Figure 2.5-6

Bathymetric Map of Windy Lake, 2006

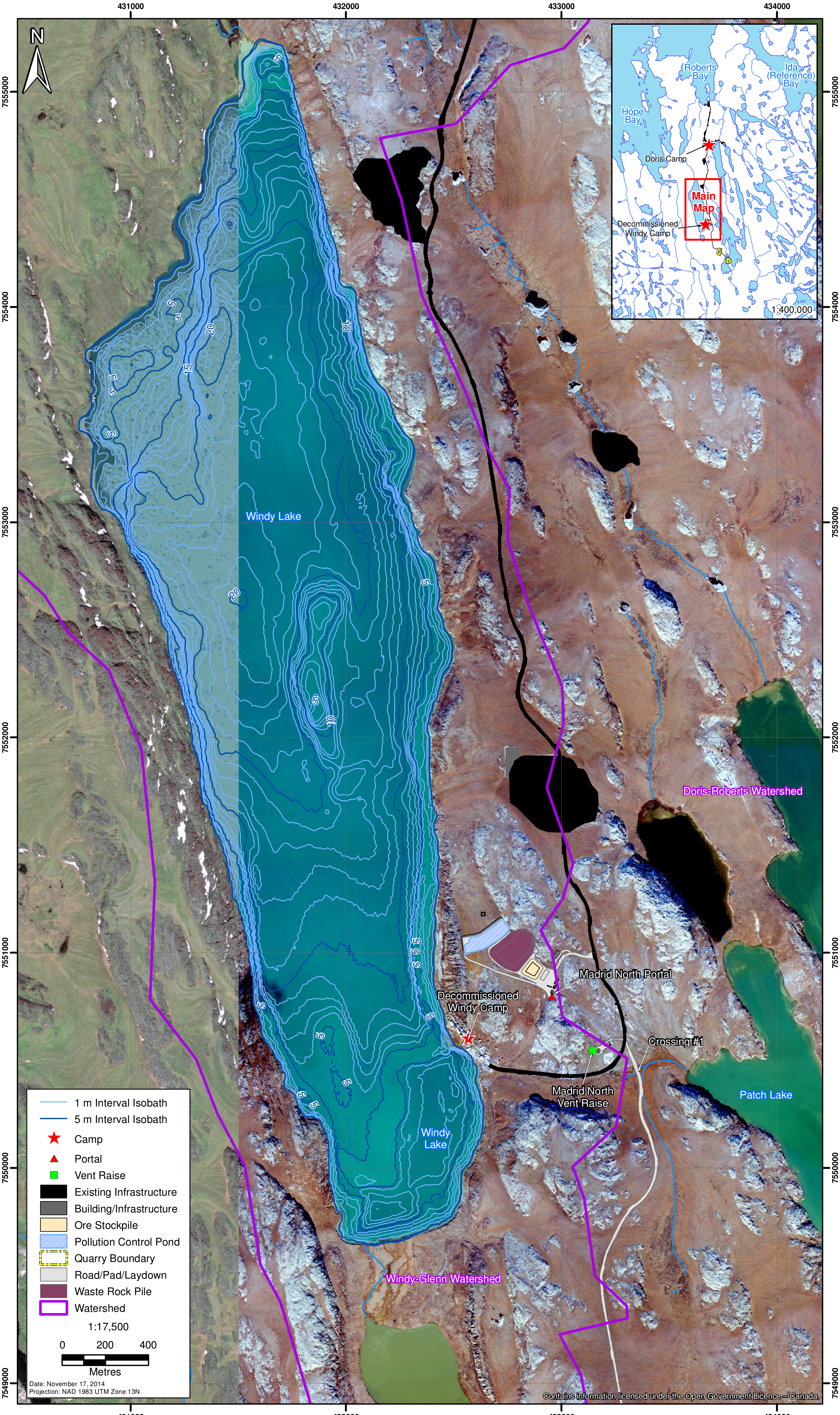
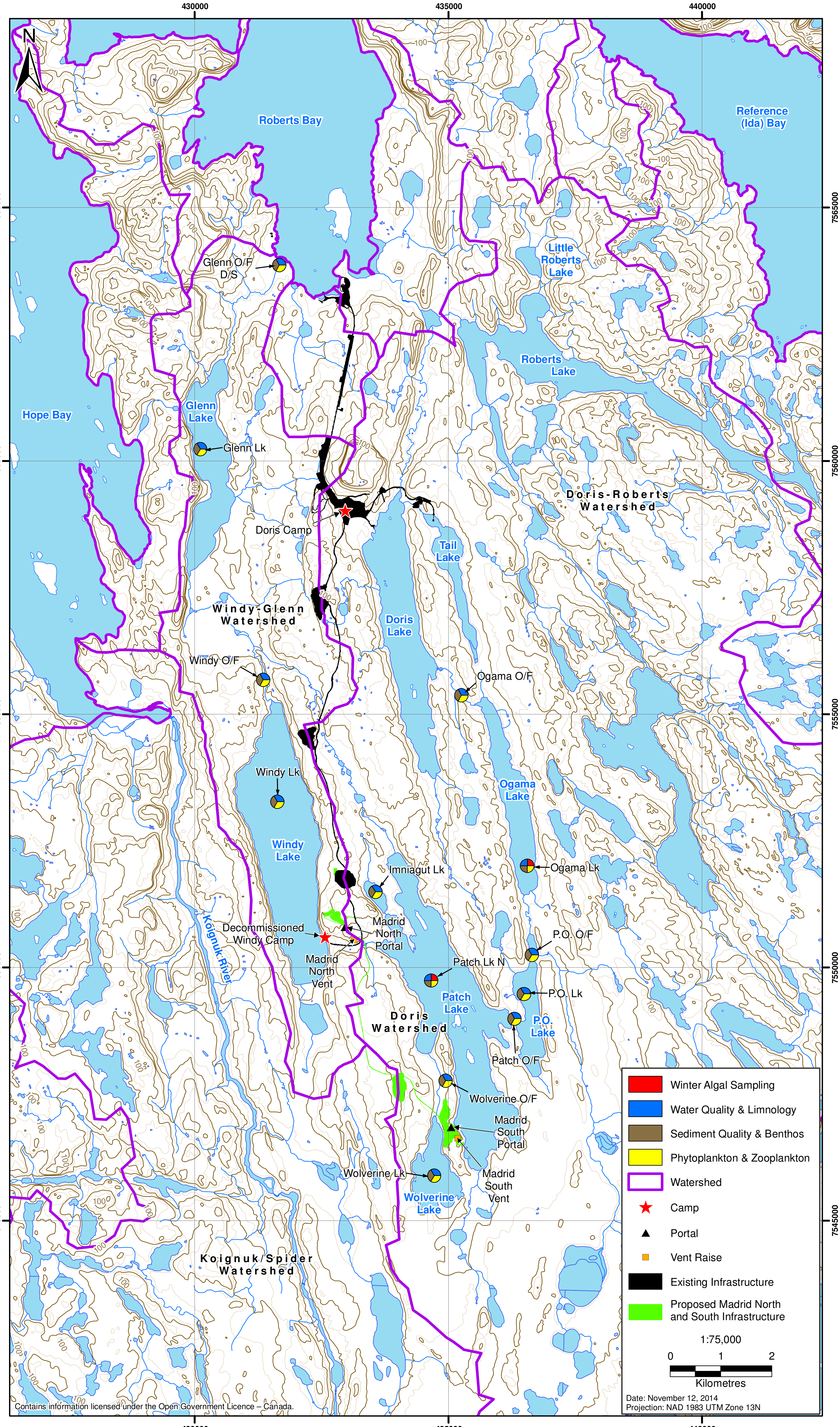


Figure 2.5-7

Physical Limnology, Water and Sediment Quality, and Aquatic Biology Sampling Locations, Madrid Advanced Exploration Program



The Canadian Council of Ministers of the Environment (CCME) has established guideline oxygen concentrations for the protection of (cold-water) aquatic life of 9.5 mg/L for early life stages and 6.5 mg/L for other life stages (CCME 1999). Most lakes had dissolved oxygen concentrations above these guidelines in the upper portions of the water column; however, bottom water concentrations were below guidelines in Wolverine, Ogama, and Windy lakes in the winter and in Patch Lake in the summer. Oxygen concentrations in Wolverine Lake were consistently lower than 6.5 mg/L throughout the water column during winter under-ice sampling.

Water clarity varied among lakes. Secchi depths (an index of water clarity) in Glenn, P.O., and Ogama lakes were relatively low (less than 1.3 m). Reduced water clarity was likely attributable to relatively high phytoplankton biomass or to the re-suspension of fine sediments along the shorelines of lakes resulting from wave action and high winds common to the area. Secchi depths in the clearest lakes, Windy, Wolverine, and Imniagut, ranged from 3 to 3.5 m. The calculated euphotic zone depth extended through the entire water column in all but the deepest lakes (Windy, Glenn, and Patch Lake South). This indicates that light levels were generally sufficient to support phytoplankton photosynthesis throughout the water column (Rescan 2010f, 2011g).

Table 2.5-5 summarizes data collected at sampling sites near the proposed Madrid Area sample locations.

2.5.3 Surface Water Quality

In 2009, surface water baseline studies were conducted to complement existing data. These studies focused on the northern portion of the Hope Bay belt as well as reference areas well away from future Project activities. Lakes and streams sampled near the Madrid Area included stations at Windy Lake, Wolverine Lake, Patch Lake, Imniagut Lake, and Wolverine Outflow. Lakes and streams downstream of the Madrid North and South areas were also sampled, including Glenn Lake, P.O. Lake, Ogama Lake, Windy Outflow, Glenn Outflow, Patch Outflow, P.O. Outflow, and Ogama Outflow (see Figure 2.5-7).

2.5.3.1 Lakes

Baseline historical surface water quality data are available for some Madrid Area lakes for periods from 1995 to 2000, and 2006 to 2010 (Table 1.1-1). Samples were collected during the ice-covered season and/or the open-water season. A comprehensive sampling program was conducted in 2009 (Rescan 2010f), and additional baseline samples were collected in 2010 (Rescan 2011g).

Lakes in the Madrid Area were neutral to slightly alkaline and contained variable concentrations of nutrients and metals. Several of these lakes were characterized as being relatively clear (e.g., Imniagut, Wolverine, and Windy lakes), while others were more turbid (e.g., Glenn Lake). Seasonal water quality trends were apparent in some lakes, with winter concentrations of certain parameters greatly exceeding summer concentrations. This trend was particularly evident for total dissolved solids (TDS), total organic carbon (TOC), sulphate, total phosphorus, ammonia, nitrate, and several metals (e.g., chromium, copper, iron, and lead; Rescan 2010f).

Concentrations of nutrients were typically low in lakes surrounding the Madrid Area, particularly during the summer when growth of phytoplankton draws down surface nutrients. Nitrate, nitrite, and ammonia concentrations were below applicable CCME water quality guidelines (Rescan 2010f). Total phosphorus concentrations were variable among lakes and across seasons, ranging from 0.003 to 0.018 mg/L. Based on the CCME recommended trigger ranges for total phosphorus, lakes in the Madrid area of the Belt can be categorized as ultra-oligotrophic to mesotrophic. The trophic status of some lakes was dependent on the season because phosphorus concentrations were highest during winter (Rescan 2010f).

Table 2.5-5. Lake Dissolved Oxygen Concentrations and Secchi Depths (2009) in the Vicinity of the Madrid South and North Sites

Watershed	Lake	Winter					Summer					Secchi Depth D_s (m)	Euphotic Zone Depth (m)
		Bottom Depth (m)	Dissolved Oxygen Concentration (mg/L)*		Dissolved Oxygen Saturation (%)*		Bottom Depth (m)	Dissolved Oxygen Concentration (mg/L)*		Dissolved Oxygen Saturation (%)*			
			Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.		
Windy-Glenn	Windy Lake	17.7	9.3	15.0	67.0	104	18.0	11.6	11.8	99.7	101	3.00	12.2
	Glenn Lake	11.5	14.7	16.9	101	117	19.7	10.9	11.5	94.6	96.9	1.00	4.1
Doris-Roberts	Wolverine Lake	4.3	1.3	6.2	8.6	43.4	3.7	10.8	11.1	105	106	3.00	12.2
	Patch Lake (North)	4.0	13.0	14.6	92.3	102	8.5	7.7	10.5	73.0	95.6	2.20	8.9
	Patch Lake (South)	14.5	10.2	16.3	73.4	114	14.0	10.5	10.7	92.9	95.4	2.00	8.1
	Imniagut Lake	2.5	Ice thickness extended to the bottom				4.0	9.71	10.7	96.2	99.6	3.50	14.2
	P.O. Lake	2.2	13.7	13.7	94.3	94.3	3.3	10.7	10.9	95.3	96.2	1.25	5.1
	Ogama Lake	7.3	0.1	9.5	1.0	66.4	5.0	10.8	11.4	95.8	102	1.20	4.9

** CCME guideline for dissolved oxygen is 9.5 mg/L for early life stages, 6.5 mg/L for other life stages.* ***Bold values*** *indicate concentrations that are below at least one CCME guideline level.*

Windy Lake (Table 2.5-6) would be categorized as ultra-oligotrophic to oligotrophic (depending on the season), Patch North and South (Table 2.5-7), P.O., and Imniagut lakes would be categorized as oligotrophic, and Glenn, Wolverine, and Ogama lakes would be categorized as mesotrophic (Rescan 2010f). Mean metal concentrations in Madrid Area lakes were generally below CCME guidelines, with the following exceptions:

- aluminum in P.O., Ogama, and Glenn lakes;
- chromium in Wolverine and Glenn lakes;
- copper in Ogama and Glenn lakes; and
- iron in Wolverine and Glenn lakes.

These elevated metal concentrations occur naturally within lakes in the area. Glenn Lake (in the Windy-Glenn Watershed) tended to contain the highest mean aluminum, copper, and iron concentrations. Nickel concentrations in Imniagut Lake were markedly higher than in other lakes, but remained below the CCME guideline for nickel (Rescan 2010f).

2.5.3.2 Streams

Baseline historical surface water quality data are available for some streams in the Madrid Area for the following periods: 1996, 1997, and 2006 to 2009. A comprehensive sampling program was conducted in 2009 (Rescan 2010f). Streams in the Madrid Area of the Belt were neutral to slightly basic, with pH ranging from 7.1 to 8.0 in 2009. Turbidity levels were variable across streams, and seasonal trends were apparent in some streams. The hydrological cycle varies dramatically during the open-water season, which can cause significant changes in stream water quality. Freshet (typically in June) is when the majority of water passes through streams due to melted snow and ice. This water has been in contact with soil, tundra, and rocks. In addition, the large volume of water passing through streams can cause mixing and erosion. Hence, freshet is usually when maximum concentrations of some nutrients and metals occur. This was generally true of the streams sampled in the Belt as parameters such as ammonia, total phosphorus, chromium, and nickel tended to be highest during freshet and lowest during the summer (Rescan 2010f).

Nitrate, nitrite, and ammonia concentrations were usually below detection limits in stream samples, and were always below CCME guidelines for the protection of freshwater aquatic life. Total phosphorus levels were variable across streams in 2009, ranging from 0.002 mg/L (Wolverine Outflow in June) to 0.053 mg/L (Glenn Outflow Downstream in June). Within the watersheds in the Madrid Area, total phosphorus concentrations generally increased with distance downstream. In the Doris Watershed, the lowest levels of total phosphorus were observed in Wolverine and Patch outflows, which would be categorized as ultra-oligotrophic and oligotrophic, respectively, based on the CCME trigger ranges for total phosphorus. A similar trend was apparent in the Windy Watershed, where the upstream Windy Outflow would be categorized as ultra-oligotrophic to oligotrophic, while the downstream Glenn Outflow Downstream would be considered mesotrophic to eutrophic. The trophic status of streams was dependent on the season because phosphorus concentrations were highest during freshet (Rescan 2010f).

In general, concentrations of total metals were highest in Glenn Outflow Downstream and lowest in Windy Outflow. Molybdenum levels tended to be highest within the streams of the Windy Watershed compared to the other watersheds. These trends are consistent with the lake water quality data, indicating that the water quality of streams reflects the water quality of the upstream lakes that feed them.

Table 2.5-6. Mean Seasonal Concentrations of Water Quality Variables in Windy Lake

Variable	Units	CCME[a]	Winter[b]		Spring		Summer		Fall	
			Average	SD	Average	SD	Average	SD	Average	SD
Conductivity	μS/cm		482.3	41.5	417.0	163.0	407.4	70.1	448.1	47.5
Hardness (as $CaCO_3$)	mg/L		73.2	13.4	79.7	2.5	67.1	5.2	66.3	6.3
pH	pH	*6.5-9.0*	7.8	0.2	7.1	0.5	7.6	0.5	8.0	0.1
Total Suspended Solids	mg/L		1.38	0.44	0.50	0	1.22	0.86	3.18	5.43
Alkalinity, Total (as $CaCO_3$)	mg/L		60.0	5.8	49.4	19.7	45.9	7.5	48.8	1.0
Ammonia as N	mg/L		0.0047	0.0021	0.0116	0.0077	0.0085	0.0070	0.0040	0.0024
Nitrate (as N)	mg/L	*3.0 long term; 124 short term*	0.0094	0.0067	0.0093	0.0179	0.0039	0.0063	0.0029	0.0041
Aluminum (Al)-Total	mg/L	*0.005-0.1*[c]	0.0122	0.0038	0.0106	0.0050	0.0585	0.0296	0.0929	0.0414
Arsenic (As)-Total	mg/L	*0.005*	0.0004	0.0001	0.0007	0.0001	0.0006	0.0007	0.0012	0.0014
Cadmium (Cd)-Total	mg/L	*0.00004-0.00037 long term; 0.00011-0.0077 short term*	0.000048	0.000049	0.000026	0.000046	0.000021	0.000029	0.000021	0.000028
Copper (Cu)-Total	mg/L	*0.002-0.004*[d]	0.0014	0.0006	0.0008	0.0003	0.0009	0.0003	0.0011	0.0004
Iron (Fe)-Total	mg/L	*0.3*	0.008	0.005	0.004	0.005	0.048	0.020	0.088	0.046
Lead (Pb)-Total	mg/L	*0.001-0.007*[d]	0.0003	0.0004	0.0002	0.0004	0.0002	0.0002	0.0002	0.0002
Mercury (Hg)-Total	mg/L	*0.000026*	0.000013	0.000010	0.000001	0.000001	0.000010	0.000010	0.000001	0.000002
Molybdenum (Mo)-Total	mg/L	*0.073*[e]	0.0006	0.0001	0.0008	0.0001	0.0006	0.0002	0.0006	0.0001
Nickel (Ni)-Total	mg/L	*0.025-0.15*[e]	0.0004	0.0001	0.0001	0.0001	0.0003	0.0003	0.0006	0.0005
Selenium (Se)-Total	mg/L	*0.001*	0.0003	0	0.0014	0.0008	0.0011	0.0009	0.0021	0.0010
Zinc (Zn)-Total	mg/L	*0.03*	0.0015	0.0017	0.0030	0.0043	0.0017	0.0020	0.0026	0.0017
Cyanide, Total	mg/L		-	-	0.00067	0.00026	0.00054	0.00014	0.00050	0
Radium-226	Bq/L		-	-	0.0025	0	0.0036	0.0023	0.0025	0

Note: Table includes all available data and shows parameters included in current AEMP or considered relevant (conductivity and selenium).
[a] *Canadian water quality guidelines for the protection of aquatic life (CCME 2014)*
[b] *Seasons were determined as follows; winter, April to early May; spring, end of May to June; summer, July to mid August; fall, late August to September.*
[c] *0.005 mg/L at pH <6.5; 0.1 mg/L a pH ≥6.5*
[d] *Hardness dependent*
[e] *Interim guideline*

Table 2.5-7. Mean Seasonal Concentrations of Water Quality Variables in Patch Lake

Variable	Units	CCME[a]	Winter[b]		Spring		Summer		Fall	
			Average	SD	Average	SD	Average	SD	Average	SD
Conductivity	μS/cm		417.3	70.0	359.6	223.7	328.7	93.4	299.0	39.0
Hardness (as $CaCO_3$)	mg/L		73.8	15.9	93.9	7.3	61.5	12.0	52.3	10.4
pH	pH	*6.5-9.0*	7.4	0.4	6.7	0.4	7.3	0.4	7.6	0.4
Total Suspended Solids	mg/L		1.50	1.28	0.50	0	1.23	1.07	2.87	2.82
Alkalinity, Total (as $CaCO_3$)	mg/L		52.0	4.4	39.9	25.1	35.4	8.9	33.8	2.5
Ammonia as N	mg/L		0.0098	0.0054	0.0164	0.0088	0.0077	0.0039	0.0075	0.0048
Nitrate (as N)	mg/L	*3.0 long term; 124 short term*	0.0110	0.0120	0.0138	0.0134	0.0044	0.0054	0.0025	0.0000
Aluminum (Al)-Total	mg/L	*0.005-0.1*[c]	0.0434	0.0331	0.0406	0.0179	0.1331	0.0948	0.1181	0.0707
Arsenic (As)-Total	mg/L	*0.005*	0.0005	0.0002	0.0008	0.0000	0.0005	0.0002	0.0006	0.0004
Cadmium (Cd)-Total	mg/L	*0.00004-0.00037 long term; 0.00011-0.0077 short term*	0.000087	0.000059	0.000031	0.000047	0.000021	0.000041	0.000042	0.000050
Copper (Cu)-Total	mg/L	*0.002-0.004*[d]	0.0035	0.0016	0.0014	0.0005	0.0015	0.0007	0.0012	0.0006
Iron (Fe)-Total	mg/L	*0.3*	0.050	0.020	0.030	0.019	0.106	0.071	0.088	0.041
Lead (Pb)-Total	mg/L	*0.001-0.007*[d]	0.0006	0.0006	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Mercury (Hg)-Total	mg/L	*0.000026*	0.000014	0.000011	0.000001	0.000002	0.000006	0.000013	0.000005	0.000006
Molybdenum (Mo)-Total	mg/L	*0.073*[e]	0.0003	0.0002	0.0002	0.0000	0.0002	0.0001	0.0010	0.0034
Nickel (Ni)-Total	mg/L	*0.025-0.15*[e]	0.0007	0.0002	0.0017	0.0030	0.0005	0.0001	0.0009	0.0011
Selenium (Se)-Total	mg/L	*0.001*	0.0006	0.0006	0.0012	0.0010	0.0011	0.0005	0.0008	0.0006
Zinc (Zn)-Total	mg/L	*0.03*	0.0055	0.0063	0.0079	0.0081	0.0022	0.0017	0.0015	0.0010
Cyanide, Total	mg/L		0.00250	0	0.00060	0.00022	0.00071	0.00045	0.00058	0.00020
Radium-226	Bq/L		-	-	0.0025	0	0.0031	0.0013	0.0025	0

Note: Table includes all available data and shows parameters included in current AEMP or considered relevant (conductivity and selenium).
[a] *Canadian water quality guidelines for the protection of aquatic life (CCME 2014)*
[b] *Seasons were determined as follows; winter, April to early May; spring, end of May to June; summer, July to mid August; fall, late August to September.*
[c] *0.005 mg/L at pH <6.5; 0.1 mg/L a pH ≥6.5*
[d] *Hardness dependent*
[e] *Interim guideline*

Mean total metal concentrations in streams were generally below CCME guidelines, with the following exceptions:

- aluminum in all streams except Wolverine Outflow;
- chromium in P.O. Outflow and Glenn Outflow Downstream;
- copper in Glenn Outflow Downstream; and
- iron in Glenn Outflow Downstream and P.O. and Ogama outflows.

These elevated metal concentrations occur naturally within streams in the area (HBML 2011).

2.5.4 Sediment Quality

2.5.4.1 Lakes

Characteristics of sediments are less temporally variable than water, providing useful markers of environmental conditions over longer periods of time. Sediments also play an important role in benthic invertebrate habitat quality. Baseline historical sediment quality data are available for some lakes in the Madrid Area for the following open-water seasons: 1996, 1997, 2007, 2009, and 2010 (Table 1.1-1). A comprehensive sampling program was conducted in 2009 (Rescan 2010f), and additional baseline samples were collected in 2010 (Rescan 2011g).

Sediments in the north end of the Belt were largely composed of clay, silt, and sand, with little gravel. The proportion of fine particles in sediments increased with depth. An increase in fine sediments (clay and silt) within a lake was generally associated with an increase in sediment metal and organic carbon concentrations. There were few clear trends in sediment chemistry among lakes surveyed in 2009, though sediments from Wolverine and Imniagut lakes in the Doris Watershed contained relatively high concentrations of TOC, ammonium, total nitrogen, and total sulphur (Rescan 2010f).

All sediment samples collected in 2009 were compared to CCME guidelines for the protection of aquatic life: the interim sediment quality guidelines (ISQGs) and the probable effects levels (PELs). The more conservative ISQGs are levels below which adverse biological effects are rarely observed, whereas the higher PELs correspond to concentrations above which negative effects frequently occur. Lake sediments in the Madrid Area were naturally elevated in arsenic, chromium, and copper, and concentrations of these metals were often higher than CCME ISQGs. Metal concentrations in sediments were always below PELs, with the exception of one sediment sample collected from Glenn Lake which contained elevated levels of chromium (Rescan 2010f).

2.5.4.2 Streams

Baseline historical sediment quality data were collected for some streams in the Madrid Area in 2009 (Rescan 2010f). Stream sediments consisted of a highly variable mixture of gravel, sand, silt and clay. There was no apparent relationship between sediment particle size distribution and sediment metal concentrations, but the proportion of TOC in sediments tended to be highest in sediments containing more fine sediments. The mean TOC content of sediments ranged from 0.3% in Ogama Outflow sediments (which consisted of more coarse sediments) to 2.9% in P.O. Outflow sediments (which consisted of more fine sediments). In general, stream sediments contained lower metal concentrations than lake sediments. Stream sediments in the Madrid Area were naturally high in chromium. Concentrations of chromium and copper in sediments collected from Ogama and Windy outflows were occasionally higher than CCME ISQGs. Sediment metal concentrations were always below CCME PELs (Rescan 2010f).

3. Biological Environment

3. Biological Environment

3.1 VEGETATION

Baseline vegetation studies have been conducted in the Hope Bay Belt area from 1996 to 2011 (Rescan 1997b, 1997c; Golder 2009d; Rescan 2010g). A comprehensive site level ecological classification system has not been developed for Nunavut or the Northwest Territories. A coarse level vegetation classification system (based on satellite imagery interpretations conducted in 2000) was developed for the West Kitikmeot/Slave Study (WKSS) region (RWED 2000), which includes the Hope Bay Belt area (Golder 2009d). At local scales, multiple ecosystem classification projects were also completed (Rescan 1997b, 1997c; Burt 2003). From these studies, Golder (2009d) created a preliminary regional Ecosystem Land Classification (ELC) system. The ELC was developed to compare local ecosystems with the broad level WKSS classification system, and to enable the assessment of environmental impacts at both local and regional levels (Golder 2009d). The ELC system was used to classify vegetation in the Madrid area in 2010 (Rescan 2010g).

3.1.1 Ecoregions

The Hope Bay Belt area lies north of the tree line in the "tundra, high shrub zone", in the Southern Arctic Ecozone (WKRLUP 2005). It is situated on the border between the Queen Maud Gulf Lowland and Bathurst Hills Ecoregions (Figure 3.1-1). The Madrid Area falls in the Queen Maud Gulf Lowland Ecoregion. The Queen Maud Gulf Lowland ecoregion is also considered to have a low Arctic ecoclimate. Archean rocks form broad, sloping uplands that reach about 300 m in elevation in the south, and subdued undulating plains near the coast. The coastal areas are mantled by silts and clay of postglacial marine overlap. Bare bedrock is common, and turbic and static cryosols developed on discontinuous, thin, sandy moraine, level alluvial, and marine deposits are the dominant soils in the ecoregion. Permafrost is continuous and deep with low ice content. Vegetation is characterized by shrub tundra, consisting of dwarf birch, willow, northern Labrador tea, *Dryas* spp., and *Vaccinium* spp. Tall dwarf birch, willow, and alder occur on warm sites; wet sites are dominated by sphagnum moss and sedge tussocks.

3.1.2 Vegetation Communities

Using the ELC system for the Madrid Area, there were eleven dominant vegetation communities identified (Table 3.1-1; Rescan 2010g). Of the eleven dominant vegetation communities, Eriophorum Tussock meadow was the most common (Rescan 2010g).

3.1.3 Rare Plants

A formal ranking system for identification or status determination for plant species potentially at risk has not been established in Nunavut. Thus, the NWT Department of Environmental and Natural Resources database was used to create a list of species at risk known to occur within Nunavut. The resultant plant list was used to identify potential habitat that may support rare species. A list of dominant plants in each field plot from baseline vegetation field surveys (Rescan 1997b, 1997c; Burt 2003; Golder 2009d; Rescan 2010g) was recorded and evaluated for the presence of rare/at risk plants according to the NWT General Status Ranking Program (GSRP; Northwest Territories Environment and Natural Resources 2010).

Figure 3.1-1
Arctic Ecozones and Ecoregions

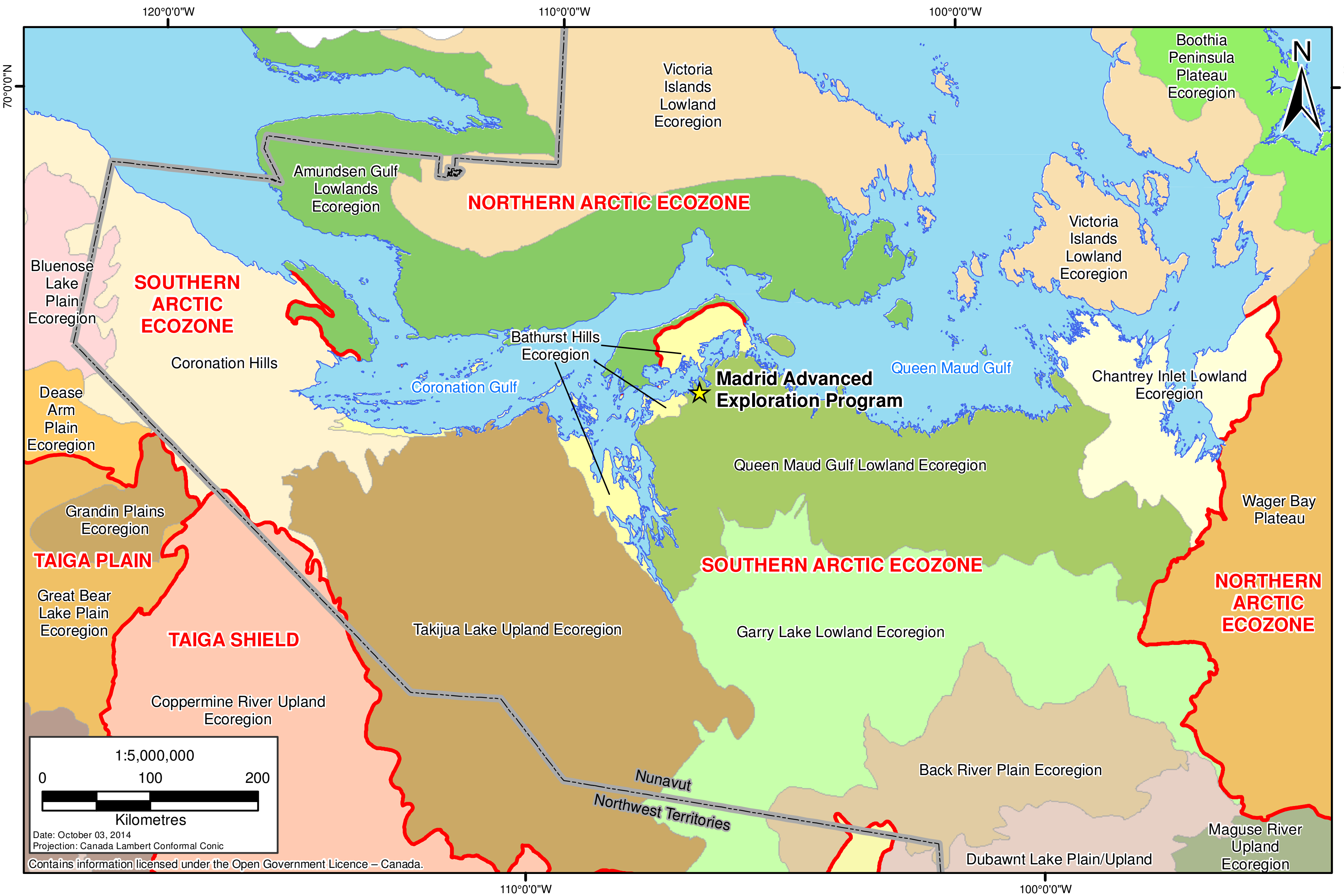


Table 3.1-1. ELC Vegetation Communities in the Madrid Area

General Ecosystem Unit	Description
Dry Carex-Lichen	Dry, nutrient poor community restricted to exposed bedrock outcrops characterized by a sparse cover of sedges, lichens and dwarf shrubs.
Riparian Willow	Wet to very wet, medium to rich nutrient community restricted to active floodplains and seasonally fluctuating water tables with a thick cover of willow species and variable (often extensive) cover of sedges, cotton-grass, and moss species.
Dryas-Herb Mat	Dry to mesic, poor to medium nutrient community occurring on very thin, poorly developed soils on bedrock outcrops and morainal deposits dominated by Arctic avens and a high diversity of dwarf shrubs and herbs.
Wet Meadow	Wet to very wet, medium to rich nutrient community occurring on plains and gentle lower slopes with constant water seepage dominated by thick covers of cotton-grass and sedges, few shrubs and lichens, and limited moss cover.
Betula-Ledum-Lichen	Dry to mesic, poor to medium nutrient community occurring on hillslopes of glacial till containing thick covers of low dwarf birch, Labrador tea and a variety of dwarf shrubs, sedges, herbs and lichens.
Emergent Marsh	Permanently saturated rich to very rich communities which are rarely extensive and dominated by sedges, some hydrophilic herbs, and no shrubs of lichens, typically occurring along watercourses and ponds.
Dwarf Shrub-Heath	Mesic, poor to medium nutrient community restricted to moderate to steep slopes of glacial till over bedrock (often containing frost mounds) containing arctic heather and a highly variable assemblage of dwarf shrubs, herbs, moss and lichen in response to microtopography and aspect.
Betula-Moss	Mesic to moist, poor to medium nutrient community located in depressions or gently sloping fluvial and lacustrine plains typified by a high cover of dwarf birch (and often willow) and a thick moss layer, with few herbs or lichens present.
Eriophorum Tussock	Moist to wet, medium to rich nutrient, widespread community type characterized by deep tussocks of sheathed cotton-grass and a variety of dwarf shrubs (on drier tussock tops), herbs, and mosses found in low lying plain of organic material overlying fine textures marine and lacustrine materials (permafrost almost always occurs at the organic – mineral transition).
Dry Willow	Mesic, medium nutrient community occurring on steep slopes (typically fluvial, marine or lacustrine) with a thick cover of willow (occasionally dwarf birch) and few other species.
Polygonal Ground	Mosaic of disjunct communities comprised of drier communities (raised palsa mounds with communities similar to birch-ledum-lichen or birch-moss) and wet depressions (normally wet meadows) which typically occur in depressions and valley bottoms near lakes and ponds.

No species of conservation concern were identified during the baseline field surveys for the Madrid Area; however, three species considered vulnerable or at risk were identified in previous baseline studies in the Hope Bay Belt (Golder 2009d). Three species were identified as being rare, including the bryophyte *Sphagnum orientale* (considered vulnerable with a global ranking status of Globally Imperilled to Apparently Secure [G2G4]), as well as *Cinclidium latifolium* and *Frullania tamarisci*. One exotic species, common dandelion (*Taraxacum officinale*), was also identified during field surveys.

3.1.4 Wetlands

The Federal Wetland Class was used to classify wetlands, which could not be distinguished from satellite imagery, during ground field surveys (Warner and Rubec 1997). Over half of the wetlands surveyed in the HB Belt were characterized as fens, followed by bogs. Of the form types, lowland polygon fens were the most common, followed by lowland polygon bogs, and lacustrine marshes. The ecological characteristics and typical vegetation communities for each of these ecosystems are summarized in Table 3.1-2.

Table 3.1-2. Wetland Form Types in the Madrid Area

Primary Wetland Form	Description
Lowland polygon fens	Lowland polygon fens form when the active layer within the soil directly influences surface landscape morphology. They are characterised by repeating variations of wet depressions (flarks) and dry linear hillocks (ribs) resulting from the displacement of soil due to freeze thaw cycles and permafrost dynamics. The wet soil conditions within the depressions support predominantly *Carex* species, including *C. aquatilis* (Plate 3.2-4), *C. membranacea, C. rotundata and C. atrofusca,* as well as *Eriophorum Angustifolium*. The drier hillocks support plant species assemblages characteristic of Arctic bog ecosystems, such as bog blueberry (*Vaccinium uliginosum*), lingonberry (*Vaccinium vitis idaea)* and to a lesser extent bearberry (*Arctostaphylos* spp).
Lowland polygonal bog	Lowland polygonal bogs are perennially frozen peatlands characterized by linear ridges underlain by ice-wedges. This ecosystem occurs in conjunction with the lowland polygon fen and represents the raised drier portions of the wetland complex. Lowland polygon bogs occur most commonly near estuaries, along river floodplains, and in depressions.
Lacustrine marsh	Lacustrine marshes occur along lake margins or, less commonly, along unconfined low-gradient streams in microsites protected from erosional flows and ice and wave scour. Water sources are a combination of inputs from adjacent lakes, rivers and streams flowing into the lake, as well as surface runoff from adjacent catchment areas.

3.2 TERRESTRIAL FAUNA

Terrestrial vertebrate studies have been conducted in the Hope Bay Belt area from 1996 through 2013. An active Wildlife Mitigation and Monitoring Program (WMMP) has been in place since 2006 across the entire Regional Study Area (RSA) of the Hope Bay Belt (Figure 3.2-1), and continues to collect information on wildlife species in the area. Wildlife in the area is evaluated at the RSA scale to account for the extensive home ranges and seasonal movements of large mammals such as Caribou (*Rangifer tarandus*), muskoxen (*Ovibos moschatus*), and Grizzly Bear (*Ursus arctos horribilis*). In 2010 and 2011, deoxyribonucleic acid (DNA) studies were conducted to determine Grizzly Bear and Wolverine (*Gulo gulo*) abundance and distribution patterns.

Additional wildlife surveys have been conducted in the region since the 1970s. These other wildlife surveys have included descriptions and mapping of wildlife habitats, inventories of wildlife sightings and signs (e.g., tracks and scat) collected during ground and helicopter reconnaissance trips, government radio-collar data, academic research projects and other historical work. Existing data sources from historical studies include the following:

- status reports of the Canadian Endangered Species Conservation Council (CESCC);
- assessment and status reports of COSEWIC;
- published literature on general ecology and population dynamics of wildlife species in the area (e.g., McLoughlin, Taylor, Cluff, Gau, Mulders, Case and Boutin 2003; McLoughlin, Taylor, Cluff, Gau, Mulders, Case and Messier 2003; McLoughlin et al. 2004);
- wildlife research conducted as part of the WKSS;
- satellite-collar data from wolf studies (Walton et al. 2001); and
- satellite-collar data from barren-ground Grizzly bears and Caribou collected by the Northwest Territories Department of Environment and Natural Resources.