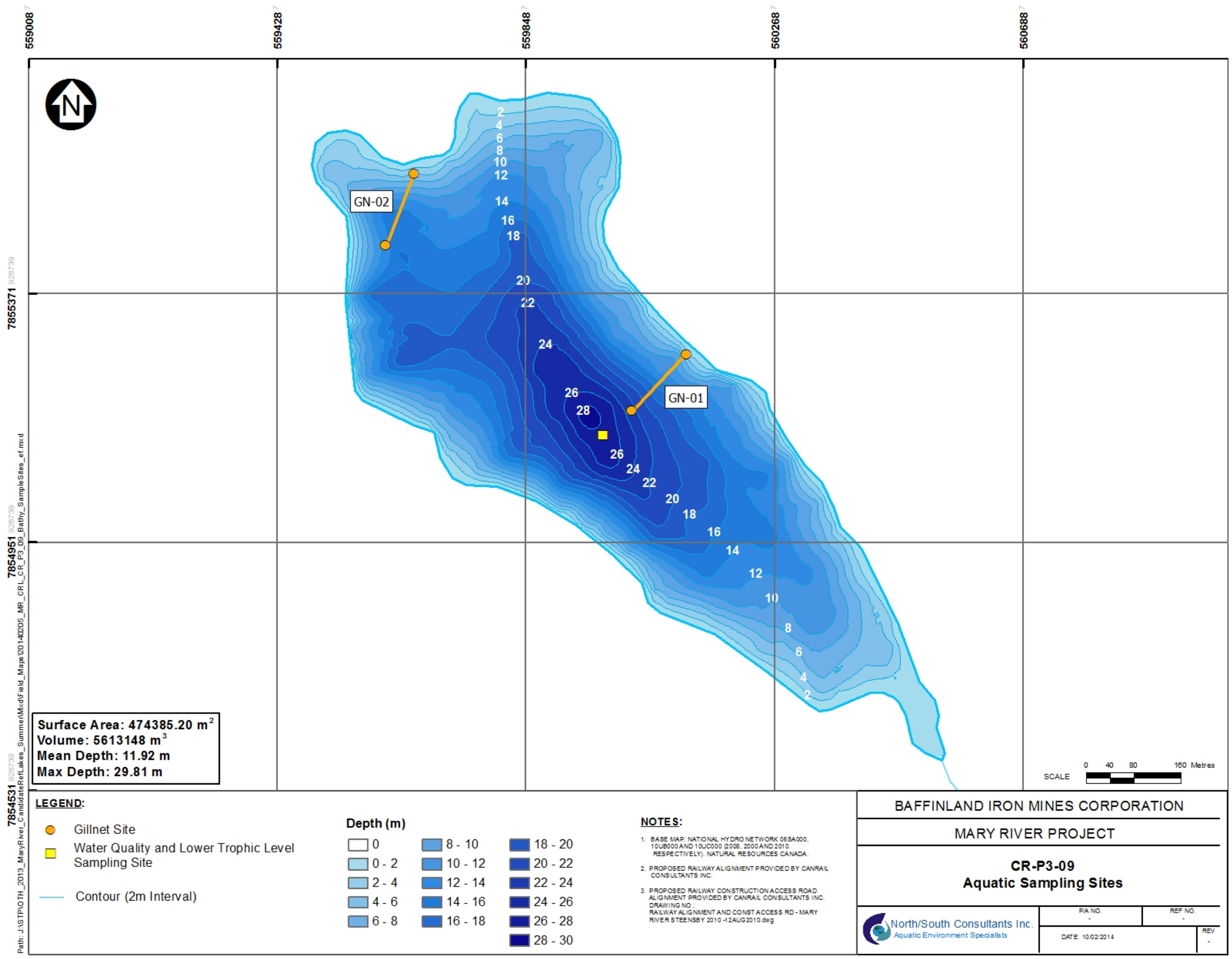

Figure 2. Bathymetry and locations of water quality, lower trophic level (phytoplankton & zooplankton), and fish sampling sites in Lake CR-P3-09.

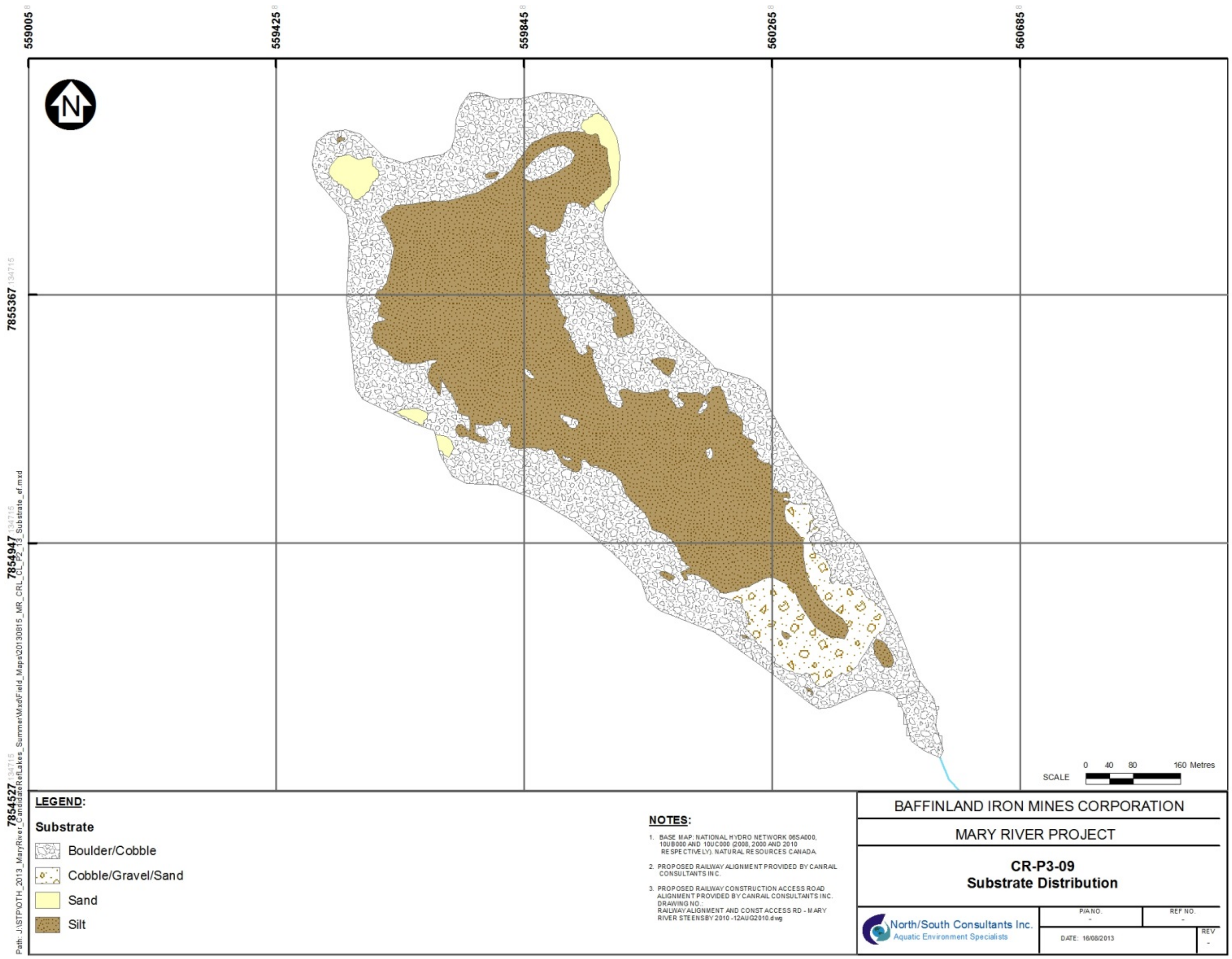

Figure 3. Substrate distribution map for Lake CR-P3-09, summer 2013.

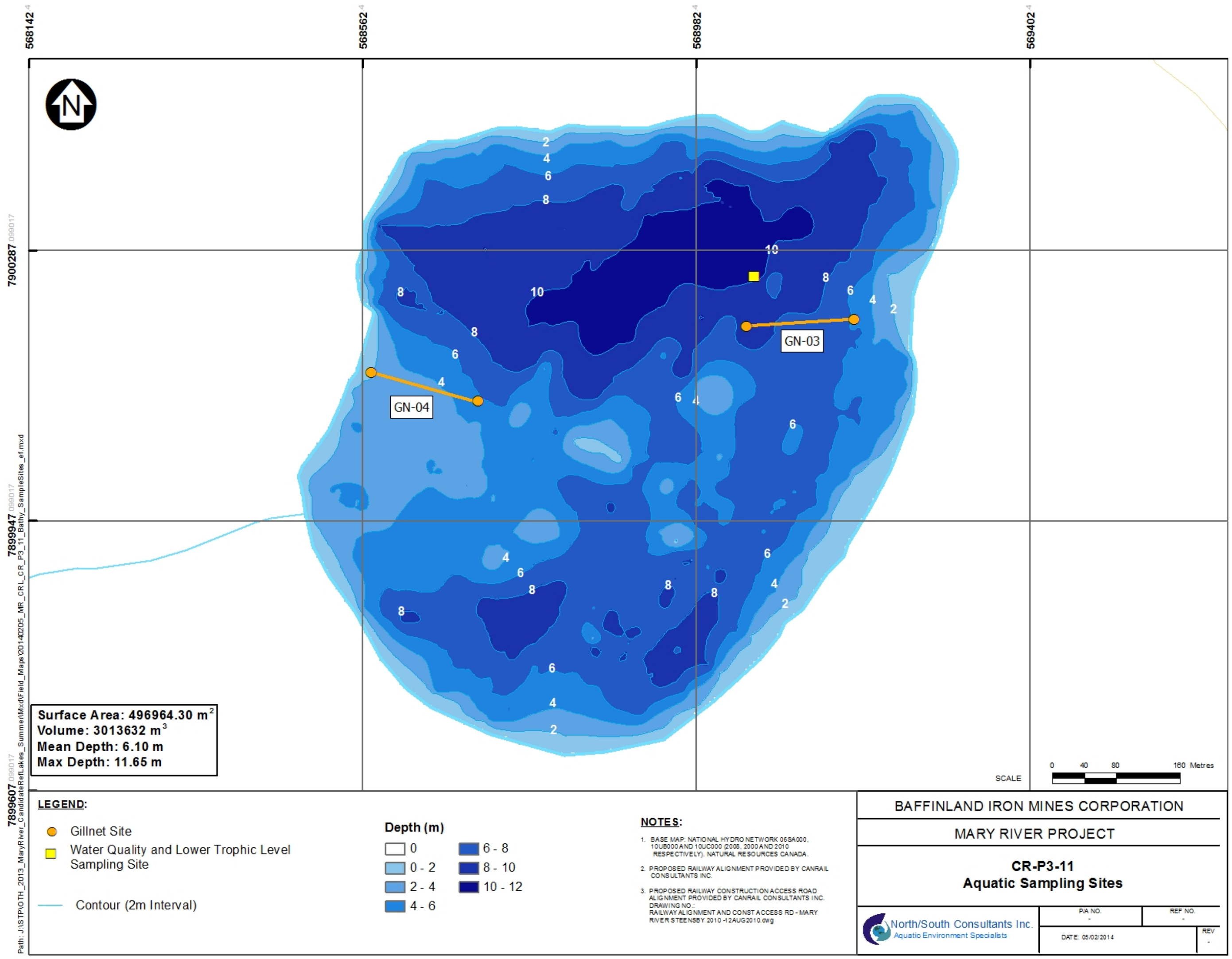

Figure 4. **Bathymetry and locations of water quality, lower trophic level (phytoplankton, zooplankton & BMI), and fish sampling sites in Lake CR-P3-11.**

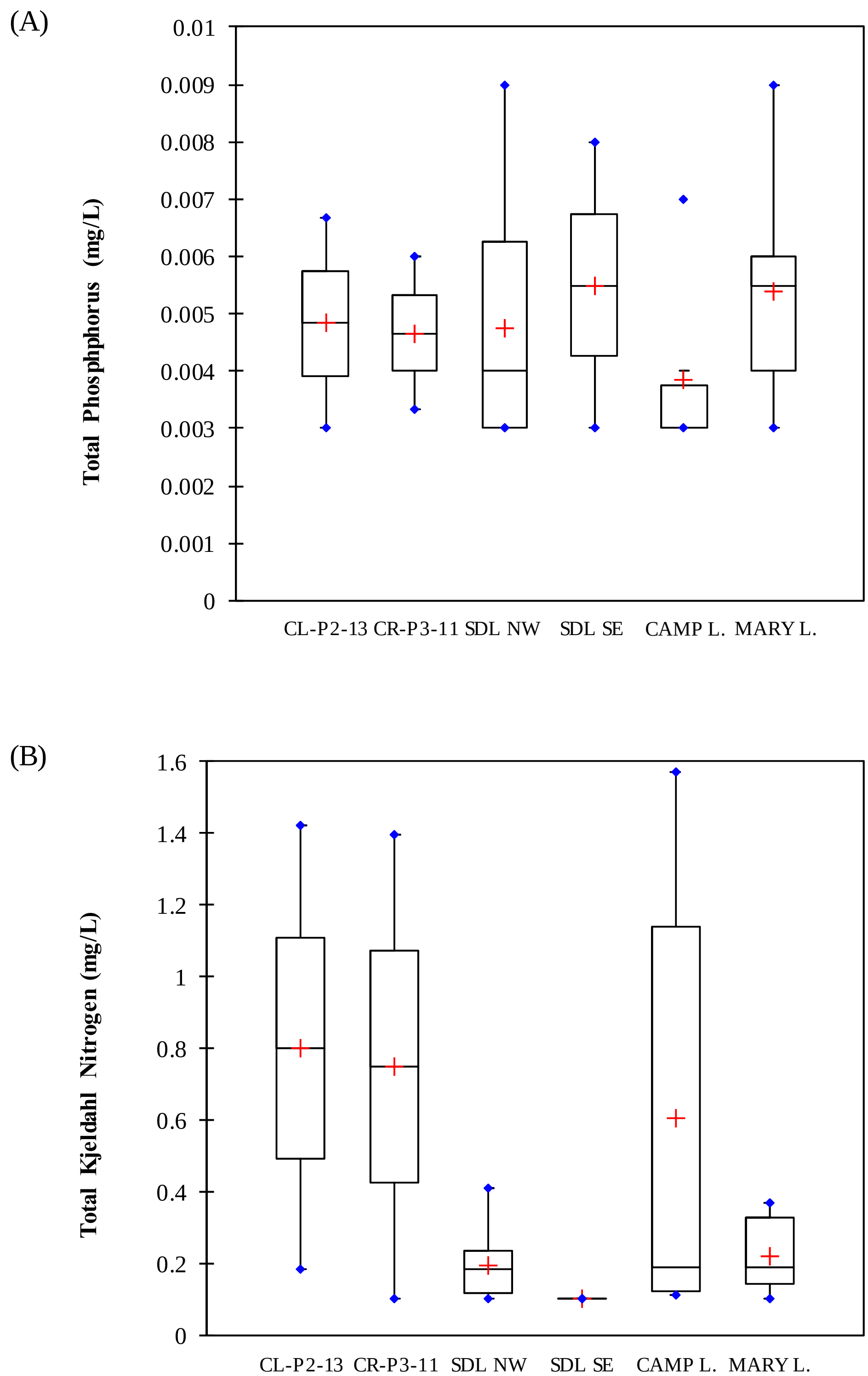

Figure 5. Total phosphorus (A) and total Kjeldahl nitrogen (B) measured in candidate reference lakes and Mine Area lakes in the open-water season, 2013.

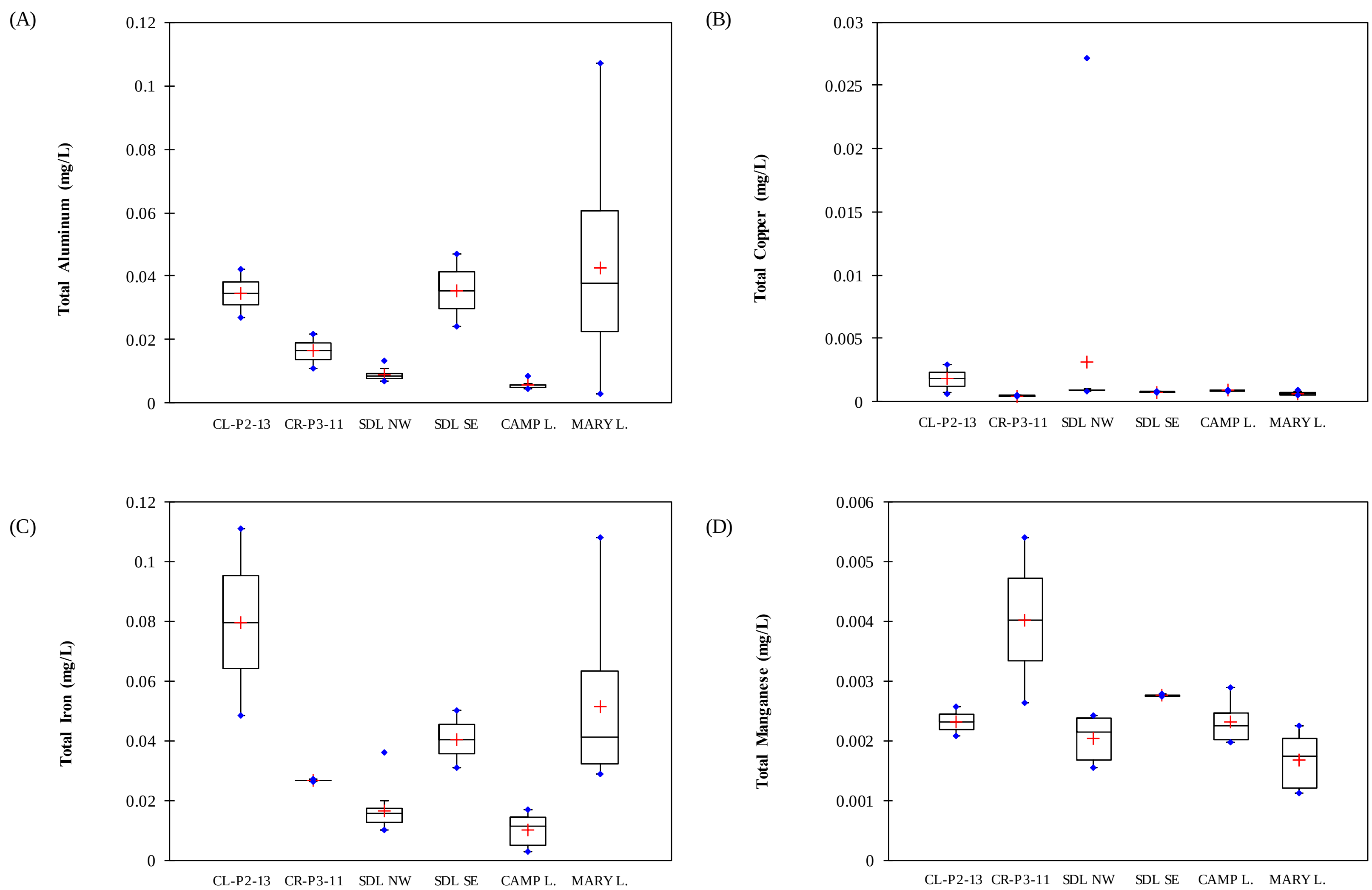

Figure 6. Total aluminum (A), total copper (B), total iron (C), and total manganese (D) measured in candidate reference lakes and Mine Area lakes in the open-water season, 2013.

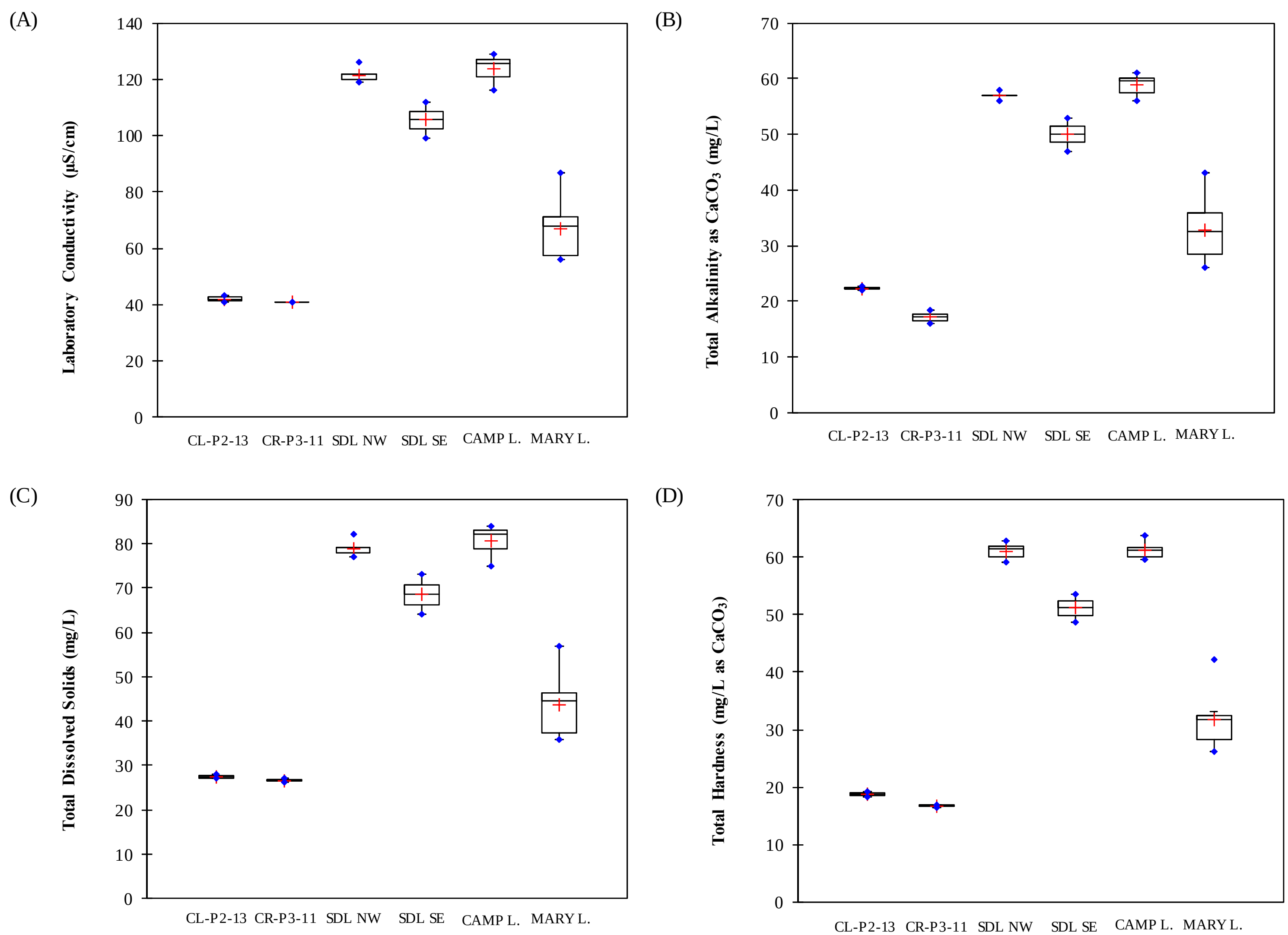

Figure 7. Laboratory conductivity (A), total alkalinity (B), total dissolved solids (C), and hardness (D) measured in candidate reference lakes and Mine Area lakes in the open-water season, 2013.

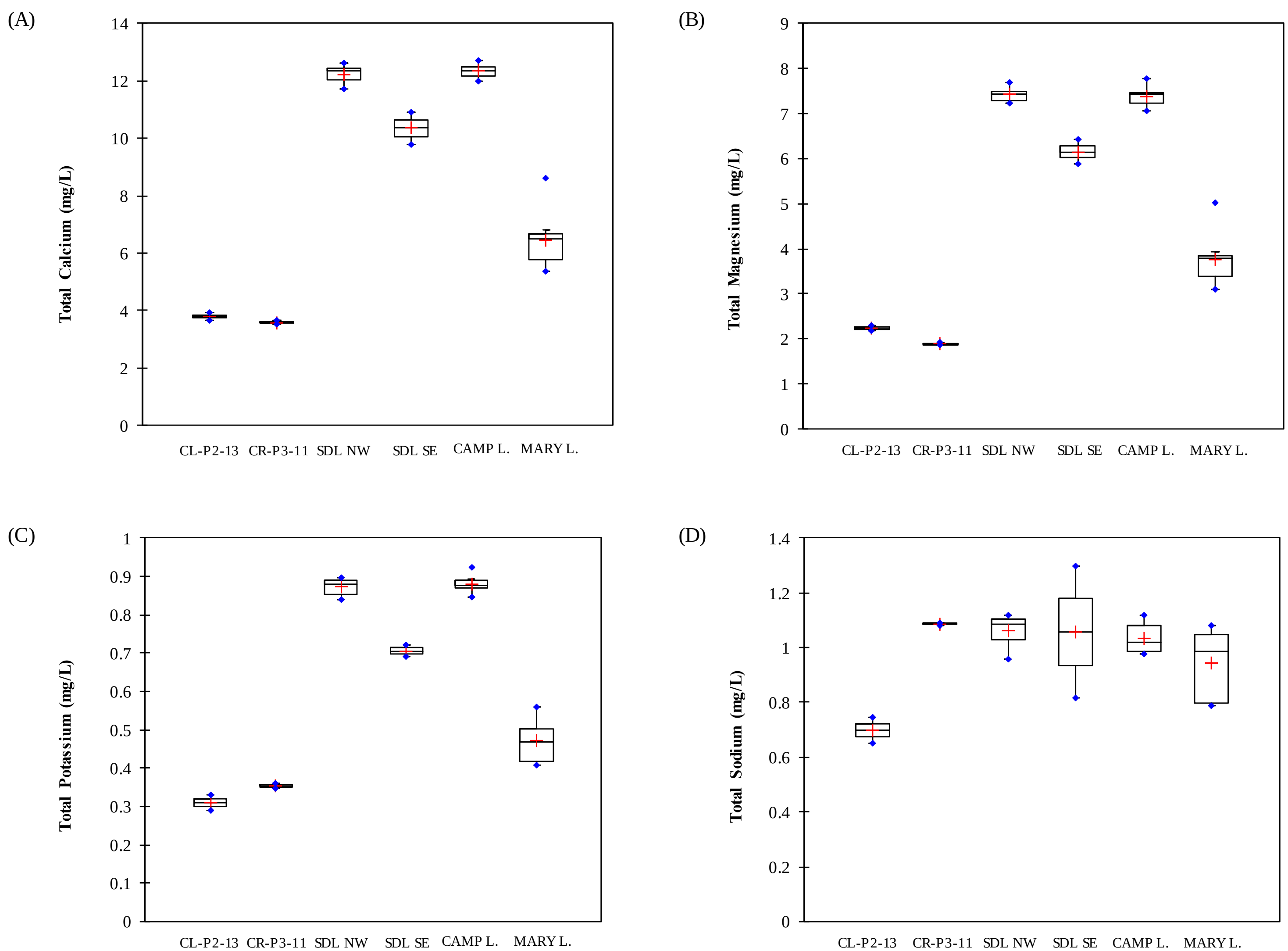

Figure 8. Total calcium (A), total magnesium (B), total potassium (C), and total sodium (D) measured in candidate reference lakes and Mine Area lakes in the open-water season, 2013.

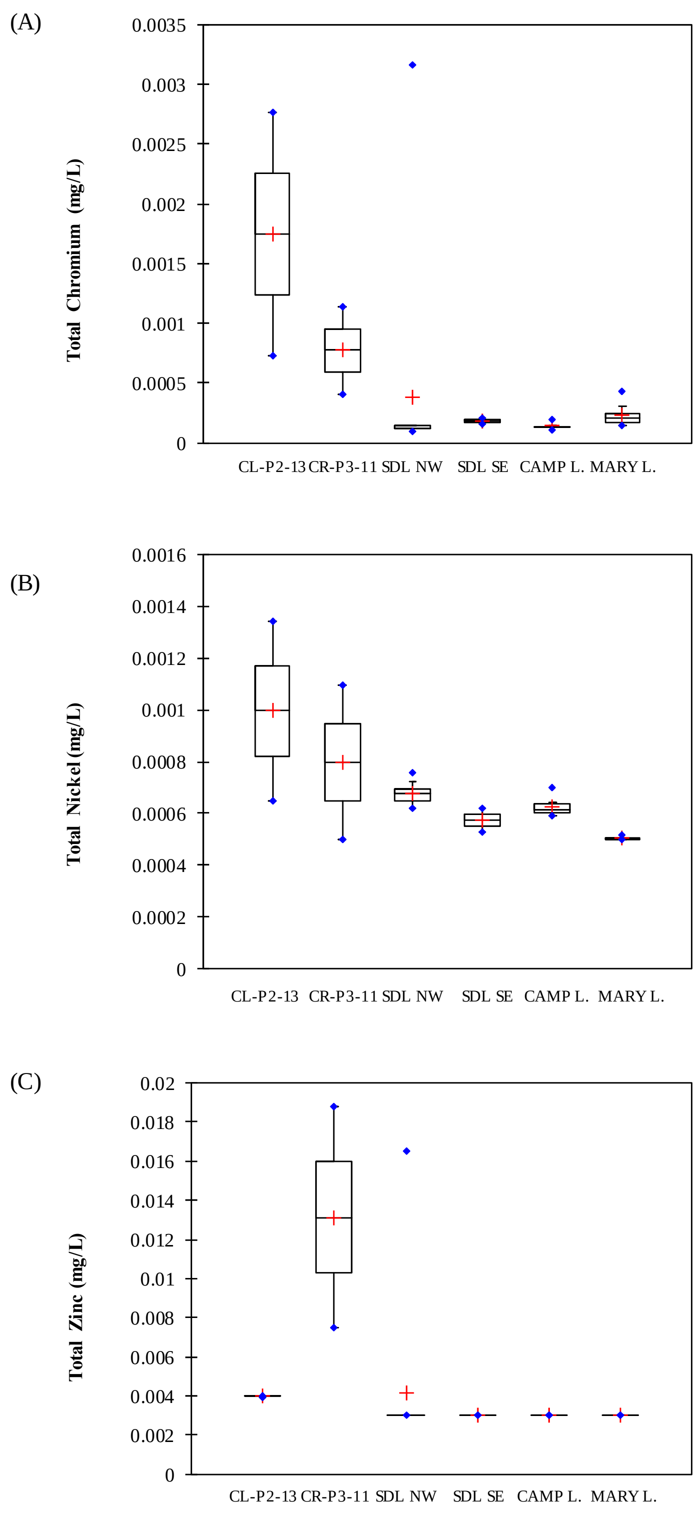

Figure 9. Total chromium (A), total nickel (B), and total zinc (C) measured in candidate reference lakes and Mine Area lakes in the open-water season, 2013.

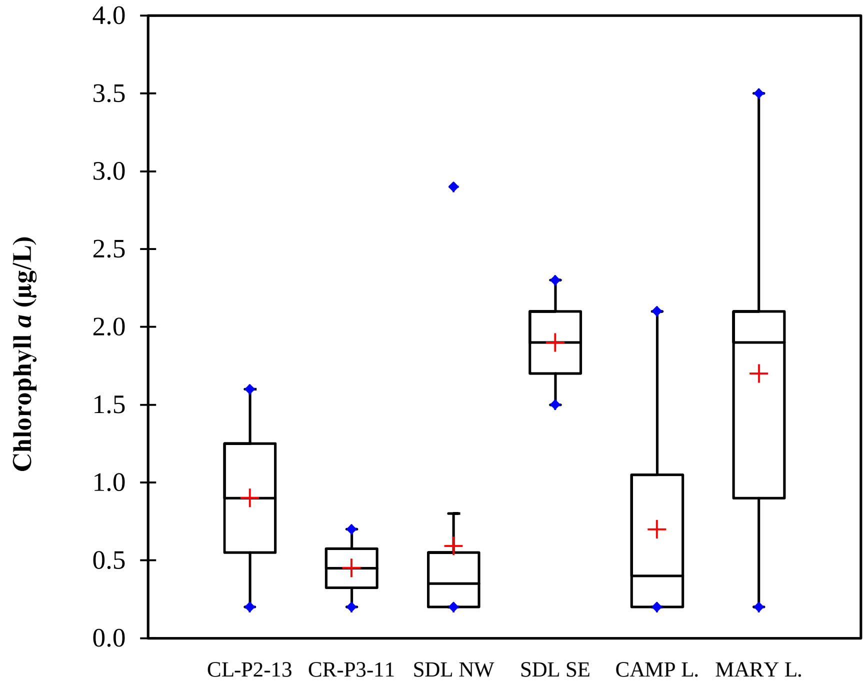

Figure 10. Chlorophyll *a* measured in candidate reference lakes and Mine Area lakes in the open-water season, 2013.

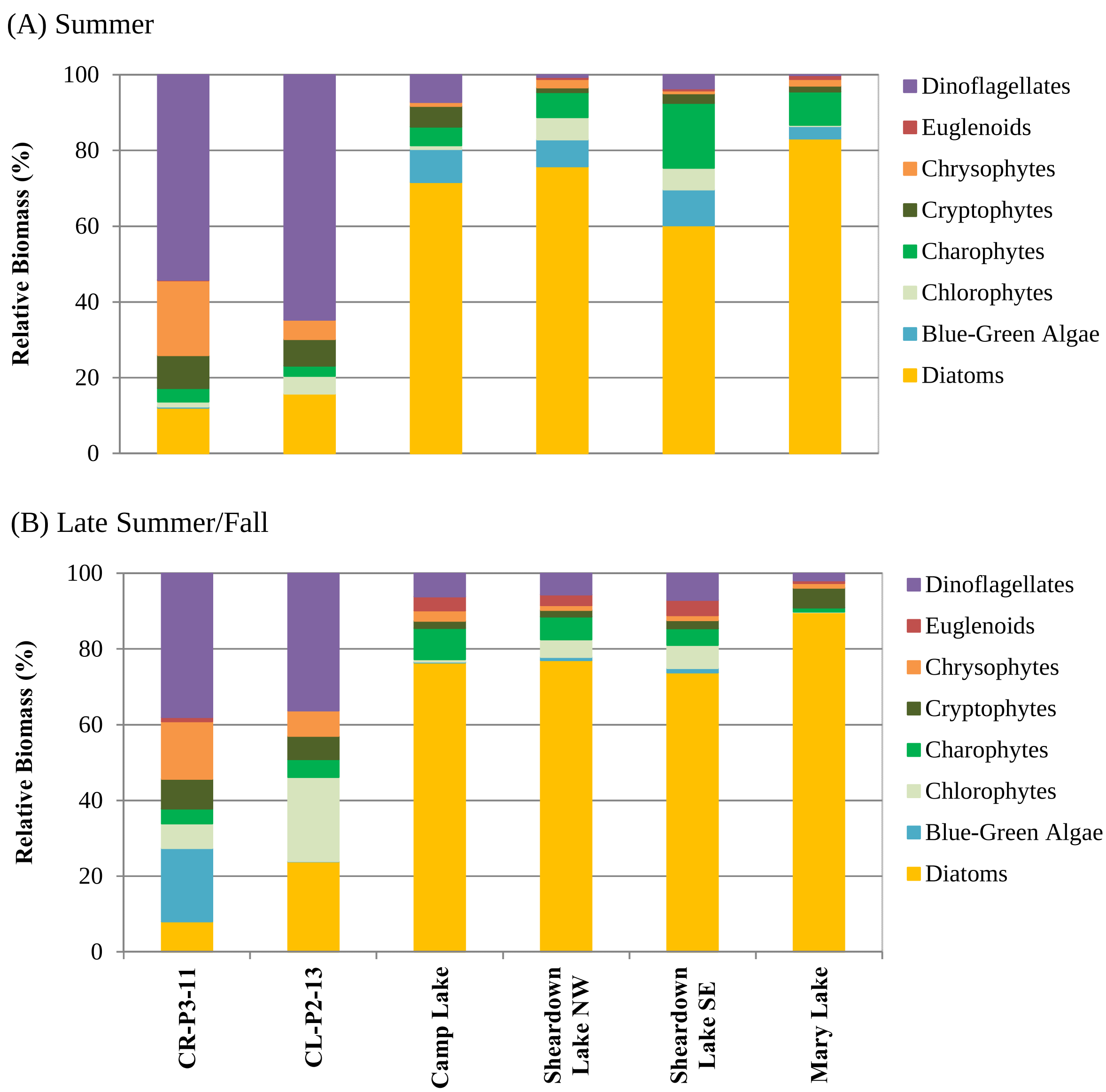

Figure 11. Percent relative biomass of major groups of phytoplankton measured in reference lakes (summer and fall 2013) and Mine Area lakes (summer and late summer/fall, 2007 and 2008).

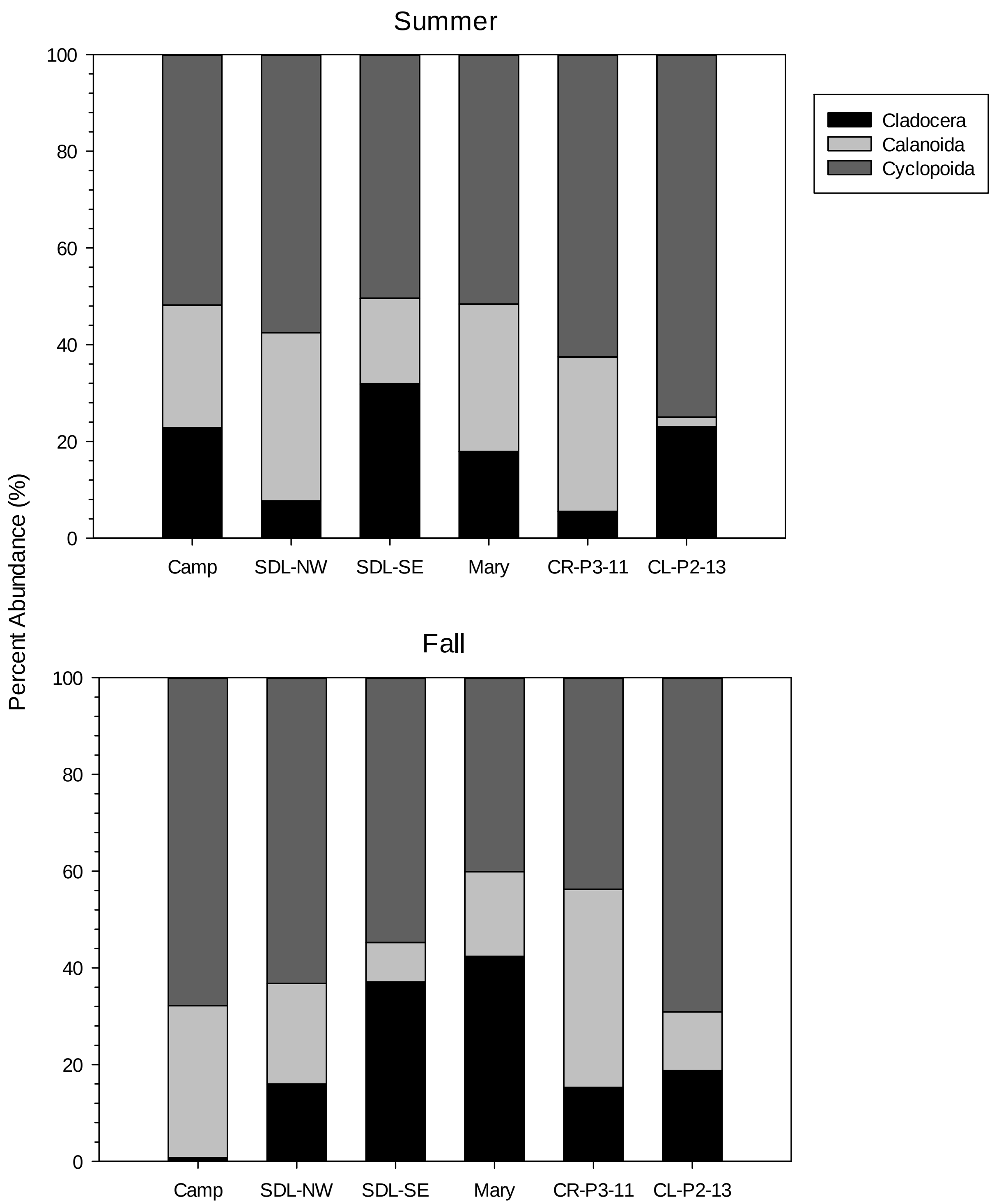

Figure 12. Seasonal relative abundance of crustacean zooplankton in Mine Area (2007 and 2008) and candidate reference (2013) lakes.

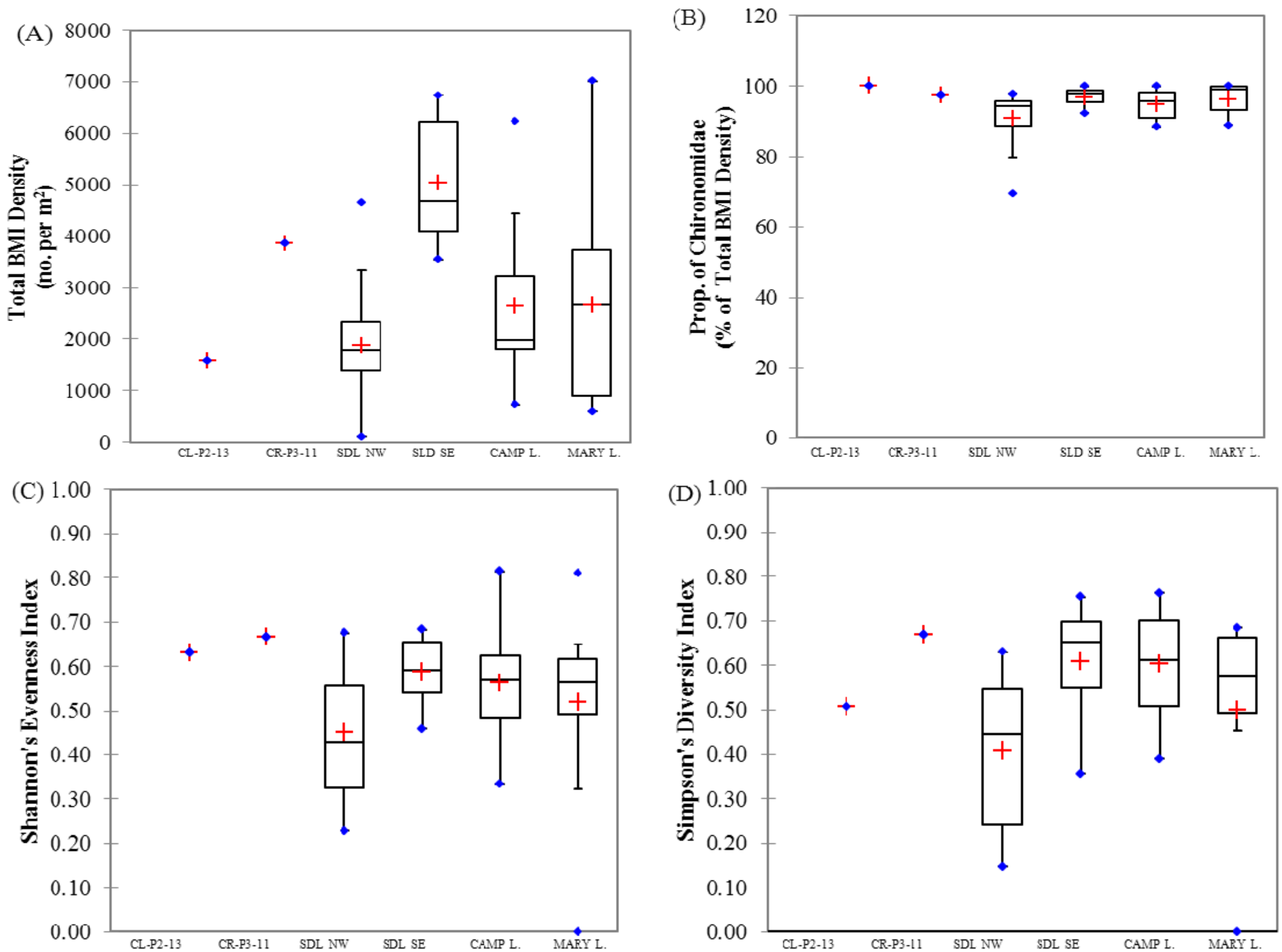

Figure 13. Total benthic macroinvertebrate (BMI) density (A), proportion of Chironomidae (B), Shannon's evenness index (C), and Simpson's diversity index (D) measures calculated from samples collected in the offshore profundal zone of candidate reference lakes (2013) and Mine Area lakes (2006, 2007, 2008, 2011, 2013).

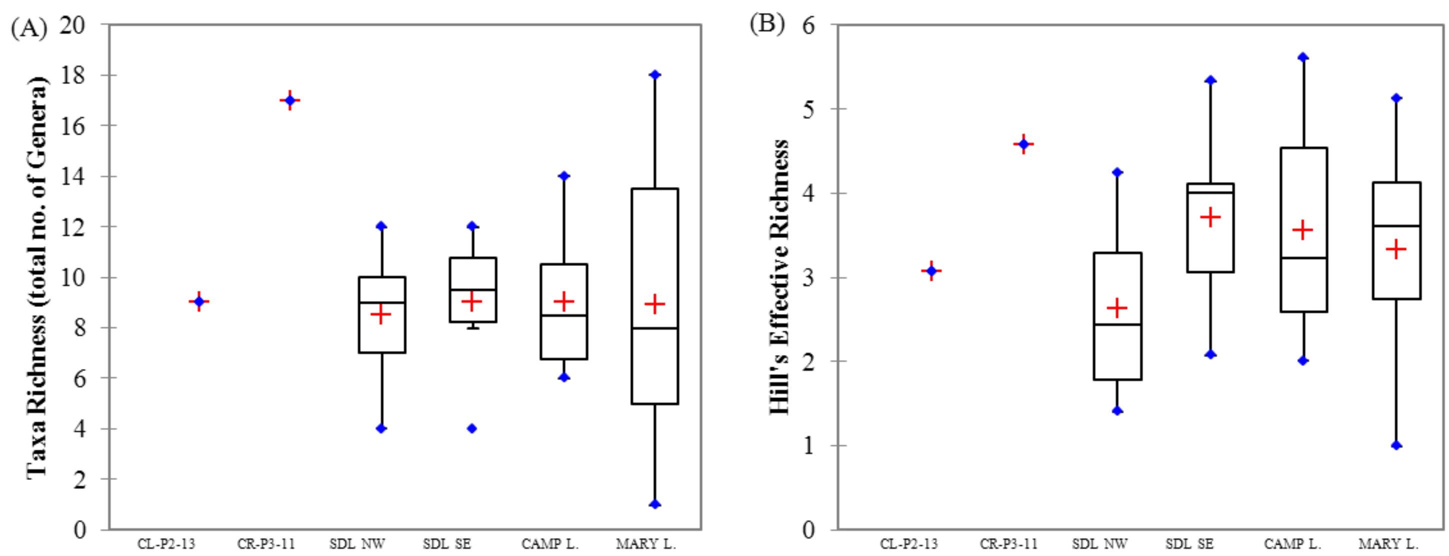

Figure 14. Total number of benthic macroinvertebrate taxa (genus-level) (A), and Hill's effective richness (B) measures calculated from samples collected in the offshore profundal zone of candidate reference lakes (CL-P2-13 and CR-P3-11; 2013) and Mine Area lakes (2006, 2007, 2008, 2011, 2013). Note: taxa richness for candidate reference lakes is the total number of taxa observed, not the average number of taxa.

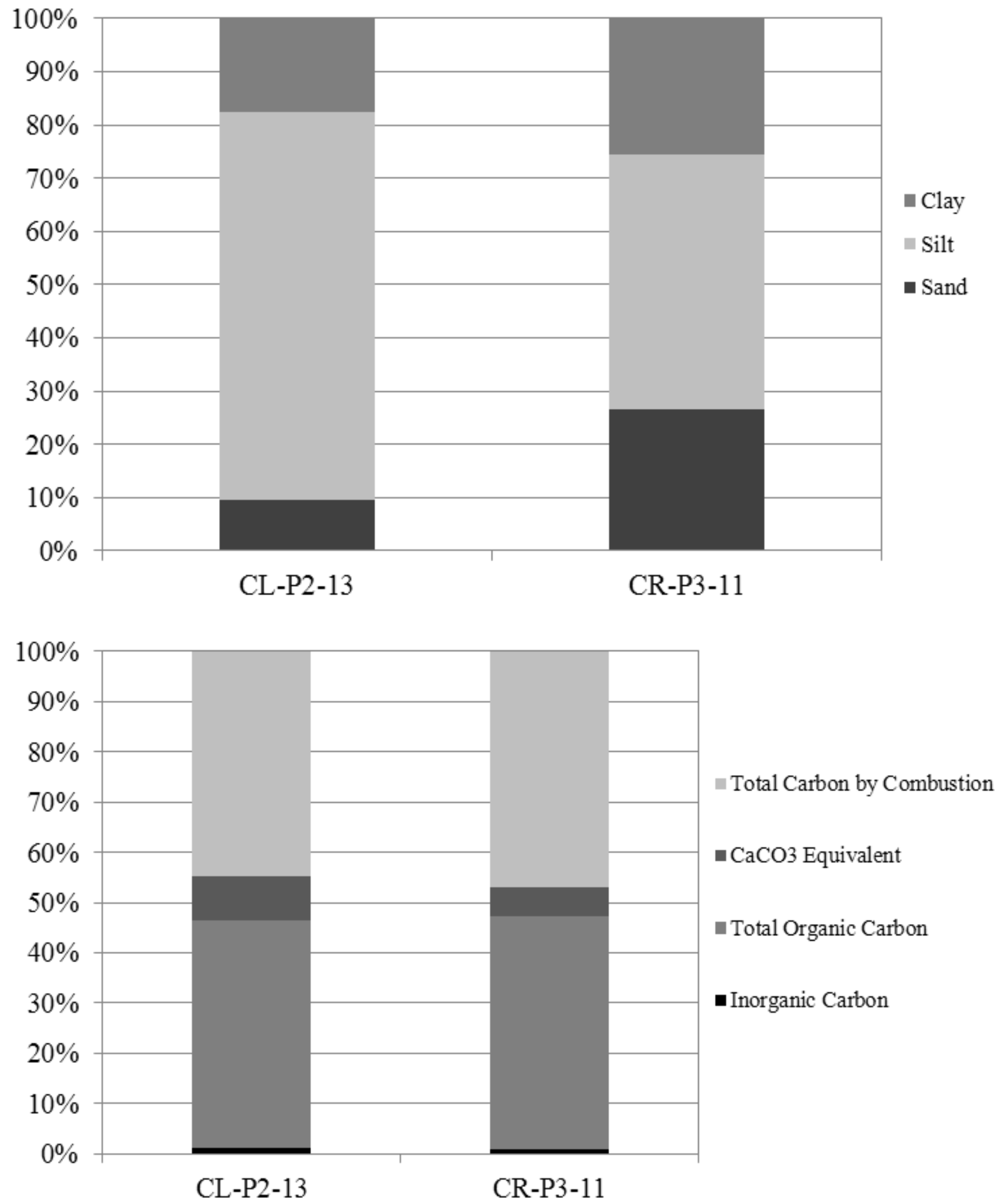

Figure 15. Particle size (% sand, % silt, % clay) (A) and organic carbon analyses (%) (B) from benthic sediment samples collected in the offshore profundal zone of candidate reference lakes (CL-P2-13 and CR-P3-11; 2013).

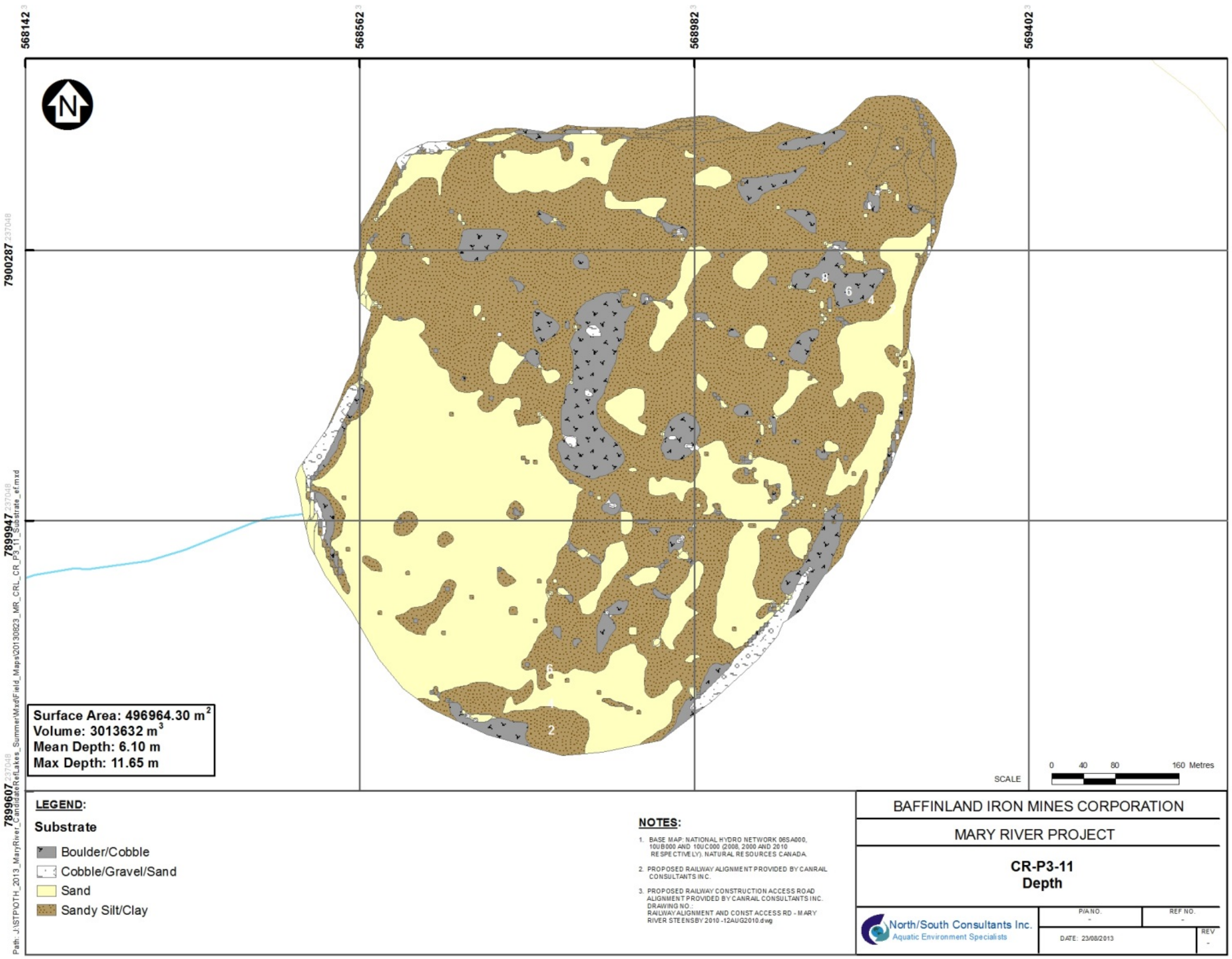

Figure 16. Substrate distribution map for Lake CR-P3-11, summer 2013.

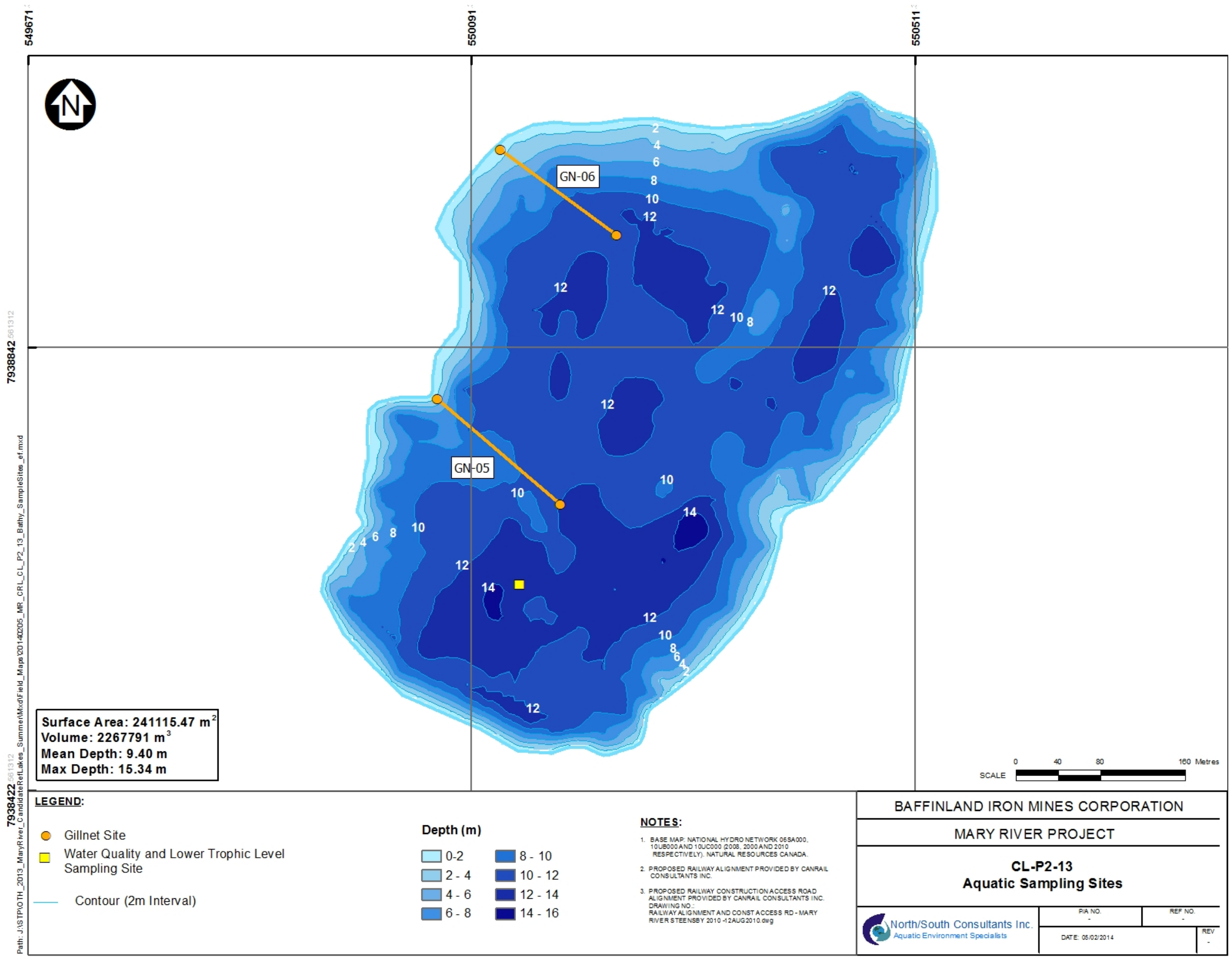

Figure 17. Bathymetry and locations of water quality, lower trophic level (phytoplankton, zooplankton & BMI), and fish sampling sites in Lake CL-P2-13.

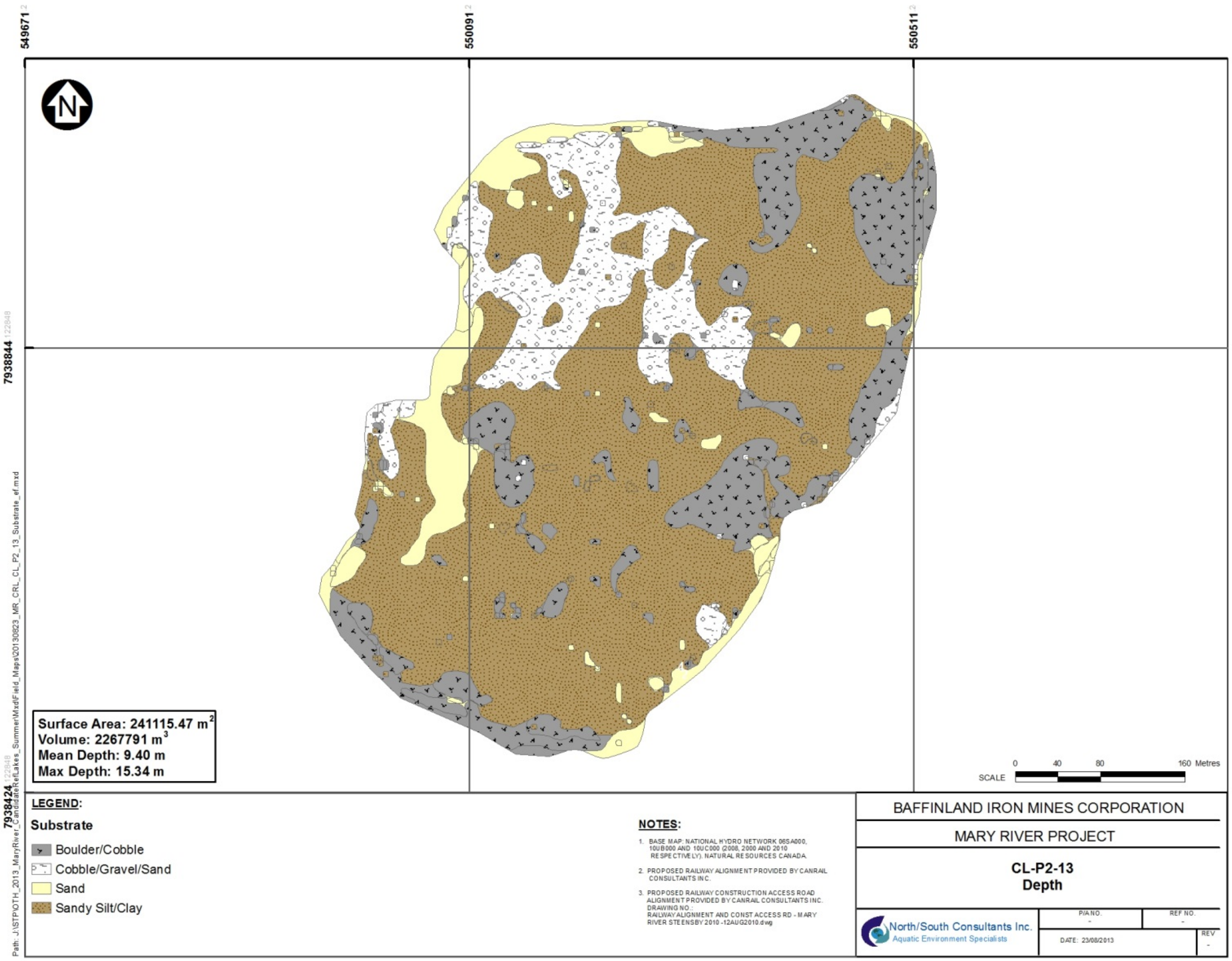

Figure 18. Substrate distribution map for Lake CL-P2-13, summer 2013.

APPENDIX 1. CANDIDATE REFERENCE LAKE WATER QUALITY DATA, 2013

Table A1-1. Summary of water quality sampling conducted in candidate reference lakes, 2013.

Waterbody	Sample ID	Site UTM (17W)		Sample Date	Sample Time	Site Depth (m)	Secchi Depth (m)	*in situ* Sample	Surface Sample	Bottom Sample
		Easting	Northing							
CR-P3-09	WQ-01	559980	7855131	05-Aug-13	15:10	28.4	9.25	Y	Y	N
CR-P3-11	WQ-02	569055	7900254	06-Aug-13	17:00	10.5	6.50	Y	Y	Y
CL-P2-13	WQ-03	550137	7938617	07-Aug-13	14:00	12.9	4.35	Y	Y	Y

Table A1-2. *In situ* water quality parameters measured in Lake CR-P3-09, summer 2013.

Depth (m)	Temperature (°C)	Specific Conductance (µS/cm)	DO (% saturation)	DO (mg/L)	pH	Turbidity (FNU)	Secchi Disk Depth (m)
1	8.5	44.9	95.8	11.30	8.11	0.04	9.25
2	8.2	44.9	96.6	11.43	8.03	0.08	
3	7.6	45.2	96.4	11.53	7.94	0.04	
4	7.6	45.2	96.8	11.58	7.88	0.05	
5	7.4	45.3	96.2	11.58	7.85	0.04	
6	7.3	45.5	96.5	11.63	7.71	0.06	
7	7.2	45.5	96.4	11.63	7.69	0.03	
8	7.2	45.5	96.2	11.64	7.68	0.05	
9	7.1	45.5	96.1	11.65	7.68	0.05	
10	7.0	45.6	96.1	11.66	7.67	0.06	
11	7.0	45.5	96.0	11.67	7.65	0.06	
12	6.9	45.6	95.9	11.67	7.66	0.04	
13	6.8	45.6	95.7	11.69	7.65	0.04	
14	6.7	45.6	95.5	11.71	7.64	0.05	
15	6.6	45.6	95.5	11.72	7.64	0.05	
16	6.5	45.6	95.3	11.73	7.63	0.05	
17	6.2	45.6	94.9	11.77	7.62	0.05	
18	6.1	45.6	95.0	11.79	7.61	0.04	
19	6.1	45.6	95.0	11.79	7.60	0.04	
20	6.0	45.6	94.8	11.80	7.59	0.05	
21	6.0	45.6	94.7	11.80	7.58	0.03	
22	5.8	45.6	94.6	11.81	7.58	0.06	
23	5.9	45.6	94.6	11.80	7.58	0.04	
24	5.9	45.6	94.6	11.81	7.57	0.05	
25	5.8	45.6	94.5	11.81	7.57	0.04	

Table A1-3. *In situ* water quality parameters measured in potential reference Lake CR-P3-11, summer and fall 2013.

Depth (m)	Temperature (°C)	Specific Conductance (µS/cm)	DO (%)	DO (mg/L)	pH	Turbidity (FNU)	Secchi Disk Depth (m)
August 6, 2013							
1	9.6	38.7	99.4	11.33	7.91	0.06	6.5
2	9.6	38.7	99.8	11.37	7.83	0.06	
3	9.6	38.7	99.9	11.39	7.77	0.06	
4	9.4	38.7	99.8	11.42	7.73	0.07	
5	9.4	38.7	99.8	11.43	7.67	0.08	
6	9.3	38.7	99.8	11.46	7.64	0.07	
7	9.3	38.7	99.7	11.45	7.61	0.08	
8	9.0	38.7	99.4	11.50	7.60	0.08	
9	8.2	38.6	98.3	11.60	7.57	0.05	
September 4, 2013							
1	4.4	41.5	90.6	11.75	8.10	0.32	5.75
2	4.4	44.1	91.8	11.90	7.82	0.29	
3	4.4	44.1	91.2	11.82	7.74	0.33	
4	4.4	44.0	91.5	11.87	7.63	0.32	
5	4.4	44.0	91.4	11.85	7.59	0.32	
6	4.4	44.0	91.2	11.84	7.52	0.30	
7	4.4	44.0	91.2	11.83	7.50	0.29	
8	4.4	43.9	90.4	11.73	7.56	0.37	
9	4.4	43.8	90.5	11.74	7.55	0.32	

Table A1-4. *In situ* water quality parameters measured in potential reference Lake CL-P2-13, summer and fall 2013.

Depth (m)	Temperature (°C)	Specific Conductance (µS/cm)	DO (%)	DO (mg/L)	pH	Turbidity (FNU)	Secchi Disk Depth (m)
August 7, 2013							
1	6.9	40.8	93.7	11..46	8.23	0.58	4.35
2	6.8	40.7	96.3	11.75	8.02	0.60	
3	6.8	40.7	97.3	11.88	7.96	0.58	
4	6.8	40.7	97.7	11.92	7.82	0.63	
5	6.7	40.7	97.6	11.93	7.73	0.57	
6	6.6	40.7	97.4	11.96	7.59	0.61	
7	6.4	40.7	97.6	12.01	7.42	0.59	
8	6.4	40.8	97.5	12.01	7.37	0.62	
9	5.8	40.6	96.8	12.08	7.29	0.59	
10	5.6	40.7	96.7	12.14	7.23	0.58	
11	5.4	40.6	96.4	12.18	7.20	0.61	
September 4, 2013							
1	3.8	43.2	87.8	11.55	7.42	0.73	4.25
2	3.8	43.2	87.5	11.52	7.66	0.74	
3	3.8	43.3	87.2	11.49	7.58	0.71	
4	3.8	43.3	87.1	11.47	7.66	0.67	
5	3.8	43.2	87.0	11.46	7.61	0.66	
6	3.8	43.3	86.9	11.45	7.48	0.70	
7	3.8	43.2	86.8	11.43	7.43	0.64	
8	3.8	43.2	86.7	11.43	7.62	0.70	
9	3.8	43.3	86.7	11.42	7.60	0.66	
10	3.8	43.2	86.6	11.41	7.51	0.70	
11	3.8	43.2	86.5	11.40	7.46	0.70	
12	3.8	43.3	86.5	11.39	7.38	0.67	

Table A1-5. Laboratory water quality results for lakes CR-P3-11 and CL-P2-13, 2013.

Waterbody	Site ID	Sampling Date	Surface/ Bottom	Notes	Chlorophyll *a*	Pheophytin *a*	pH	Conductivity	Turbidity	Alkalinity as $CaCO_3$	Bromide	Chloride	Hardness as $CaCO_3$ (Dissolved)	Hardness as $CaCO_3$ (Total)	Ammonia	Nitrite	Nitrate/nitrite	Nitrate	Sulphate	Total Dissolved Solids	Total Suspended Solids
					μg/L	μg/L		μS/cm	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg N/L	mg N/L	mg N/L	mg N/L	mg/L	mg/L	mg/L
CP-P3-11	CP-P3-11SA	2013-08-06	Surface	Replicate 1	<0.2	0.2	6.72	39	0.3	17	<0.25	2	15.8	16.2	0.03	<0.005	<0.10	<0.10	<3	25	<2
CP-P3-11	CP-P3-11SB	2013-08-06	Surface	Replicate 2	<0.2	2.8	6.71	39	0.4	17	<0.25	2	15.9	16.5	0.04	<0.005	<0.10	<0.10	<3	25	<2
CP-P3-11	CP-P3-11SC	2013-08-06	Surface	Replicate 3	<0.2	0.7	6.86	45	0.5	21	<0.25	2	15.9	16.7	0.03	<0.005	<0.10	<0.10	<3	29	<2
CP-P3-11	CP-P3-11Bot	2013-08-06	Bottom		1.1	<0.2	6.71	39	0.5	16	<0.25	2	15.8	16.2	0.04	<0.005	<0.10	<0.10	<3	25	<2
CP-P3-11	CR-P3-11S	2013-09-04	Surface		0.7	<0.2	6.64	41	0.8	16	<0.25	2	16.2	17.0	0.03	<0.005	<0.10	<0.10	<3	27	<2
CP-P3-11	CR-P3-11Bot	2013-09-04	Bottom		1.8	<0.2	6.63	41	0.7	17	<0.25	2	16.0	16.8	0.05	<0.005	<0.10	<0.10	<3	27	<2
CL-P2-13	CL-P2-13S	2013-08-07	Surface		<0.2	1.4	6.77	41	0.8	22	<0.25	<1	18.5	18.2	1.01	<0.005	<0.10	<0.10	<3	27	<2
CL-P2-13	CL-P2-13BOT	2013-08-07	Bottom		<0.2	2.7	6.76	41	0.9	22	<0.25	<1	18.8	18.0	0.04	<0.005	<0.10	<0.10	<3	27	<2
CL-P2-13	CL-P2-13S	2013-09-04	Surface	Replicate 1	1.5	<0.2	6.69	42	0.9	23	<0.25	<1	18.7	19.1	<0.02	<0.005	<0.10	<0.10	<3	27	<2
CL-P2-13	CL-P2-13SA	2013-09-04	Surface	Replicate 2	2.3	<0.2	6.68	43	1.1	22	<0.25	<1	19.1	19.3	<0.02	<0.005	<0.10	<0.10	<3	28	<2
CL-P2-13	CL-P2-13SB	2013-09-04	Surface	Replicate 3	1.0	<0.2	6.71	44	1.0	23	<0.25	<1	19.2	19.2	<0.02	<0.005	<0.10	<0.10	<3	29	<2
CL-P2-13	CL-P2-13Bot	2013-09-04	Bottom		3.8	<0.2	6.69	43	0.8	23	<0.25	<1	18.9	19.1	0.93	<0.005	<0.10	<0.10	<3	28	<2
	CL-P2-13F	2013-08-07		Field Blank	<0.2	<0.2	5.75	<5	0.1	<5	<0.25	<1	<0.5	<0.5	0.17	<0.005	<0.10	<0.10	<3	<1	<2
	Trip Blank	2013-09-04		Trip Blank	1.5	<0.2	6.19	<5	<0.1	<5	<0.25	<1	<0.5	<0.5	<0.02	<0.005	<0.10	<0.10	<3	<1	<2
	Field Blank	2013-09-04		Field Blank	2.0	<0.2	5.72	<5	<0.1	<5	<0.25	<1	<0.5	<0.5	<0.02	<0.005	<0.10	<0.10	<3	<1	<2

Table A1-5. - continued -

Waterbody	Site ID	Sampling Date	Surface/ Bottom	Notes	Total Phosphorus	Total Kjeldahl Nitrogen	Phenols	Total Organic Carbon	Dissolved Organic Carbon	Aluminum (Dissolved)	Aluminum (Total)	Antimony (Dissolved)	Antimony (Total)	Arsenic (Dissolved)	Arsenic (Total)	Barium (Dissolved)	Barium (Total)	Beryllium (Dissolved)	Beryllium (Total)	Bismuth (Dissolved)	Bismuth (Total)
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CP-P3-11	CP-P3-11SA	2013-08-06	Surface	Replicate 1	0.004	0.68	<0.001	1.7	1.7	0.0042	0.0106	<0.00010	<0.00010	<0.00010	<0.00010	0.0026	0.00260	<0.00010	<0.00002	<0.00050	<0.00050
CP-P3-11	CP-P3-11SB	2013-08-06	Surface	Replicate 2	0.003	0.14	<0.001	1.8	1.6	0.0039	0.0114	<0.00010	<0.00010	<0.00010	<0.00010	0.00261	0.00269	<0.00010	<0.00002	<0.00050	<0.00050
CP-P3-11	CP-P3-11SC	2013-08-06	Surface	Replicate 3	0.003	3.37	<0.001	2	1.7	0.0039	0.0112	<0.00010	<0.00010	<0.00010	<0.00010	0.00259	0.00274	<0.00010	<0.00002	<0.00050	<0.00050
CP-P3-11	CP-P3-11Bot	2013-08-06	Bottom		0.003	0.11	<0.001	1.8	1.7	0.0047	0.0136	<0.00010	<0.00010	<0.00010	<0.00010	0.00268	0.00263	<0.00010	<0.00002	<0.00050	<0.00050
CP-P3-11	CR-P3-11S	2013-09-04	Surface		0.006	<0.10	<0.001	2.2	2.2	0.0046	0.0218	<0.00010	<0.00010	<0.00010	<0.00010	0.00287	0.00284	<0.00010	<0.00002	<0.00050	<0.00050
CP-P3-11	CR-P3-11Bot	2013-09-04	Bottom		0.005	0.11	<0.001	2	2	0.0044	0.0237	<0.00010	<0.00010	<0.00010	<0.00010	0.00287	0.00287	<0.00010	<0.00002	<0.00050	<0.00050
CL-P2-13	CL-P2-13S	2013-08-07	Surface		<0.003	1.42	<0.001	1.1	0.8	0.0040	0.0271	<0.00010	<0.00010	<0.00010	<0.00010	0.00215	0.00233	<0.00010	<0.00002	<0.00050	<0.00050
CL-P2-13	CL-P2-13BOT	2013-08-07	Bottom		0.003	1.33	<0.001	0.9	0.8	0.0046	0.0287	<0.00010	<0.00010	<0.00010	<0.00010	0.00211	0.00218	<0.00010	<0.00002	<0.00050	<0.00050
CL-P2-13	CL-P2-13S	2013-09-04	Surface	Replicate 1	0.004	0.35	<0.001	1.4	1.2	0.0033	0.0323	<0.00010	<0.00010	<0.00010	0.00013	0.00231	0.00248	<0.00010	<0.00002	<0.00050	<0.00050
CL-P2-13	CL-P2-13SA	2013-09-04	Surface	Replicate 2	0.009	<0.10	0.021	1.1	1.3	0.0037	0.0504	<0.00010	<0.00010	<0.00010	0.00014	0.00223	0.00248	<0.00010	<0.00002	<0.00050	<0.00050
CL-P2-13	CL-P2-13SB	2013-09-04	Surface	Replicate 3	0.007	<0.10	0.029	1.2	1.4	0.0044	0.0434	<0.00010	<0.00010	<0.00010	0.00015	0.00222	0.00263	<0.00010	<0.00002	<0.00050	<0.00050
CL-P2-13	CL-P2-13Bot	2013-09-04	Bottom		0.06	1.12	<0.001	1.1	1.2	0.0042	0.3870	<0.00010	<0.00010	<0.00010	<0.00010	0.00226	0.00381	<0.00010	<0.00002	<0.00050	<0.00050
	CL-P2-13F	2013-08-07		Field Blank	<0.003	0.37	<0.001	<0.5	<0.5	<0.001	<0.001	<0.00010	<0.00010	<0.00010	<0.00010	0.000788	0.000596	<0.00010	<0.00002	<0.00050	<0.00050
	Trip Blank	2013-09-04		Trip Blank	<0.003	<0.10	<0.001	<0.5	<0.5	<0.001	<0.001	<0.00010	<0.00010	<0.00010	<0.00010	<0.000050	<0.000050	<0.00010	<0.00002	<0.00050	<0.00050
	Field Blank	2013-09-04		Field Blank	<0.003	<0.10	<0.001	<0.5	<0.5	<0.001	<0.001	<0.00010	<0.00010	<0.00010	<0.00010	<0.000050	<0.000050	<0.00010	<0.00002	<0.00050	<0.00050

Table A1-5. - continued -

Waterbody	Site ID	Sampling Date	Surface/ Bottom	Notes	Boron (Dissolved)	Boron (Total)	Cadmium (Dissolved)	Cadmium (Total)	Calcium (Dissolved)	Calcium (Total)	Chromium (Dissolved)	Chromium (Total)	Hexavalent Chromium (dissolved(	Cobalt (Dissolved)	Cobalt (Total)	Copper (Dissolved)	Copper (Total)	Iron (Dissolved)	Iron (Total)
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CP-P3-11	CP-P3-11SA	2013-08-06	Surface	Replicate 1	<0.01	<0.01	<0.000010	<0.000010	3.37	3.47	<0.00010	0.00029	<0.001	<0.00010	<0.00010	0.0003	<0.00020	<0.01	0.02
CP-P3-11	CP-P3-11SB	2013-08-06	Surface	Replicate 2	<0.01	<0.01	<0.000010	<0.000010	3.4	3.53	<0.00010	0.0022	<0.001	<0.00010	<0.00010	0.00031	0.0005	<0.01	0.032
CP-P3-11	CP-P3-11SC	2013-08-06	Surface	Replicate 3	<0.01	<0.01	<0.000010	<0.000010	3.38	3.57	<0.00010	0.00092	<0.001	<0.00010	<0.00010	0.00034	0.00054	<0.01	0.027
CP-P3-11	CP-P3-11Bot	2013-08-06	Bottom		<0.01	<0.01	<0.000010	<0.000010	3.37	3.45	<0.00010	0.00951	<0.001	<0.00010	<0.00010	0.00039	0.00052	<0.01	0.059
CP-P3-11	CR-P3-11S	2013-09-04	Surface		<0.01	<0.01	<0.000010	<0.000010	3.5	3.65	<0.00010	0.00041	<0.001	<0.00010	<0.00010	0.0004	0.0005	<0.01	0.027
CP-P3-11	CR-P3-11Bot	2013-09-04	Bottom		<0.01	<0.01	<0.000010	0.000021	3.43	3.58	0.00015	0.00037	<0.001	<0.00010	<0.00010	0.00037	<0.00020	<0.01	0.03
CL-P2-13	CL-P2-13S	2013-08-07	Surface		<0.01	<0.01	<0.000010	<0.000010	3.73	3.68	<0.00010	0.00277	<0.001	<0.00010	<0.00010	0.00045	0.00292	<0.01	0.111
CL-P2-13	CL-P2-13BOT	2013-08-07	Bottom		<0.01	<0.01	<0.000010	<0.000010	3.79	3.65	<0.00010	0.00019	<0.001	<0.00010	<0.00010	0.00053	0.00053	<0.01	0.028
CL-P2-13	CL-P2-13S	2013-09-04	Surface	Replicate 1	<0.01	<0.01	<0.000010	<0.000010	3.81	3.88	0.0001	0.00037	<0.001	<0.00010	<0.00010	0.00054	0.00063	<0.01	0.038
CL-P2-13	CL-P2-13SA	2013-09-04	Surface	Replicate 2	<0.01	<0.01	<0.000010	<0.000010	3.96	3.94	<0.00010	0.0009	<0.001	<0.00010	<0.00010	0.00026	0.00071	<0.01	0.055
CL-P2-13	CL-P2-13SB	2013-09-04	Surface	Replicate 3	<0.01	<0.01	<0.000010	<0.000010	3.99	3.95	<0.00010	0.00093	<0.001	<0.00010	<0.00010	0.00031	0.00066	<0.01	0.052
CL-P2-13	CL-P2-13Bot	2013-09-04	Bottom		<0.01	<0.01	<0.000010	<0.000010	3.87	3.77	<0.00010	0.00137	<0.001	<0.00010	0.00021	0.00046	0.00133	<0.01	0.522
	CL-P2-13F	2013-08-07		Field Blank	<0.01	<0.01	<0.000010	<0.000010	0.115	0.126	<0.00010	<0.00002	<0.001	<0.00010	<0.00010	<0.00020	<0.00020	<0.01	<0.003
	Trip Blank	2013-09-04		Trip Blank	<0.01	<0.01	<0.000010	<0.000010	<0.050	<0.050	<0.00010	<0.00002	<0.001	<0.00010	<0.00010	<0.00020	<0.00020	<0.01	<0.003
	Field Blank	2013-09-04		Field Blank	<0.01	<0.01	<0.000010	<0.000010	<0.050	<0.050	<0.00010	<0.00002	<0.001	<0.00010	<0.00010	<0.00020	<0.00020	<0.01	<0.003

Table A1-5. - continued -

Waterbody	Site ID	Sampling Date	Surface/ Bottom	Notes	Lead (Dissolved)	Lead (Total)	Lithium (Dissolved)	Lithium (Total)	Magnesium (Dissolved)	Magnesium (Total)	Manganese (Dissolved)	Manganese (Total)	Mercury (Dissolved)	Mercury (Total)	Molybdenum (Dissolved)	Molybdenum (Total)	Nickel (Dissolved)	Nickel (Total)	Potassium (Dissolved)	Potassium (Total)
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CP-P3-11	CP-P3-11SA	2013-08-06	Surface	Replicate 1	<0.00005	<0.00005	<0.00005	<0.00005	1.80	1.83	0.00168	0.00534	<0.000010	<0.000010	<0.000050	<0.000050	<0.00050	<0.00050	0.342	0.351
CP-P3-11	CP-P3-11SB	2013-08-06	Surface	Replicate 2	<0.00005	<0.00005	<0.00005	<0.00005	1.80	1.86	0.00154	0.00556	<0.000010	<0.000010	<0.000050	0.000072	<0.00050	0.00173	0.341	0.348
CP-P3-11	CP-P3-11SC	2013-08-06	Surface	Replicate 3	<0.00005	0.00019	<0.00005	<0.00005	1.81	1.90	0.00171	0.00532	<0.000010	<0.000010	<0.000050	0.000063	<0.00050	0.00106	0.341	0.342
CP-P3-11	CP-P3-11Bot	2013-08-06	Bottom		<0.00005	0.00006	<0.00005	<0.00005	1.80	1.83	0.00170	0.00647	<0.000010	<0.000010	0.000075	0.000216	0.00167	0.00524	0.347	0.336
CP-P3-11	CR-P3-11S	2013-09-04	Surface		<0.00005	<0.00005	<0.00005	<0.00005	1.82	1.91	0.000671	0.00263	<0.000010	<0.000010	<0.000050	0.000056	<0.00050	<0.00050	0.357	0.362
CP-P3-11	CR-P3-11Bot	2013-09-04	Bottom		<0.00005	<0.00005	<0.00005	<0.00005	1.80	1.90	0.00144	0.00257	<0.000010	<0.000010	0.052	<0.000050	<0.00050	<0.00050	0.346	0.357
CL-P2-13	CL-P2-13S	2013-08-07	Surface		<0.00005	0.00013	<0.00005	<0.00005	2.24	2.19	0.00121	0.00256	<0.000010	<0.000010	0.000181	0.00076	0.00166	0.00134	0.286	0.290
CL-P2-13	CL-P2-13BOT	2013-08-07	Bottom		<0.00005	<0.00005	<0.00005	<0.00005	2.26	2.17	0.000627	0.00192	<0.000010	<0.000010	0.000087	0.000052	0.00061	<0.00050	0.286	0.285
CL-P2-13	CL-P2-13S	2013-09-04	Surface	Replicate 1	<0.00005	0.00005	<0.00005	<0.00005	2.24	2.28	0.000505	0.00187	<0.000010	<0.000010	0.000075	0.000077	0.00051	<0.00050	0.289	0.322
CL-P2-13	CL-P2-13SA	2013-09-04	Surface	Replicate 2	<0.00005	0.00006	<0.00005	<0.00005	2.23	2.29	0.000447	0.00217	<0.000010	<0.000010	<0.000050	0.000073	<0.00050	0.00078	0.287	0.334
CL-P2-13	CL-P2-13SB	2013-09-04	Surface	Replicate 3	<0.00005	0.00006	<0.00005	<0.00005	2.24	2.28	0.000439	0.00217	<0.000010	<0.000010	<0.000050	0.000064	0.00053	0.00067	0.296	0.333
CL-P2-13	CL-P2-13Bot	2013-09-04	Bottom		<0.00005	0.00033	<0.00005	0.00061	2.25	2.35	0.000444	0.0109	<0.000010	<0.000010	0.000053	0.000056	<0.00050	0.00105	0.299	0.449
	CL-P2-13F	2013-08-07		Field Blank	<0.00005	<0.00005	<0.00005	<0.00005	<0.10	<0.10	<0.000050	0.000092	<0.000010	<0.000010	<0.000050	<0.000050	<0.00050	<0.00050	<0.050	<0.050
	Trip Blank	2013-09-04		Trip Blank	<0.00005	<0.00005	<0.00005	<0.00005	<0.10	<0.10	<0.000050	<0.000050	<0.000010	<0.000010	<0.000050	<0.000050	<0.00050	<0.00050	<0.050	<0.050
	Field Blank	2013-09-04		Field Blank	<0.00005	<0.00005	<0.00005	<0.00005	<0.10	<0.10	<0.000050	<0.000050	<0.000010	<0.000010	<0.000050	<0.000050	<0.00050	<0.00050	<0.050	<0.050

Table A1-5. - continued -

Waterbody	Site ID	Sampling Date	Surface/ Bottom	Notes	Selenium (Dissolved)	Selenium (Total)	Silicon (Dissolved)	Silicon (Total)	Silver (Dissolved)	Silver (Total)	Sodium (Dissolved)	Sodium (Total)	Strontium (Dissolved)	Strontium (Total)	Thallium (Dissolved)	Thallium (Total)	Tin (Dissolved)	Tin (Total)	Titanium (Dissolved)	Titanium (Total)
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CP-P3-11	CP-P3-11SA	2013-08-06	Surface	Replicate 1	<0.0001	<0.00001	0.25	0.26	<0.0000010	<0.0000010	1.06	1.08	0.00462	0.00481	<0.000010	<0.000001	0.00031	0.00019	<0.01	<0.01
CP-P3-11	CP-P3-11SB	2013-08-06	Surface	Replicate 2	<0.0001	<0.00001	0.25	0.26	<0.0000010	<0.0000010	1.07	1.1	0.0046	0.00479	<0.000010	<0.000001	0.00023	0.00018	<0.01	<0.01
CP-P3-11	CP-P3-11SC	2013-08-06	Surface	Replicate 3	<0.0001	<0.00001	0.25	0.26	<0.0000010	<0.0000010	1.07	1.07	0.00461	0.00483	<0.000010	<0.000001	0.00039	0.0004	<0.01	<0.01
CP-P3-11	CP-P3-11Bot	2013-08-06	Bottom		<0.0001	<0.00001	0.26	0.26	<0.0000010	<0.0000010	1.12	1.12	0.00467	0.00479	<0.000010	<0.000001	0.00098	0.00098	<0.01	<0.01
CP-P3-11	CR-P3-11S	2013-09-04	Surface		<0.0001	<0.00001	0.21	0.27	<0.0000010	<0.0000010	1.15	1.09	0.00489	0.00502	<0.000010	<0.000001	0.00047	0.0003	<0.01	<0.01
CP-P3-11	CR-P3-11Bot	2013-09-04	Bottom		<0.0001	<0.00001	0.19	0.27	<0.0000010	<0.0000010	1.09	1.12	0.00475	0.00498	<0.000010	<0.000001	0.00038	0.0002	<0.01	<0.01
CL-P2-13	CL-P2-13S	2013-08-07	Surface		<0.0001	<0.00001	0.32	0.35	<0.0000010	0.000016	0.667	0.652	0.00353	0.00352	<0.000010	<0.000001	0.0014	0.00077	<0.01	<0.01
CL-P2-13	CL-P2-13BOT	2013-08-07	Bottom		<0.0001	<0.00001	0.32	0.35	<0.0000010	<0.0000010	0.656	0.636	0.00344	0.0035	<0.000010	<0.000001	0.00036	0.00021	<0.01	<0.01
CL-P2-13	CL-P2-13S	2013-09-04	Surface	Replicate 1	<0.0001	<0.00001	0.33	0.37	<0.0000010	<0.0000010	0.67	0.709	0.00357	0.00379	<0.000010	<0.000001	0.0005	0.00021	<0.01	<0.01
CL-P2-13	CL-P2-13SA	2013-09-04	Surface	Replicate 2	<0.0001	<0.00001	0.32	0.42	<0.0000010	<0.0000010	0.668	0.732	0.00351	0.00382	<0.000010	<0.000001	<0.00010	0.00019	<0.01	<0.01
CL-P2-13	CL-P2-13SB	2013-09-04	Surface	Replicate 3	<0.0001	<0.00001	0.32	0.37	<0.0000010	<0.0000010	0.679	0.791	0.00345	0.00391	<0.000010	<0.000001	<0.00010	0.00027	<0.01	<0.01
CL-P2-13	CL-P2-13Bot	2013-09-04	Bottom		<0.0001	<0.00001	0.34	1.02	<0.0000010	0.000019	0.728	0.68	0.00358	0.00381	<0.000010	<0.000001	0.00034	0.00015	<0.01	0.02
	CL-P2-13F	2013-08-07		Field Blank	<0.0001	<0.00001	<0.050	<0.050	<0.0000010	<0.0000010	<0.0012	<0.0012	<0.00040	<0.00040	<0.000010	<0.000001	<0.00010	<0.00010	<0.01	<0.01
	Trip Blank	2013-09-04		Trip Blank	<0.0001	<0.00001	<0.050	<0.050	<0.0000010	<0.0000010	<0.0012	<0.0012	<0.00040	<0.00040	<0.000010	<0.000001	<0.00010	<0.00010	<0.01	<0.01
	Field Blank	2013-09-04		Field Blank	<0.0001	<0.00001	<0.050	<0.050	<0.0000010	<0.0000010	<0.0012	<0.0012	<0.00040	<0.00040	<0.000010	<0.000001	<0.00010	<0.00010	<0.01	<0.01

Table A1-5. - continued -

Waterbody	Site ID	Sampling Date	Surface/ Bottom	Notes	Uranium (Dissolved)	Uranium (Total)	Vanadium (Dissolved)	Vanadium (Total)	Zinc (Dissolved)	Zinc (Total)
					mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
CP-P3-11	CP-P3-11SA	2013-08-06	Surface	Replicate 1	0.00006	0.00007	<0.001	<0.001	<0.00033	<0.003
CP-P3-11	CP-P3-11SB	2013-08-06	Surface	Replicate 2	0.000063	0.00007	<0.001	<0.001	<0.00033	<0.003
CP-P3-11	CP-P3-11SC	2013-08-06	Surface	Replicate 3	0.000062	0.00007	<0.001	<0.001	0.0014	0.0164
CP-P3-11	CP-P3-11Bot	2013-08-06	Bottom		0.000061	0.000071	<0.001	<0.001	0.0016	<0.003
CP-P3-11	CR-P3-11S	2013-09-04	Surface		0.000065	0.000077	<0.001	<0.001	0.0021	0.0188
CP-P3-11	CR-P3-11Bot	2013-09-04	Bottom		0.000066	0.000078	<0.001	<0.001	0.0013	<0.003
CL-P2-13	CL-P2-13S	2013-08-07	Surface		0.000113	0.000127	<0.001	<0.001	0.0018	0.004
CL-P2-13	CL-P2-13BOT	2013-08-07	Bottom		0.000121	0.000136	<0.001	<0.001	0.0014	<0.003
CL-P2-13	CL-P2-13S	2013-09-04	Surface	Replicate 1	0.000126	0.000141	<0.001	<0.001	0.0011	<0.003
CL-P2-13	CL-P2-13SA	2013-09-04	Surface	Replicate 2	0.000121	0.000142	<0.001	<0.001	0.0051	0.004
CL-P2-13	CL-P2-13SB	2013-09-04	Surface	Replicate 3	0.000124	0.000149	<0.001	<0.001	0.0037	0.0049
CL-P2-13	CL-P2-13Bot	2013-09-04	Bottom		0.000133	0.000242	<0.001	<0.001	<0.00033	<0.003
	CL-P2-13F	2013-08-07		Field Blank	<0.000010	<0.000010	<0.001	<0.001	0.0012	<0.003
	Trip Blank	2013-09-04		Trip Blank	<0.000010	<0.000010	<0.001	<0.001	<0.00033	<0.003
	Field Blank	2013-09-04		Field Blank	<0.000010	<0.000010	<0.001	<0.001	<0.00033	<0.003

APPENDIX 2. SUMMARY OF LOWER TROPHIC LEVEL SAMPLING CONDUCTED IN CANDIDATE REFERENCE LAKES, 2013

Table A2-1. Summary of phytoplankton sampling completed in candidate reference lakes, 2013.

Waterbody	Sample ID	Site UTM (17W)		Sample Date	Sample Time	Site Depth (m)	Secchi Depth (m)	Euphotic Zone Depth (m)	Sampled Depth Range (m)
		Easting	Northing						
CR-P3-09	PHYTO-01U	559980	7855131	05-Aug-13	15:10	28.4	9.25	27.75	0-10
CR-P3-09	PHYTO-01L	559980	7855131	05-Aug-13	15:10	28.4	9.25	27.75	10-27
CR-P3-11	PHYTO-02	569055	7900254	06-Aug-13	17:00	10.5	6.50	19.50	0-9
CL-P2-13	PHYTO-03	550137	7938617	07-Aug-13	14:00	12.9	4.35	13.05	0-11

Table A2-2. Summary of zooplankton sampling completed in candidate reference lakes, 2013.

Waterbody	Sample ID	Site UTM (17W)		Sample Date	Sample Time	Site Depth (m)	Secchi Depth (m)	Sampled Depth Range (m)	No. of Tows
		Easting	Northing						
CR-P3-09	ZOO-01	559980	7855131	05-Aug-13	15:10	28.4	9.25	0-27	1
CR-P3-11	ZOO-02	569055	7900254	06-Aug-13	17:00	10.5	6.50	0-9	1
CL-P2-13	ZOO-03	550137	7938617	07-Aug-13	14:00	12.9	4.35	0-11	1
CR-P3-11	ZOO-02	569055	7900254	04-Sep-13	12:05	10.6	5.75	0-9	1
CL-P2-13	ZOO-03	550137	7938617	04-Sep-13	15:40	12.5	4.25	0-11	1

Table A2-3. Summary of benthic macroinvertebrate sampling completed in candidate reference lakes, 2013.

Waterbody	Sample ID	Site UTM (17W)		Sample Date	Sample Time	Secchi Depth (m)	No. of Replicate Grabs	Depth Range of Grabs (m)	Macrophyte Abundance	Dominant Substrate(s)
		Easting	Northing							
CR-P3-11	BMI-01	569055	7900254	04-Sep-13	12:57	18:00	5	8.2 - 9.7	Absent	Sand/Silt
CL-P2-13	BMI-02	550137	7938617	04-Sep-13	18:10	6:00	5	12.1 - 13.8	Absent	Silt/Sand

APPENDIX 3. PHYTOPLANKTON COMMUNITY COMPOSITION IN CANDIDATE REFERENCE LAKES, 2013.

Table A3-1. Phytoplankton biomass and composition measured in reference lakes in 2013. Means and relative percent mean difference (RPMD) have been calculated for duplicate samples.

Waterbody	Sample ID	Sample Date	Sample Type	Major Group	Diatoms						
				Class	Bacillariophyceae					Coscinodiscophyceae	
				Genus	*Eunotia*	*Navicula*	*Nitzschia*	*Rhoicosphenia*	*Surirella*	*Cyclotella*	*Rhizosolenia*
				Species	*sp.*	*sp.*	*sp.*	*sp.*	*sp.*	*sp.*	*sp.*
CR-P3-11	CR-P3-11 A	6-Aug-13	Duplicate		1.35	10.00	0.77	-	-	4.50	-
	CR-P3-11 B	6-Aug-13	Duplicate		13.50	4.80	0.77	-	-	6.66	-
	CR-P3-11	6-Aug-13	Mean		7.43	7.40	0.77	-	-	5.58	-
			RPMD		164	70	0	-	-	39	-
	CR-P3-11	4-Sep-13	Normal		-	-	7.17	0.45	-	4.50	-
CL-P2-13	CL-P2-13	7-Aug-13	Normal		3.60	-	1.60	-	-	49.60	1.55
	CL-P2-13 REP 1	4-Sep-13	Duplicate		-	-	0.77	-	6.40	54.40	0.71
	CL-P2-13 REP 2	4-Sep-13	Duplicate		5.00	4.80	0.77	-	-	24.80	1.67
	CL-P2-13	4-Sep-13	Mean		2.50	2.40	0.77	-	3.20	39.60	1.19
			RPMD		200	200	0	-	200	75	81

Table A3-1. - continued -

Waterbody	Sample ID	Sample Date	Sample Type	Diatoms				Chlorophyta			
				Fragilariophyceae				Chlorophyceae			
				Asterionella	*Diatoma*	*Synedra*	*Tabellaria*	*Botryococcus*	*Dictyosphaerium*	*Elakatothrix*	*Tetraedron*
				formosa	*sp.*	*sp.*	*sp.*	*sp.*	*sp.*	*sp.*	*minimum*
CR-P3-11	CR-P3-11 A	6-Aug-13	Duplicate	4.70	0.96	15.07	8.80	-	-	6.25	0.20
	CR-P3-11 B	6-Aug-13	Duplicate	3.46	2.00	17.09	-	-	-	3.35	0.20
	CR-P3-11	6-Aug-13	Mean	4.08	1.48	16.08	4.40	-	-	4.80	0.20
			RPMD	30	70	13	200	-	-	60	0
	CR-P3-11	4-Sep-13	Normal	2.70	2.00	3.00	0.80	-	-	11.61	-
CL-P2-13	CL-P2-13	7-Aug-13	Normal	22.79	0.96	26.08	-	10.80	-	6.70	1.71
	CL-P2-13 REP 1	4-Sep-13	Duplicate	18.74	0.96	30.13	-	-	135.94	8.71	3.01
	CL-P2-13 REP 2	4-Sep-13	Duplicate	14.74	-	11.99	-	-	-	3.13	2.26
	CL-P2-13	4-Sep-13	Mean	16.74	0.48	21.06	-	-	67.97	5.92	2.64
			RPMD	24	200	86	-	-	200	94	29

Table A3-1. - continued -

Waterbody	Sample ID	Sample Date	Sample Type	Chlorophyta			Charophyta			Chrysophytes		
				Trebouxiophyceae			Conjugophyceae			Chrysophyceae		
				Lagerheimia sp.	***Monoraphidium sp.***	***Oocystis sp.***	***Cosmarium sp.***	***Staurastrum sp.***	***Staurodesmus sp.***	***Bitrichia sp.***	***Dinobryon bavaricum***	***Dinobryon sp.***
CR-P3-11	CR-P3-11 A	6-Aug-13	Duplicate	-	-	-	-	1.35	10.00	0.15	9.40	26.78
	CR-P3-11 B	6-Aug-13	Duplicate	-	-	-	14.40	-	2.40	0.47	20.09	22.79
	CR-P3-11	6-Aug-13	Mean	-	-	-	7.20	0.68	6.20	0.31	14.74	24.79
			RPMD	-	-	-	200	200	123	102	73	16
	CR-P3-11	4-Sep-13	Normal	-	-	5.00	-	-	10.00	0.15	4.00	12.74
CL-P2-13	CL-P2-13	7-Aug-13	Normal	0.32	9.53	2.40	18.00	-	-	0.32	0.65	16.74
	CL-P2-13 REP 1	4-Sep-13	Duplicate	0.64	1.63	-	26.65	-	-	0.15	-	1.35
	CL-P2-13 REP 2	4-Sep-13	Duplicate	0.15	8.18	-	8.05	-	-	0.15	-	14.74
	CL-P2-13	4-Sep-13	Mean	0.40	4.91	-	17.35	-	-	0.15	-	8.05
			RPMD	123	133	-	107	-	-	0	-	166

Table A3-1. - continued -

Waterbody	Sample ID	Sample Date	Sample Type	Chrysophytes	Cryptophytes		Blue-Green Algae				
				Chrysophyceae	Cryptophyceae		Cyanophyceae				
				small chrysophytes	*Cryptomonas* sp.	*Unidentified*	*Anabaena* sp.	*Aphanocapsa* sp.	*Aphanothece* sp.	*Oscillatoria* sp.	*Planktolyngbya* sp.
CR-P3-11	CR-P3-11 A	6-Aug-13	Duplicate	32.22	44.40	5.68	-	-	-	-	1.20
	CR-P3-11 B	6-Aug-13	Duplicate	42.85	14.40	3.84	-	-	-	-	1.20
	CR-P3-11	6-Aug-13	Mean	37.54	29.40	4.76	-	-	-	-	1.20
			RPMD	28	102	39	-	-	-	-	0
	CR-P3-11	4-Sep-13	Normal	21.90	14.40	5.68	0.86	18.23	29.60	0.58	0.19
CL-P2-13	CL-P2-13	7-Aug-13	Normal	16.83	44.40	2.84	-	-	-	-	-
	CL-P2-13 REP 1	4-Sep-13	Duplicate	16.03	7.20	7.60	-	-	-	-	-
	CL-P2-13 REP 2	4-Sep-13	Duplicate	17.22	14.40	16.20	-	-	-	-	0.58
	CL-P2-13	4-Sep-13	Mean	16.63	10.80	11.90	-	-	-	-	0.29
			RPMD	7	67	72	-	-	-	-	200

Table A3-1. - continued -

Waterbody	Sample ID	Sample Date	Sample Type	Blue-Green Algae	Euglenoids	Dinoflagellates		Total Biomass
				Cyanophyceae	Euglenophyceae	Dinophyceae		
				Pseudanabaena	*Euglena*	*Gymnodinium*	*Peridinium*	
				sp.	*sp.*	*sp.*	*sp.*	(mg/m^3)
CR-P3-11	CR-P3-11 A	6-Aug-13	Duplicate	0.10	1.20	72.90	-	258.0
	CR-P3-11 B	6-Aug-13	Duplicate	-	-	178.20	172.80	525.3
	CR-P3-11	6-Aug-13	Mean	0.05	0.60	125.55	86.40	391.6
			RPMD	200	200	84	200	68
	CR-P3-11	4-Sep-13	Normal	-	2.70	97.20	-	255.5
CL-P2-13	CL-P2-13	7-Aug-13	Normal	-	-	434.70	-	672.1
	CL-P2-13 REP 1	4-Sep-13	Duplicate	-	-	32.40	-	353.4
	CL-P2-13 REP 2	4-Sep-13	Duplicate	-	-	234.90	-	383.7
	CL-P2-13	4-Sep-13	Mean	-	-	133.65	-	365.4
			RPMD	-	-	152	-	8

APPENDIX 4. ZOOPLANKTON ABUNDANCE AND COMMUNITY COMPOSITION IN CANDIDATE REFERENCE LAKES, 2013.

Table A4-1. Crustacean zooplankton (individuals/m^3) collected in vertical net tows from reference lakes during 2013. Individual abundances may not add up to totals due to rounding.

Waterbody	**Lake CR-P3-11**										
Site ID	**Stn CR P3-11**										
Sampling Date	**6-Aug-13**							**4-Sep-13**		**Overall**	
Replicate	**A**	**B**	**C**	**Mean**	**SD** [1]	**%** [2]	**PRSD** [3]		**%**	**Mean**	**%**
water volume filtered (m^3)	0.09	0.09	0.09	-	-	-	-	0.09	-		
Cladocera (water fleas)											
Alona guttata	0	0	0	0	0	0	-	0	0	0	0
Bosmina longirostris	197	219	219	212	13	3	6	395	5	258	3
Chydorus sphaericus	0	0	0	0	0	0	-	0	0	0	0
Daphnia longiremis	132	307	176	205	91	3	45	812	10	357	4
Holopedium gibberum	44	22	0	22	22	0	*100*	0	0	16	0
Total Cladocera	**373**	**549**	**395**	**439**	**96**	**6**	**22**	**1207**	**15**	**631**	**8**
Copepoda (copepods)											
Calanoida											
Diaptomus minutus	1404	1163	1646	1404	241	18	17	2743	35	1739	22
Limnocalanus macrurus	0	0	0	0	0	0	-	0	0	0	0
Calanoida copepodite	658	1426	1316	1134	415	14	37	505	6	976	12
Total Calanoida	**2062**	**2589**	**2962**	**2538**	**452**	**32**	**18**	**3247**	**41**	**2715**	**34**
Cyclopoida											
Cyclops scutifer	2567	2194	2084	2282	253	29	11	1997	25	2210	28
Cyclopoida nauplii	2150	2721	3181	2684	517	34	19	1470	19	2381	30
Total Cyclopoida	**4717**	**4915**	**5266**	**4966**	**278**	**63**	**6**	**3467**	**44**	**4591**	**58**
Harpacticoida	0	0	0	0	0	0	-	0	0	0	0
Total Copepoda	**6780**	**7504**	**8228**	**7504**	**724**	**94**	**10**	**6714**	**85**	**7306**	**92**
OVERALL TOTAL	**7153**	**8052**	**8623**	**7942**	**741**	**100**	**9**	**7920**	**100**	**7937**	**100**
Taxonomic Richness [4]	**5**	**5**	**4**	**5**	**-**	**-**	**-**	**4**	**-**	**5**	**-**

Table A4-1. - continued -

Waterbody	Lake CL-P2-13										
Site ID	**Stn CL P2-13**										
Sampling Date	**7-Aug-13**		**4-Sep-13**							**Overall**	
Replicate		**%**	**A**	**B**	**C**	**Mean**	**SD**	**%**	**PRSD**	**Mean**	**%**
water volume filtered (m^3)	0.13		0.13	0.13	0.13	-	-		-		
Cladocera (water fleas)											
Alona guttata	0	0	0	0	0	0	0	0	-	0	0
Bosmina longirostris	214	18	260	130	84	158	91	10	*58*	172	11
Chydorus sphaericus	0	0	0	0	0	0	0	0	-	0	0
Daphnia longiremis	46	4	199	76	138	138	61	9	44	115	8
Holopedium gibberum	8	1	0	0	23	8	13	0	*173*	8	1
Total Cladocera	**268**	**23**	**459**	**207**	**245**	**303**	**136**	**19**	**45**	**294**	**20**
Copepoda (copepods)											
Calanoida											
Diaptomus minutus	23	2	444	38	8	163	243	10	*149*	128	9
Limnocalanus macrurus	0	0	0	0	0	0	0	0	-	0	0
Calanoida copepodite	0	0	31	54	15	33	19	2	*58*	25	2
Total Calanoida	**23**	**2**	**474**	**92**	**23**	**196**	**243**	**12**	***124***	**153**	**10**
Cyclopoida											
Cyclops scutifer	849	73	765	765	773	767	4	47	1	788	52
Cyclopoida nauplii	23	2	398	344	314	352	43	22	12	270	18
Total Cyclopoida	**872**	**75**	**1163**	**1109**	**1086**	**1119**	**39**	**69**	**4**	**1057**	**70**
Harpacticoida	0	0	0	0	0	0	0	0	-	0	0
Total Copepoda	**895**	**77**	**1637**	**1201**	**1109**	**1316**	**282**	**81**	**21**	**1210**	**80**
OVERALL TOTAL	**1163**	**100**	**2096**	**1407**	**1354**	**1619**	**414**	**100**	**26**	**1505**	**100**
Taxonomic Richness [4]	**5**	**-**	**4**	**4**	**5**	**5**	**-**	**-**	**-**	**5**	**-**

[1] Standard deviation
[2] Percent abundance of the overall total
[3] Percent relative standard deviation; evaluation of precision for triplicate samples
[4]Total number of taxa observed to species-level, not the average number of taxa

APPENDIX 5. BENTHIC MACROINVERTEBRATE ABUNDANCE AND COMMUNITY COMPOSITION IN CANDIDATE REFERENCE LAKES, 2013.

Table A5-1. Benthic macroinvertebrates (no. of individuals/m^2) collected in petite Ponar grab (area 0.023 m^2) samples from reference lake candidate CR-P3-11 during 2013. Individual abundances may not add up to totals due to rounding.

Waterbody				**CR-P3-11**				
Habitat Type				**Offshore Profundal (14)**				
Subsample no.				**1**	**2**	**3**	**4**	**5**
Sample ID				**CR-P3-11-1**	**CR-P3-11-2**	**CR-P3-11-3**	**CR-P3-11-4**	**CR-P3-11-5**
Number of invertebrates per m^2								
ROUNDWORMS				0	0	0	0	0
P. Nemata				0	0	0	0	43
ANNELIDS				0	0	0	0	0
P. Annelida				0	0	0	0	0
	WORMS			0	0	0	0	0
	Cl. Oligochaeta			0	0	0	0	0
		F. Naididae		0	0	0	0	0
	S.F. Tubificinae			0	0	0	0	0
			Aulodrilus limnobius	0	0	0	0	0
		F. Lumbriculidae		0	0	0	0	0
			Lumbriculus	0	0	0	0	0
ARTHROPODS				0	0	0	0	0
P. Arthropoda				0	0	0	0	0
	MITES			0	0	0	0	0
	Cl. Arachnida			0	0	0	0	0
	Subcl. Acari			43	87	43	87	43
	HARPACTICOIDS			0	0	0	0	0
	O. Harpacticoida			0	0	0	0	0
	SEED SHRIMPS			0	0	0	0	0
	Cl. Ostracoda			0	43	0	43	0
INSECTS				0	0	0	0	0
	Cl. Insecta			0	0	0	0	0
	CADDISFLIES			0	0	0	0	0
	O. Trichoptera			0	0	0	0	0
		F. Apataniidae		0	0	0	0	0
			Apatania	0	0	0	0	0
TRUE FLIES				0	0	0	0	0
	O. Diptera			0	0	0	0	0
	MIDGES			0	0	0	0	0
		F. Chironomidae		0	0	0	0	0
			chironomid pupae	0	0	0	0	0
	S.F. Chironominae			0	0	0	0	0
			Chironomus	0	0	2640	1169	1169
			Corynocera	0	0	173	0	0
			Micropsectra	87	303	0	0	0
			Paratanytarsus	0	0	0	0	0
			Sergentia	0	0	0	0	0
			Stictochironomus	173	649	0	43	0
			Tanytarsus	390	519	1342	3246	2554
	S.F. Diamesinae			0	0	0	0	0
			Protanypus	0	0	43	0	0
			Pseudodiamesa	0	0	0	0	0

Table A5-1. - continued -

Waterbody				CR-P3-11				
Habitat Type				**Offshore Profundal (14)**				
Subsample no.				**1**	**2**	**3**	**4**	**5**
Sample ID				**CR-P3-11-1**	**CR-P3-11-2**	**CR-P3-11-3**	**CR-P3-11-4**	**CR-P3-11-5**
Number of invertebrates per m²								
	S.F. Orthocladiinae			0	0	0	0	0
			Abiskomyia	87	87	346	260	216
			Corynoneura	0	0	0	0	0
			Cricotopus/Orthocladius	0	0	0	0	0
			Genus "Greenland"	0	0	0	0	0
			Heterotrissocladius	693	173	173	216	260
			Mesocricotopus	0	0	0	0	0
			Paracladius	0	0	0	0	43
			Parakiefferiella	43	43	0	0	0
			Psectrocladius	87	260	0	0	0
			Pseudosmittia	0	0	43	0	0
			Zalutschia	0	43	43	43	0
			indeterminate	0	0	0	0	0
	S.F. Tanypodinae			0	0	0	0	0
			Procladius	390	822	0	0	0
			Thienemannimyia complex	0	0	0	0	0
Total Density (no. per m²)				1991	3030	4848	5107	4328
Proportion of Chironomidae (% of total density)				98	96	99	97	98
Shannon's Evenness Index				0.82	0.82	0.58	0.53	0.58
Simpson's Diversity Index				0.79	0.83	0.62	0.54	0.57
Taxonomic Richness (genus-level) [1]				9	11	9	8	7
Hill's Effective Richness				6.01	7.21	3.60	3.01	3.07

[1] Total number of taxa observed to genus-level

Table A5-2. Benthic macroinvertebrates (no. of individuals/m^2) collected in petite Ponar grab (area 0.023 m^2) samples from reference lake candidate CL-P2-13 during 2013. Individual abundances may not add up to totals due to rounding.

Waterbody				**CL-P2-13**				
Habitat Type				**Offshore Profundal (14)**				
Subsample no.				**1**	**2**	**3**	**4**	**5**
Sample ID				**CL-P2-13-1**	**CL-P2-13-2**	**CL-P2-13-3**	**CL-P2-13-4**	**CL-P2-13-5**
Number of invertebrates per m^2								
ROUNDWORMS				0	0	0	0	0
P. Nemata				0	0	0	0	0
ANNELIDS				0	0	0	0	0
P. Annelida				0	0	0	0	0
	WORMS			0	0	0	0	0
	Cl. Oligochaeta			0	0	0	0	0
		F. Naididae		0	0	0	0	0
	S.F. Tubificinae			0	0	0	0	0
			Aulodrilus limnobius	0	0	0	0	0
		F. Lumbriculidae		0	0	0	0	0
			Lumbriculus	0	0	0	0	0
ARTHROPODS				0	0	0	0	0
P. Arthropoda				0	0	0	0	0
	MITES			0	0	0	0	0
	Cl. Arachnida			0	0	0	0	0
	Subcl. Acari			0	0	0	0	0
	HARPACTICOIDS			0	0	0	0	0
	O. Harpacticoida			0	0	0	0	0
	SEED SHRIMPS			0	0	0	0	0
	Cl. Ostracoda			0	0	0	0	0
INSECTS				0	0	0	0	0
	Cl. Insecta			0	0	0	0	0
	CADDISFLIES			0	0	0	0	0
	O. Trichoptera			0	0	0	0	0
		F. Apataniidae		0	0	0	0	0
			Apatania	0	0	0	0	0
TRUE FLIES				0	0	0	0	0
	O. Diptera			0	0	0	0	0
	MIDGES			0	0	0	0	0
		F. Chironomidae		0	0	0	0	0
			chironomid pupae	0	0	0	0	0
	S.F. Chironominae			0	0	0	0	0
			Chironomus	43	43	3333	1212	0
			Corynocera	0	0	0	0	0
			Micropsectra	0	43	43	0	0
			Paratanytarsus	0	0	0	0	0
			Sergentia	0	0	0	0	0
			Stictochironomus	0	43	0	87	0
			Tanytarsus	0	0	0	0	0
	S.F. Diamesinae			0	0	0	0	0
			Protanypus	216	0	43	43	87
			Pseudodiamesa	0	0	0	0	0

Table A5-2. - continued -

Waterbody				CL-P2-13				
Habitat Type				Offshore Profundal (14)				
Subsample no.				1	2	3	4	5
Sample ID				CL-P2-13-1	CL-P2-13-2	CL-P2-13-3	CL-P2-13-4	CL-P2-13-5
Number of invertebrates per m²								
	S.F. Orthocladiinae			0	0	0	0	0
			Abiskomyia	87	130	0	130	0
			Corynoneura	0	0	0	0	0
			Cricotopus/Orthocladius	0	0	0	0	0
			Genus "Greenland"	0	0	0	0	0
			Heterotrissocladius	87	0	0	43	519
			Mesocricotopus	0	0	0	0	0
			Paracladius	476	260	0	87	606
			Parakiefferiella	0	43	0	216	0
			Psectrocladius	0	0	0	0	0
			Pseudosmittia	0	0	0	0	0
			Zalutschia	43	0	0	0	0
			indeterminate	0	0	0	0	0
	S.F. Tanypodinae			0	0	0	0	0
			Procladius	0	0	0	0	0
			Thienemannimyia complex	0	0	0	0	0
Total Density (no. per m²)				952	563	3419	1818	1212
Proportion of Chironomidae (% of total density)				100	100	100	100	100
Shannon's Evenness Index				0.78	0.83	0.12	0.61	0.82
Simpson's Diversity Index				0.68	0.71	0.05	0.53	0.56
Taxonomic Richness (genus-level) [1]				6	6	3	7	3
Hill's Effective Richness				4.06	4.41	1.15	3.25	2.46

[1] Total number of taxa observed to genus-level