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Author: **Rescan Environmental Services Ltd.**
Date: **November 2007**

the BATHURST INLET PORT AND ROAD PROJECT

Bathurst Inlet Port and Road Project

Nunavut, Canada

Bathurst Inlet Port and Road Project Surficial Geology, Soils and Ecosystem Mapping

Prepared by:

Rescan™ Environmental Services Ltd
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November 2007

SURFICIAL GEOLOGY, SOILS & ECOSYSTEM MAPPING

BATHURST INLET PORT AND ROAD PROJECT

(Updated by Rescan in 2007 to reflect PROJECT changes)

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The Bathurst Inlet Port and Road project involves the construction of a marine port on Bathurst Inlet and the building of an all-weather road between the port and Contwoyto Lake (211 km). This report provides a detailed summary of the surficial geology, soils, and ecosystem units identified along this 211 km route. This report forms only one component of a larger study that was completed for the Bathurst Inlet Port and Road Project; other work was completed for engineering studies (Nishi-Khon/SNC Lavalin Ltd. 2002), bedrock geology (Rescan 2003a), freshwater fisheries (Rescan 2002a), marine environment (Rescan 2002b), meteorology (Rescan 2003b) and wildlife (Rescan 2003c).

Mapping occurred using color 1:15 000 scale aerial photographs obtained during late July and early August 2001. Fieldwork was completed by a combination of surficial geologists and vegetation ecologists during the month of August 2001. Inuit assistants assisted in all fieldwork. Plots were established along the proposed corridor.

Surficial Geology and Soils Mapping

From a physiographic perspective, the project area occurs within the Bathurst Hills and the Bear-Slave Upland physiographic regions of the Canadian Shield. The Bathurst Hills are composed of down-faulted, folded sediments and sills that lie within and extend south from Bathurst Inlet between higher upland areas of massive rocks. The softer strata have been eroded and in many places lie submerged beneath bays and channels, leaving the harder members, generally sills, as long cuestas more than 300 meters in elevation. Marine silts and reworked deposits from the marine overlap mantle some of the lower parts. The Bear-Slave Upland consists mainly of massive rocks, though some stratified rocks lie in the northwestern part. Generally the peneplain surface is typical of the treeless, bare-rock parts of the Shield. Numerous lakes fill shallow basins; rounded rocky hills, exhibiting a relief of 100 m, are characteristic. Few outcrops of rock are evident as the rock is covered with a shallow granite boulder till in a sandy matrix.

Nearly 4,500 terrain units (or polygons) were delineated along the route (at 1:15 000), resulting in an average polygon size of approximately 6.5 ha; this level of mapping is considered quite detailed for 1:15 000 scale; despite this level of detail, not all features were able to be properly delineated. East of the Amagok River, coarse to moderately coarse-textured, stone-free marine sediments occur as blankets and veneers overlying bedrock or as thick sediments within valley bottoms. West of the Amagok River, moderately coarse-textured moraine is the most extensive surficial material; it generally occurs as veneers and blankets overlying bedrock, and to a lesser extent, as pronounced drumlins. Variable-textured lacustrine sediments are typically found adjacent to most water bodies. In depressional terrain where the groundwater flow is at or near the surface for much of the year or where seepage is pronounced, organic accumulations commonly overlay morainal or lacustrine materials. Numerous large esker complexes are found throughout the corridor; many of the eskers reach up to 20 m in height and may be over 30 km in length.

Numerous geomorphic processes have occurred over the past 10 000 years, resulting in the present day landscape. These processes have varied from isostatic rebound, active permafrost processes including cryoturbation and solifluction to slumping along some of the steeper slopes where thick surficial sediments are found. These processes will have an impact on the construction and maintenance of the proposed road. Although a number of

recommendations related to surficial geology are presented within this report, one recommendation should be emphasized:

> The field inventory program resulted in the identification of "jelly-like" materials along the corridor. Because of the site-specific nature of these occurrences, they could not be mapped at 1:10 000 with any level of confidence. It is suggested that these materials will only pose problems if the road is used as an all-season road. Hence, it is recommended that these areas be avoided during road construction and that the proposed road be kept on bedrock wherever possible. During the construction phase, field technicians should probe surficial materials ahead of the road construction to determine if, in fact, these "jelly-like" (super-saturated) materials exist.

Vegetation Inventory and Ecosystem Mapping

The corridor of the proposed road is located in the Southern Arctic Ecozone, as defined by Wiken (1986). The area adjacent to Bathurst Inlet is part of the Bathurst Hills Ecoregion, while most of the proposed road corridor is found in the Takijuq Lake Upland Ecoregion. This general area is also known floristically as "low Arctic". The study area is characterized by dwarf shrub tundra in which members of the heath family and dwarf birches are dominant, by wetlands dominated by sedges and cottongrasses, and by exposed rocky outcrops and boulder fields covered by crustose lichens. The entire area was under ice until less than 9,000 years before present, so the current vegetation has developed since that time.

The vegetation was studied intensively through the use of vegetation plots in which as many species as possible were recorded, and percentage of cover was visually estimated for all recorded species. Three teams established 332 plots, each consisting of a vegetation ecologist plus a local field assistant. Each plot was classified as to vegetation type, and data has been stored in a VENUS database developed by BC Forestry.

The outline of the main vegetation types and subtypes was further refined based on the field data, resulting in two levels of classification: mapping units and descriptive units. Mapping units in general are large areas that can be mapped at 1:15 000. These are plant "communities", each of which may be made up of subgroups or "associations". These associations can be described and illustrated, but not mapped, due to their size or the fact that they intergrade into each other. A few plant communities (snowbank communities or avens community) are too small to map, but are sufficiently distinct to rate being called a "community".

Lists of all plant species encountered in the project are appended, as well as a list of plants by community, and a list of the potential vascular plant species that occur at the coast. The vegetation was mapped onto 1:15 000 airphotos, and digital maps are included in this report. In mapping, for most part, the vegetation units were matched to the soils and terrain units.

There are some general differences between the vegetation at the coast as compared to inland areas, a much richer, more diverse flora, due to elevation (sea level), richer soils, and a more protected local climate. In addition, there are some halophytic species at the coast, marine communities, and a series of bird nesting islands that are nowhere duplicated inland. The road corridor rises rapidly close to the coast, passing over the edge of the Bathurst graben, and then ascends gently to an interior elevation of approximately 630 m. Inland areas offer harsher Arctic weather, less snow insulation, and thinner soils, and the plant communities are correspondingly less diverse than at the coast.

Although there are locally uncommon species such as ferns, orchids, louseworts, legumes, and violets, in this study no species considered “rare” by international standards were encountered. In many cases, the project area occurs at the edges of the ranges of certain species, or in habitat that does not support them. This study produced a few range extensions, not unexpected, as the area is not botanically well known.

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1. RESOURCE SYPNOSIS

CHAPTER 1

Resource Synopsis

CHAPTER 1 - RESOURCE SYNOPSIS

Chapter 1 provides general background information for the project. It provides a brief discussion of the history of the Bathurst Port & Road project, the goals and objectives of the study, as well as a brief synopsis of the natural resources of the area. The surficial geology, soils and vegetation study is one of several inventory components that were completed for the Bathurst Port & Road project; other studies included engineering (Nishi-Khon/SNC Lavalin Ltd. 2002), bedrock geology (Rescan 2003a), meteorology (Rescan 2003b), freshwater fisheries (Rescan 2002a), marine environment (Rescan 2002b), wildlife (Rescan 2003c), and archaeology.

1-1. Project History

Road construction is considered crucial to the development of mineral resources of the West Kitikmeot. A number of road proposals have been put forward over the past decade, including a road between the Izok Lake and Kugluktuk (on Coronation Gulf) and between Contwoyto Lake and Bathurst Inlet. These road proposals include plans to construct ports that can be used to supply mining equipment, fuel and supplies and, in some cases, to ship out ore. The proposal to develop a transportation corridor from Contwoyto Lake to Bathurst Inlet, and to construct a port there, is gaining momentum (Nunavut Planning Commission 2002).

1-2. Project Goals and Objectives

The Bathurst Inlet Port and Road project involves construction of a marine port and road to Contwoyto Lake (211 km). The project would be built, operated and maintained by an Inuit / industry / government partnership (Nunavut Planning Commission 2002).

This report forms part of a larger effort by a consortium of firms (lead by Rescan™ Environmental Services Ltd. of Vancouver, BC) to conduct an Environmental and Socio-Economic study of the proposed route between Bathurst Inlet and Contwoyto Lake. This report addresses a portion of those baseline studies that were commissioned for the project, including:

- Surficial geology, terrain and soils mapping; and
- Vegetation and ecosystem mapping

Field investigations and subsequent mapping was completed at a representative scale of 1:10 000. Individual reports have been developed for other components of the larger project.

1.3. Project Location

The Bathurst Inlet – Contwoyto Lake project area is located in the far western portion of Nunavut, north of the Nunavut - Northwest Territorial boundary. It is found south of the Coronation Gulf and north of the Lac de Gras area. It is situated between 62°30’ and 67°30’ North latitude and 108°W and 112°30’ West longitude. It is found wholly within the West Kitikmeot Planning Region (Figure 1).

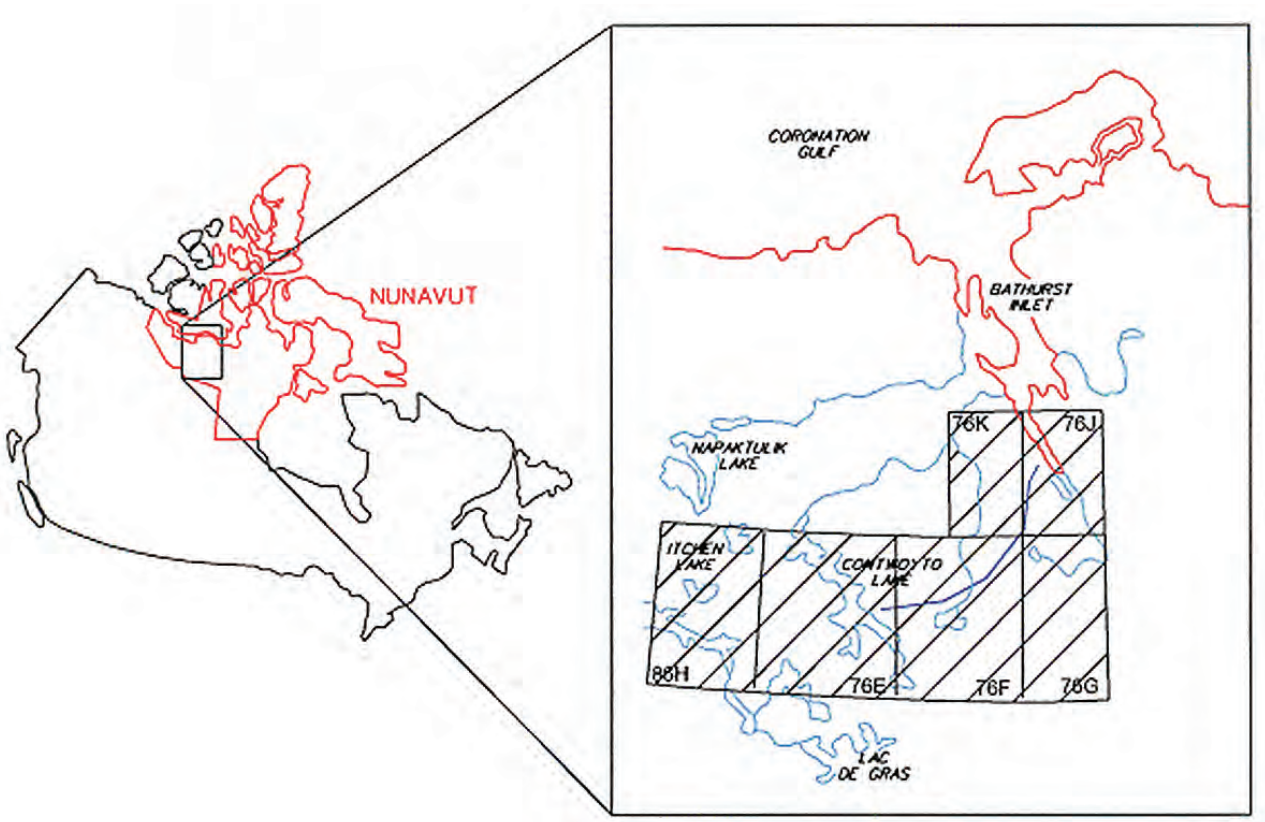

FIGURE 1

Project Location Map

the BATHURST INLET PORT AND ROAD PROJECT

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The specific corridor is approximately 211 km in length and one kilometer in width, for a total area of 290 km^2 or 29,000 ha. The corridor angles in a south/southwest direction from Bathurst Inlet to the Mara River where it turns in a westerly direction to a proposed camp facility (Contwoyto Lake Camp) along the east shoreline of southern Contwoyto Lake.

1-4. Climate

Tables 1 and 2 provide a description of climate normals for selected stations within both Nunavut and the Northwest Territories for the 1960 to 1990 and 1950 to 1980 periods. Unfortunately, the 1970 to 2002 normals are not available for comparison purposes.

When comparing the daily mean temperatures for all five stations, with the exception of Baker Lake, all stations show a warming trend of between 0.2 and 0.3 °C for the 1960 - 1990 year period when compared with the 1950 – 1980 period. Of particular note is the increase of between 0.2 to 0.5 °C for all of the stations for the mean January values and increases of between 0.1 to 0.3 °C for mean July values.

Table 1. 30 Year Temperature Normals for Selected Stations in Nunavut and Northwest Territories[1]

Station	Latitude	Longitude	Normals Period	Daily Maximum	Daily Minimum	Daily Mean	Mean January	Mean July
Cambridge Bay	69°06'N	105°07'W	1960 – 1990	-11.4	-18.5	-14.9	-33.4	8.0
			1950 – 1980	-11.5	-18.6	-15.1	-33.6	7.9
Contwoyto Lake	65°29'N	110°22'W	1960 – 1990	- 7.8	-15.8	-11.8	-31.4	9.9
			1950 – 1980	- 8.0	-16.0	-12.0	-32.1	9.7
Baker Lake	64°18'N	96°05'W	1960 – 1990	- 8.4	-16.2	-12.2	-32.6	11.1
			1950 – 1980	- 8.3	-16.0	-12.2	-33.0	11.0
Byron Bay	68°45'N	109°04'W	1960 – 1990	-10.4	-17.5	-13.9	-32.3	9.2
			1950 – 1980	-10.6	-17.7	-14.2	-32.8	8.9
Yellowknife	62°40N	114°15'W	1960 – 1990	- 0.8	- 9.7	- 5.2	-26.8	16.5
			1950 – 1980	- 1.0	- 9.8	-5.4	-27.9	16.3

From: Environment Canada, Canadian Climate Normals.

Table 2. 30 Year Precipitation Normals for Selected Stations in Nunavut and Northwest Territories[1]

Station	Latitude	Longitude	Normals Period	Rainfall (mm)	Snowfall (cm)	Precipitation (mm)
Cambridge Bay	69°06'N	105°07'W	1960 – 1990	73.2	79.6	141.0
			1950 – 1980	68.1	76.8	136.3
Contwoyto Lake	65°29'N	110°22'W	1960 – 1990	128.6	117.5	246.6
			1950 – 1980	128.8	122.0	251.3
Baker Lake	64°18'N	96°05'W	1960 – 1990	143.5	130.1	261.8
			1950 – 1980	138.3	108.0	234.6
Byron Bay	68°45'N	109°04'W	1960 – 1990	69.4	49.2	118.6
			1950 – 1980	62.2	45.8	108.0
Yellowknife	62°40N	114°15'W	1960 – 1990	154.0	143.9	267.3
			1950 – 1980	150.2	135.4	266.7

From: Environment Canada, Canadian Climate Normals.

An examination of Table 2 suggests that the precipitation values are more highly variable than temperature values. Precipitation values having increased at four of the stations, anywhere from 0.6 mm (Yellowknife) to 27.2 mm (Baker Lake). Of particular interest is the fact that the Contwoyto Lake station received, on an annual basis, 4.7 mm less precipitation during the 1960 – 1990 period than it did for the 1950 – 1980 period; in other words, precipitation values have actually decreased at this site by nearly 2% for this period.

The Nunavut Planning Commission (2002) provides the following statistics for the West Kitikmeot Region (Table 3).

Table 3. Selected Climatic Statistics for Selected Stations within the West Kitikmeot Region

Community	First Frost	Last Frost	Frost-free Season	January Minimum Temperature	July Maximum Temperature	Annual Precipitation
Cambridge Bay	August 20	June 25	55 days	- 37 ^{o} C	12^{o}C	136 mm
Kugluktuk	August 20	June 25	55 days	- 33 ^{o} C	13^{o}C	202 mm
Bathurst Inlet	August 20	June 30	50 days	- 35 ^{o} C	13^{o}C	108 mm

The following are some of the forecasted changes that may occur as a result of global warming by 2010 within the West Kitikmeot Region (Nunavut Regional Planning Commission 2002):

- An average increase in winter time temperatures of between 5^{o} and 7^{o}C;
- A 5^{o}C rise in average summer temperatures;
- Precipitation may increase by up to 25%; although this change is likely to be spread throughout the year, the biggest difference is anticipated in the summer and fall;
- In the early fall and late spring, some precipitation that at present falls in the form of snow would fall as rain
- Over half of the discontinuous permafrost zone could disappear; the boundary between continuous and discontinuous permafrost frost will shift northward by hundreds of kilometers; and
- The active layer (within the soil) will deepen in the discontinuous permafrost zone to perhaps double its current depth; this will result in increased frequency of landslides and coastal erosion

The following 50-year predictions have also been published (Nunavut Planning Commission 2002):

- The ice season in rivers will be reduced by up to a month (by the year 2050) and up to two weeks for large lakes;
- Water flows and levels in northward flowing rivers may decrease due to greater evaporation and a longer summer;
- Lake temperatures might increase;
- The Southern Arctic ecozone could effectively disappear from the mainland;
- Ecosystem composition may change; more shrubs and moisture-tolerant vegetation could be present and less nonvascular plants; plant species diversity would decrease (under this scenario);
- Increased cloud cover would decrease the forage quality for wildlife;
- Mainland caribou would be increasingly stressed; and
- Foundation and construction methods for buildings, roads, open pits and mine tailing facilities would be affected.

1-5. Physiographic Setting

The Bathurst Inlet to Contwoyto Lake area occurs within the Kazan Region of the Canadian Shield. This region consists of great areas of massive rocks that form broad sloping uplands, plateaux and lowlands – a rather expressionless terrane. Included in its northwestern part are hills formed of down-faulted and folded stratified rocks; in the southern and central parts there are some sandy planes of flat lying strata.

More specifically, the Bathurst Inlet to Contwoyto Lake area occurs within two physiographic units, including (i) the Bathurst Hills, and (ii) the Bear-Slave Upland (Bostock 1976). The Bathurst Hills are composed of down-faulted, folded sediments and sills that lie within and extend south from Bathurst Inlet between higher upland areas of massive rocks. The softer strata have been eroded and in many places lie submerged beneath bays and channels, leaving the harder members, generally sills, as long cuestas more than 300 meters in elevation. Marine silts and reworked deposits overlap mantle some of the lower parts.

The Bear-Slave Upland (also referred to by Bird and Bird (1961) as the Contwoyto Plateau) consists mainly of massive rocks, though some stratified rocks lie in the northwestern part. Generally the peneplain surface is typical of the treeless, bare-rock parts of the Shield. Numerous lakes fill shallow hallows; rounded rocky hills, exhibiting a relief of a 100 m, are characteristic (Bostock 1976). Few outcrops of rock are evident as the rock is covered with a shallow granite boulder till in a sandy matrix (Bird and Bird 1961).

1-6. Bedrock Geology

The Canadian Shield is a great region of Precambrian rocks that occupy nearly half of Canada. The Shield has been subdivided into seven structural provinces and several subprovinces based mainly on overall differences in internal structural trends and style of folding. From a geological perspective, the Bathurst Inlet to Contwoyto Lake area is wholly within the Slave Province. About two-thirds of the Slave Province is underlain by granitic rocks of which possibly half are high-grade migmatite, mixed gneiss, banded gneiss, and granitic gneiss, while the remainder consists of batholiths of massive or slightly gneissic granitic rocks of various composition (Stockwell et al., 1976). Figure 2 illustrates the geology of the project area.

The Slave Geological Province lies entirely within the Precambrian or Canadian Shield. Throughout its mainland portion, the Canadian Shield rarely exceeds elevations of 600 m above sea level (masl), with maximum relief generally limited to 70 m. Patches of muskeg and numerous lakes interspersed with bare rocky outcrops are the predominant landscape features in the Slave Geological Province. Muskeg influences the thermal characteristics of the ground and encourages the development of permafrost (Cizek *et al.*, 1994; Steffen *et al.*, 1992).

Bedrock of the Slave Geological Province includes a variety of geologic groups of widely differing genesis that straddle an unusually great time span (early Archean (~ 3,200 Ma – millions of years before present) to mid Devonian (370 Ma) ages). It is underlain by granite and related gneisses, and metamorphosed sedimentary and volcanic rocks (Nunavut Planning Commission 2002). Sediments of both the Yellowknife Supergroup and the Epworth Group underlie the Slave Province. The Archean Yellowknife Supergroup is anextensive unit within the Bathurst Inlet to Contwoyto Lake area. The Yellowknife Supergroup consists of greywacke, micaceous quartzite,

minor argillite and conglomerate, derived schist; it commonly contains some granitic material. Locally, it includes greywacke, micaceous quartzite, phyllite, and mica-quartz schist, white muscovite-quartzite, and knotted schist, garnet- and sillimanite-bearing schist.

The Early Proterozoic Epworth Group is exposed between the Mara River and Contwoyto Lake. It is comprised mainly of granite, granodiorite, and allied rocks. It locally includes pegmatitic granite, muscovite granite, muscovite-biotite granite, hornblende granite, granodiorite, quartz diorite, minor diorite and, granites with inclusions of mica-quartz schist or amphibolite). Biotite gneiss and migmatite are found immediately south of the port on Contwoyto Lake (Fraser 1964b).

The Bathurst Subprovince is a subdivision of the Slave Province – it is underlain by the Proterozoic sediments of the Goulburn Group that comprises a conformable sequence, about 4,500 m, divided into five formations. The Goulburn Group (Figure 3) is lithologically similar to the Epworth Group and a tentative correlation of these two sequences is suggested by Fraser (1964). The sediments have been moderately folded about axes that strike north-northeast. Folding is more intense along Bathurst Inlet where fold axes strike in a northerly direction. The Goulburn Group lies unconformably on the Archean Yellowknife Group and Kenoran granites. The basal formation of the Goulburn Groups attains a maximum thickness of 1,050 m and comprises, from the base up, grey to green quartzite and grit, dolomite with stromatolitic zones, and interbedded quartzite and maroon to grey argillite with local silty layers and stromatolotic dolomite. These rocks are overlain by as much as 2,300 m of thick-bedded, massive, pink to red feldspathic quartzite and orthoquartzites with thin interbeds of conglomerate.

Geology Legend:

Archeon

Yellowknife Group

2 Greywacke, micaceous quartzite, minor argillite and conglomerate, derived schist: commonly contains some granitic material: locally includes rocks of volcanic origin:
2a, greywacke, micaceous quartzite, phyllite, mico-quartz schist:
2b, white muscovite-quartzite:
2e, knotted schist, garnet and sillimanite-bearing schists.

Edworth Group

4 Granitic gneiss, mafic gneiss, mixed gneiss, mylonite: contains some massive granite rock:
4a, biotite gneiss and migmatite.

5 Granite, grandiorite, and allied rocks, massive to foliated, of more than one age: locally includes undifferentiated 4:
5a, pegmatitic granite, pegmatite:
5b, muscovite granite, muscovite-biotite granite:
5c, hornblende granite, granodiorite, quartz diorite, minor diorite:
5f, granite with inclusions of micro-quartz schist or amphibolite.

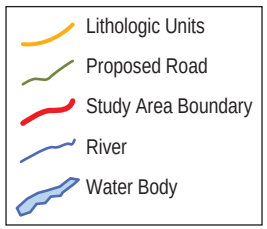
Proterozoic

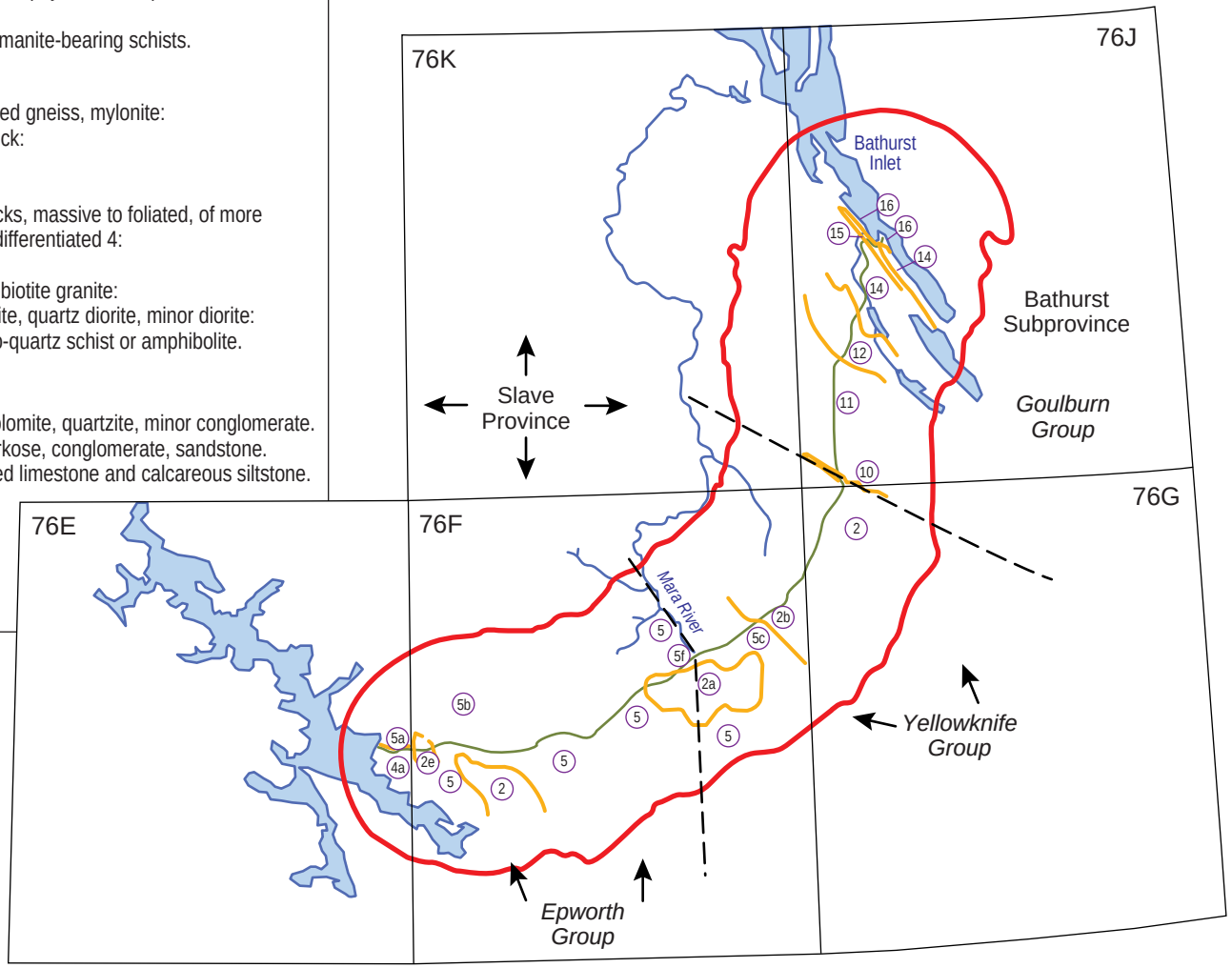
Goulburn Group

10 Argillite, concretionary argillite, dolomite, quartzite, minor conglomerate.
11 Quartzite, orthoquartzite: minor arkose, conglomerate, sandstone.
12 Argillite, argillite with interlaminated limestone and calcareous siltstone.
14 Siltstone and argillite, sandstone.
15 Sandstone, conglomerate.

Parry Bay Formation

16 Sandstone, conglomerate.





Source: Map 45-1963, Geology of Northeastern District of Mackenzie, Northwest Territories (Fraser 1964).

the BATHURST INLET PORT AND ROAD PROJECT

Bedrock Geology Map

FIGURE 2

Rescan™

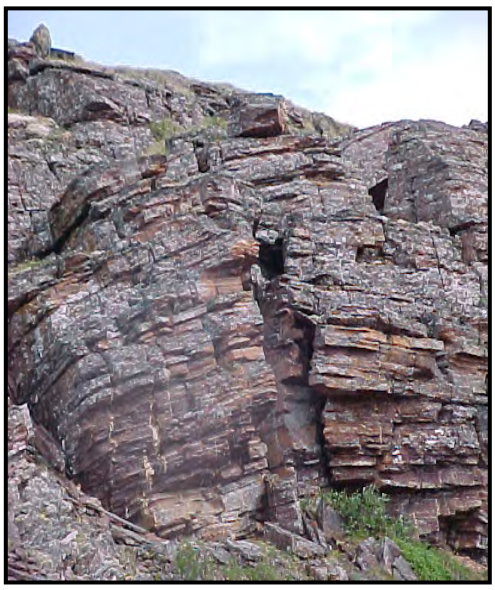


Figure 3. Uplifted red shales and sandstones of the Goulburn Group west of the Amagok River.

These rocks are succeeded by about 600 m of purplish green or grey argillites with thin interbedded grey limestone and dolomite overlain by about 250 m of grey to pink dolomite with abundant stromatolitic zones. The uppermost formation is composed of interbedded red-grey or maroon siltstone and agrillite with red crossbedded arkose near the top. These formations are exposed along Bathurst Inlet and within the Amagok and Hackett River valleys.

Formations are thickest near Bathurst Inlet and thin rapidly to the west and southwest. In the extreme western exposures near Contwoyto Lake only the lowest three formations are present and total thickness is little more than 600 m. In the Bathurst Inlet area where significant folding and faulting has occurred, the Goulburn Group is overlain by the Parry Bay Formation that consists of at least 165 m of thick-bedded sandstones and conglomerate (Fraser 1964a, Stockwell et al., 1976).

1-7. Quaternary History

The Quaternary is the present geological time period. It is often referred to as the glacial age. The internationally recommended time for the beginning of the Quaternary is 1.65 Ma (Pliocene / Pleistocene boundary). The Quaternary Period has been subdivided into Pleistocene and Holocene epochs with Holocene defined as the last 10 ka (thousand years before present). The predominant characteristics of the Quaternary are marked climatic change, glaciation, and the activity of other processes fuelled by climatic oscillations. Climate change was the cause of periods of buildup and decay of ice sheets of continental scale and also resulted in transgression and regression of oceans, advance and retreats of deserts, and migration and extinction of plants and animals. Because the Quaternary is the latest geological time period, it is the one known best and is the time during which geological processes fashioned the surface of the Earth as it is known today. Quaternary events are largely responsible for the soil in which plants grow; they are responsible for the deposition of the surface materials with which we must contend during construction in constructing buildings and roads; and they are responsible for the complex succession of units from which much of our groundwater is drawn.

With the exception of the Cordillera Rocky Mountains and the eastern Queen Elizabeth Islands, Laurentide ice covered all of Canada. During glacial periods the central part of Canada was covered by inland or Laurentide ice which has been subdivided into Labrador, Keewatin, and Baffin sectors. Keewatin Sector ice flowed from the Thelon area of Nunavut and Northwest Territories in an outwardly direction including westerly and northerly direction across the Bathurst and Contwoyto Lake area. Ice sheets have extensively scoured the entire Canadian Shield and this process has created hundreds of thousands of lake basins. The retreat centres are characterized by large fields of ribbed moraine formed in association with drumlins and flutings. Beyond those are broad zones (including the Bathurst Inlet / Contwoyto Lake area) of thick and nearly continuous drift composed mostly of streamlined till and large, long eskers (Fulton 1989). Large glacial erratics are common (Figure 4).

The Bathurst Inlet / Contwoyto Lake area was overlain with ice of the Richardson River Lobe and to a lesser extent, the Coronation Gulf Lobe around 11 ka. The ice radiated out from the Keewatin Dome located east (18 ka) and northeast (11 ka) of Great Slave Lake to just east of glacial Lake McConnell basin (present day Great Bear Lake). Between 11 ka and 10 ka, the Keewatin ice retreated in an easterly direction to an area just east of the present day Coppermine River; more specifically, the ice appeared to retreat to a line running north/south from Point Lake in the south to Napaktulok Lake and the Coronation Gulf in the north. Keewatin ice retreated rapidly between 10 ka and 8.4 ka, with the area between Nose Lake and Contwoyto Lake being ice free by 9 ka.

Bird and Bird (1961) have suggested that

> *"Ice was thickest in the Bathurst Inlet area as glacial striae are well preserved at all elevations and on every type of rock except conglomerates and certain dolomites. Away from the Inlet, striae are more difficult to find although the rocks are unchanged. This suggests that the ice may have been traveling most rapidly where it was deepest, that is, in the inlet, and that over the higher ground where it was thinner the velocity of the ice was much reduced… supporting evidence for an early ice movement from the northeast is found immediately west of the Bathurst area around the southern end of Contwoyto Lake where small fragments of Epworth dolomite are preserved in the till. The only known outcrops of Epworth dolomite are around Coronation Gulf to the north and in the Bathurst Inlet – Western River trough."*

Numerous post-glacial lakes developed adjacent to the western ice margin, especially within the Contwoyto Lake and Burnside River basins; the area to the east was still overlain by ice. By 8.4 ka, ice had retreated across the Bathurst Inlet area towards Hudson Bay finally exposing the freshly deposited sediments; this date has been confirmed by radiocarbon dating (Dyke and Prest 1987a, b). Likewise, work by Blake (1963) and Falconer et al., (1965) has confirmed the MacAlpine Moraine, south of Bathurst Inlet, is estimated to have formed about 8.5 ka, thereby indicating that the area was ice-free by 8.4 ka.

Figure 4. Large glacial erratic.

At the close of the glaciation, the crust of the earth in the vicinity of Bathurst Inlet was depressed by the weight of the ice sheet. Although the land was rising as the ice decreased in thickness it had not recovered its former position before the ice vanished. As a result the land was relatively lower than today and the sea invaded the lowlands, hastening the final stages of the deglaciation and modifying the surface deposits below the highest level reached by the waves. The land has subsequently risen over 215 m around the inlet. Elsewhere in the western Canadian Arctic the land is known to have emerged between 150 and 185 m in most places.

Within Bathurst Inlet the result of the marine submergence and subsequent emergence of the land are conspicuous. Large quantities of weathered material from sandstone, quartzite, dolomite, diabase and basalt were available for working into (marine) strandlines. As a result, strandlines can be found on many slopes extending without breaks from the upper marine limit to the modern sea level. At lower elevations, marine silts and clays are widespread and produce landforms that are

extremely vulnerable to stream and marine erosion, as well as exhibiting considerable frost action due to the quantities of ground ice that have developed in these deposits.

Numerous observations were made around the inlet of the highest elevation reached during the marine transgression and consequently of the amount of emergence of postglacial times. The most definitive evidence of the presence of the sea is the discovery of marine shells in the water-sorted deposits. The three most numerous species found were *Saxicava arctica, Mya truncata*, and *Astarte borealis;* above 75 m only *Saxicava aractica* was found (Bird and Bird 1961).

With warming conditions and the subsequent retreat of the Keewatin ice sheets, sea levels extended quite far inland with waters extending to 225 m above present levels in the Bathurst Inlet area around 8.4 ka – this marine limit elevation is among the highest in Canada, exceeded only by those in the southeastern Hudson Bay. This represents not a centre of loading but a region into which the postglacial sea entered relatively early in the deglaciation sequence. Water levels had retreated to 160 masl around 8 ka, 90 masl by 7 ka and 35 m by 5 ka (Dyke and Prest 1987b). Dyke and Dredge (1989) have constructed emergence curves for a number of locations within the Arctic, including Bathurst Inlet (Figure 5). These curves illustrate the relative isostatic response; early emergence rates, when averaged over the first 1 – 2 ka of record, as similar throughout most of the region, being approximately 10 m/century in Bathurst Inlet. Late Holocene and ongoing emergence rates are expectedly highest closest to the centre of the former ice load; they are about 1.3 m/century in central Keewatin and 0.66 m/century in Bathurst Inlet (Dyke and Dredge 1989).

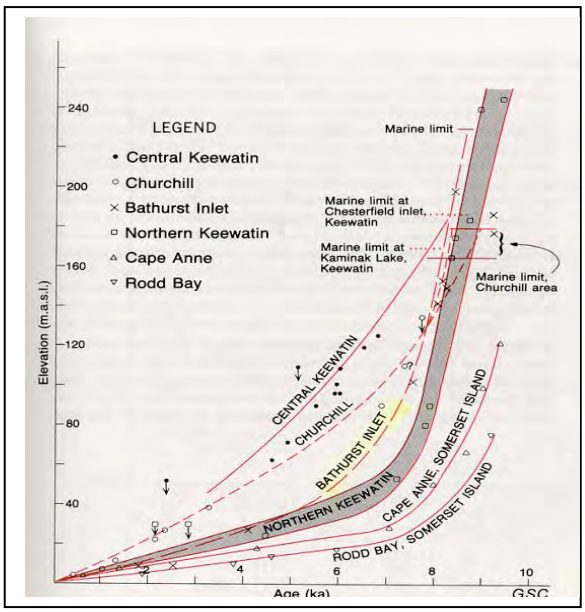


Figure 5. Family of emergence curves for Bathurst Inlet, Northern Keewatin, Somerset Island and Churchill area.

1-8. Quaternary (Surficial) Geology

A wide unconformity terminates the aforementioned Phanerozoic marine sediments and subsequent deposits are Quaternary-aged unconsolidated gravel, sand and silts. These sediments represent products of the most recent Wisconsin continental glaciation which locally retreated as recently as 9.5 - 9.0 ka. (Dyke and Prest, 1987). Generally, ice flow was from a 240^{o} direction and generated a variable till cover throughout the region (Henderson, 1985). Thick hummocky terrain, drumlins and drumlinoid ridges, though present, are not common in the study area (Aylsworth and Shilts 1989; Dredge *et al*., 1994a, 1994b). Bird and Bird (1961) have mapped a large drumlin field between the Amagok and Hacket River valleys; these drumlins are oriented in a northwest-southeast direction with numbers decreasing significantly past the Hacket River valley.

Low to variable rolling ground moraine of sandy till is the most typical glacial mantle within the region (Dredge *et al*., 1995). Till thicknesses is greatest where pre-glacial valleys survived glaciogenic scour and have been filled; Gochner (1998 pers comm.) and Bird and Bird (1961) report local depths exceeding 200 m in the lower Burnside River valley. Other thick till accumulations border fault scarp blocks, protruding dykes, or resistant volcanic outcrops; these too can be of a similar great depth. Generally till thickness is minimal (< 2 m) whenever uniformly resistant basement rocks are exposed. These tend to generate low-relief surfaces rarely exceeding gradients of 2 to 3 m (vertical) per 100 m (horizontal) and are most often are very thinly veneered or essentially free of till cover (Mollard, 1997).

Fluvioglacial sediments (eskers and kames) are common throughout the Bathurst Inlet region (Aylsworth and Shilts 1989; Bird and Bird 1961), but widely dispersed throughout the Slave Geological Province. The eskers on the uplands west of the inlet are part of the extensive esker group that reaches its greatest development around Contwoyto Lake; they are continuous for many miles cutting across the topographic grain of the landscape. In composition, the eskers vary along their length from silts and fine sands to boulders (Bird and Bird 1961). Aylsworth and Shilts (1989) and Kerr *et al*. (1996) report that extremely large esker complexes are, however, rare in the Slave Geological Province. Similarly glaciogenic spillways (valley train deposits) are uncommon since deglaciated terrain was resistant and uniform in grade; scour channels are very rare.

Deglacially enlarged lake basins (i.e. Yellowknife and Drybones lakes) (Mollard 1997), and localized ponding of ice-dammed waters (Dredge *et al*. 1995, 1996) generated thin local glaciolacustine deposits throughout the study region. More recently, the presence of perennially frozen ground and shallow-lying bedrock limits the percolation of water and promotes the accumulation of organic material (Mueller 1995). Patterned bogs, ribbed fens and swampy terrain (varied thickness) mantle large portions of the present landscape (Dredge *et al*. 1996).

Recent deposits include fluvial deposits, aeolian deposits, colluvial materials and organic accumulations. Fluvial deposits are found along many of the major watercourses while aeolian sands are commonly found atop or immediately adjacent to sandy esker deposits. Colluvial materials are indicative of instability in the landscape and were noted along the Amagok River valley where thick marine sediments have slumped into the valley. Organic accumulations consist mainly of sedge and sphagnum peats and vary in thickness from less than 50 cm to over 200 cm.

1-9. Permafrost and Other Cold Climate Processes

Most of the following section is taken directly from French (1989).

Permafrost, or perennially cryotic ground, refers to ground (i.e., soil and rock) that remains at or below 0°C for at least two years (Harris *et al.* 1988). The depth of frost penetration depends mainly upon the intensity of cold, its duration, the thermal and physical properties of the soil and rock, the overlying vegetation, and snow depth. Where the depth of seasonal frost exceeds the depth of thaw during the following summer, a zone of frozen (that is temperature below 0°C) ground persists throughout the year. From a geomorphic viewpoint, the nature and rate of both spring thaw and autumn freeze-back are of interest; the former influences the nature of the spring runoff while the later controls the nature of frost heaving and ice segregation in the soil. In areas with permafrost, thaw progression is primarily a function of time, and the depth of thaw depends on the length of the thaw season. Autumn freeze-back is an equally complex process, especially in those regions underlain by permafrost where freezing occurs both downwards and upwards from the perennially frozen ground beneath. Although the Bathurst Inlet to Contwoyto Lake area is found within the zone of "continuous permafrost" (French 1989), permafrost was not found in all parent materials; for example, in sandy materials (i.e., esker tops, outwash materials, etc.) no evidence of permafrost was found.

Both frost heaving and ice segregation are associated with ground freezing. Geomorphic indicators of frost heaving include the upthrust of bedrock blocks (Dionne 1983, Dyke 1984, 1986), the rising of objects and tilting of stones (Mackay and Burrows 1979), and the sorting and migration of soil particles (Corte 1966). Frost heaving presents numerous geotechnical problems in the construction of roads, buildings, and pipelines in cold environments (Carlson 1982).

Figure 6. Solifluction processes results in morainal materials overriding bedrock on lower slopes.

The most important bedrock weathering process has generally been assumed to be frost wedging, a physical weathering process relying upon repeated freeze-thaw activities. Features attributed to frost wedging include extensive areas of angular bedrock fragments (blockfields), scree and talus deposits, and irregular bedrock outcrops termed tors. Porous and well-bedded sedimentary rocks, such as shales, sandstones, and limestones, are regarded as being especially susceptible to frost wedging. This is of particular importance to many of the stream crossings within the Bathurst Subprovince, including the Hackett and Amagok valleys.

The most common permafrost-related landforms in the Bathurst Inlet to Contwoyto Lake area include patterned ground, mudboils, skin flows, and palsas. Most patterned ground phenomena occur in the active layer, a zone that thaws each summer and refreezes each autumn. In thermal terms, it is the layer that fluctuates above and below 0°C during the year. In permafrost areas, seasonally frozen and thawed ground can be equated with the active layer. Mass wasting processes that operate in the active layer include frost creep, gelifluction (solifluction) (Figure 6), and cryoturbation. Most patterned ground phenomena occur in the active layer.

Figure 7. Strongly disrupted horizons; tongues of mineral and organic horizons result from cryoturbation processes.

Frost creep is the ratchet-like downslope movement of particles as the result of the frost heaving of the ground and the subsequent settling upon thawing. Movement associated with frost creep decreases from the surface downwards and depends upon the frequency of freeze-thaw cycles, angle of slope, moisture available for heave, and frost susceptibility of the soil. Gelifluction is a form of solifluction occurring in areas underlain by permafrost. In contract to gelifluction, solifluction is a more general term for the mass wasting typical of cold subarctic regions not underlain by permafrost; solifluction is the slow downslope flow of saturated unfrozen earth materials (Harris *et al.* 1988). Both processes are faster than soil creep, often of the order of 0.5 to 10 cm/yr. Conditions favorable for gelifluction occur in areas where downward percolation of water through the soil is limited by the permafrost table and where the melt of segregated ice lenses provides excess water, which reduces internal friction and cohesion in the soil.

Cryoturbation is the term used to refer to the lateral and vertical displacement of soil that accompanies seasonal and/or diurnal freezing and thawing. Cryoturbation results in a body of unconsolidated earth material moved or disturbed by frost action (Figure 7). This process is associated with the formation of patterned ground phenomena, the most common of which is the nonsorted circle or hummock.

Figure 8. Jelly-like materials, also known as mudboils, will present significant difficulties in road location and maintenance; a knowledge of their location is very critical.

Mudboils occur widely in the Bathurst Inlet to Contwoyto Lake area. They develop on poorly sorted sediments (mud) with a significant silt or clay content and consist of rounded to elongated patches of bare soil 1 to 3 m in diameter (Figure 8). Natural moisture contents are near the liquid limits, so that the muds liquefy and flow readily in response to slight changes in moisture content or slight internal or external stresses. When downslope movement cannot relieve the stresses, mud may burst through a semi-rigid surface layer to create a mudboil. These structures include (i) an outer turf or stone ring, the type of ring depending on the stoniness of the mud and the severity of the climate, (ii) a thawed mud substrate lying between the permafrost table and a rigid surface layer, (iii) a carapace, a semi-rigid sandy, desiccated layer averaging 30 – 40 cm thick, and (iv) a diapir, in the case of active mudboils, which marks a zone of intrusion of mud from the thawed mud substrate through the carapace (Shilts 1978).

Rapid mass movement may also occur within the thawed or thawing active layer with the permafrost table acting as a lubricated slip plane and controlling the depth of the failure plane. These skin flows or detachment failures are usually attributed to local conditions of soil moisture saturation and high pore water pressure, commonly the result of thaw consolidation. In some cases, failure takes the form of a mudflow, in others, a distinct slump scar or hollow

is formed. They occur more frequently during warm summers or following disturbances of the vegetation or ground surface (i.e., ground fires, engineering activity, etc.) when the depth of thaw is greater than normal.

Peat palsas are not common within the Bathurst Inlet to Contwoyto Lake area; they were only noted between the Hackett and Amagok rivers. This type of frost mound forms in wetlands primarily by ice segregation beneath a peaty organic layer. They are more typical in the discontinuous permafrost zone and are rarely more than 5 m in height.

1-10. Vegetation

The area covered by the proposed road corridor is found in the Southern Arctic Ecozone (Wiken 1986) and based in part on work done by the Ecoregions Working Group (1989). It is described on the Environment Canada website at http://www.ec.gc.ca/soer-ree/English/Frameowrk/NarDesc/Region. The Southern Arctic Ecozone, delineated by the approximate treeline to the south and by the Arctic coast on the north, extends from the Yukon coastal plain to Nunavik. Ecozones are based on a combination of landscape, climate, and living organisms in a distinct area.

The Southern Arctic Ecozone is characterized by long, cold winters (mean daily January temperature of – 28°C) and short, cool summers (mean daily July temperature of + 10°C), and 40 to 80 frost-free days per year. It includes the area historically referred to as "the Barrenlands", and is, in general, tundra underlain by continuous permafrost. The general area is also known floristically as the "low Arctic".

This ecozone represents a transition between the taiga to the south and the Arctic tundra to the north, and is characterized by dwarf shrubs (dwarf birch, willows, and heaths) decreasing in size to the north, mixed with herbs and lichens.

The study area for this project is located in two ecoregions of the Southern Arctic Ecozone. The port area and first 10 to 12 kilometers of the road corridor in the Bathurst Inlet graben are part of the Bathurst Hills Ecoregion. A mean annual temperature of – 12.5°C, with a summer mean of + 4°C and a winter mean of – 28°C, characterizes this ecoregion. The mean annual precipitation ranges from 125 – 200 mm. The climate of the coastal areas, including islands and peninsulas, is moderated by open water in the late summer and early fall. Vegetation in the Bathurst Hills Ecoregion is mostly low shrub tundra, with riparian dwarf birch, willow, and alder groves in protected stream valleys, heath-lichen tundra on the more exposed ridges, and sedge or cottongrass-dominated wetlands in pond basins. Bathurst Inlet is a graben, a downdrop block, filled over millennia with sediments washed in off the surrounding Canadian Shield, so the soil is thicker and richer than in the area south of the Inlet. Because of this, the vegetation is far more diverse and lush than even a few kilometers to the south.

South of Bathurst Inlet, the proposed road corridor is located in the Takijuq Lake Upland Region. (Takijuq Lake is more correctly known as Napaktulik Lake.) This ecoregion extends from the Arctic coast between Arctic Sound and Tree River, south to the treeline, and east in a band south of Chesterfield Inlet to Hudson Bay. It is characterized by a mean annual temperature of – 10.5°C, with a summer mean of + 6°C and Arctic mean of – 26.5°C, and the mean annual precipitation ranges from 200 – 300 mm. The vegetation of this ecoregion is similar to the Bathurst Hills ecoregion, but with far fewer species and less diversity of habitats. It is predominantly low shrub tundra, with a higher percentage of dwarf birch than at the coast, mixed with sedge communities in drainage basins, around lakes, and essentially in any depression in the land. Birch and willow riparian associations occupy some stream courses, and lichen associations

characterize bedrock outcrops and boulder fields. Esker complexes generally run in an east-west orientation, and provide a mosaic of different habitats.

Vegetation studies performed for this project are described in Chapter 3 and appropriate appendices, along with a vegetation classification system and maps of the vegetation within the proposed road corridor.

2. SURFICIAL GEOLOGY AND SOILS

CHAPTER 2

Surficial Geology and Soils

CHAPTER 2 - SURFICIAL GEOLOGY AND SOILS

This section of the report provides a general discussion of the methods employed in the inventory and mapping of surficial geology and soils.

2-1. Methods

2-1.1 Pre-Field Activities

Pre-field activities mainly involved the collection and review pertinent background data related to the project. Numerous Geological Survey of Canada documents were reviewed to obtain an understanding of the area, both from a regional and local perspective. In addition to the review of existing literature, 1:60 000 black and white aerial photographs were reviewed to obtain an understanding of general terrain conditions and to help in developing the field inventory program.

2-1.2 Field Inventory Program

A total of 119 detailed plots were established between Bathurst Inlet and Contwoyto Lake (Appendix F). All sites were accessed using a combination of helicopter access and walking.

At each plot, data was collected on the following attributes:

- Slope
- Aspect
- Drainage
- Parent material(s)
- Parent material texture
- Coarse fragment content
- Soil classification (to subgroup level)
- Modifying processes (i.e., solifluction, failing, etc.)
- GPS reading

A soil pit was dug at each site (except those sites where bedrock was prevalent). The soil pit generally went to either the underlying bedrock or to a depth of 75 cm. Notes were also made at each site to assist in later classification and route alignment. In addition, digital images were taken at most sites to capture landscape attributes.

In addition to the detailed sites, reconnaissance soils and landform data were collected at many vegetation inventory sites.

2-1.3. Post-Field Activities

Final Quaternary geology mapping occurred immediately following the mapping of bedrock geology units. Lines were delineated in stereo on the 1:15 000 aerial photographs to delineate relatively homogeneous terrain units based on parent materials, slope, drainage, bedrock type, and to a lesser extent, vegetation. To properly incorporate bedrock geology into the mapping, mylars showing bedrock units were overlain on the 1:15 000 aerial photographs to delineate and classify units based on bedrock type. Plot information was used to help classify each unit. Each unit was classified as follows:

Mb/Ru – S
0 – 9
w
O.TC

Where;

M	dominant parent material, moraine
b	dominant surface expression, blanket
R	underlying material, bedrock
u	surface expression of underlying material, undulating
S	dominant modifying process, solifluction
0 – 9	dominant slope class, 0 – 9%
w	dominant drainage class, well drained
O.TC	dominant soil subgroup, Orthic Turbic Cryosol

Terrain units were delineated along the route with an average polygon size of 6.6 ha. This amount of detail is considered to be high for 1:15 000 scale mapping; generally at 1:15 000, terrain units in the 10 – 20 ha range.

For each terrain unit, attributes were provided for

- Polygon number
- Percent dominant parent material
- Dominant parent material
- Dominant surface expression
- Dominant parent material texture
- Dominant drainage class
- Percent secondary parent material
- Secondary parent material
- Secondary surface expression
- Secondary parent material texture
- Secondary drainage class
- Percent tertiary parent material
- Tertiary parent material
- Tertiary surface expression
- Tertiary parent material texture
- Tertiary drainage class
- Slope class
- Bedrock type
- Dominant soil subgroup
- Secondary soil subgroup
- Limitations to road constructions

Terrain attributes were coded onto a data-coding sheet and subsequently entered into an Excel database. Both data coding sheets and digital databases were checked for thoroughness and accuracy.

2-1.4 Production of Final Maps

Final maps were produced by Geowest using a combination of MicroStation SE and ARC/INFO 8.1 software. Polygon line work was captured using MicroStation SE software by "tieing-down" the interpreted aerial photographs to the digital base mosaics. Features common on both the aerial photographs and the digital mosaics (i.e., hydrography points, roads, sharply contrasting vegetation communities, etc.) provided the necessary control points to tie-down and subsequently digitize the line work. Individual coverages were cleaned and built to ensure proper topology (i.e., no hanging lines, etc.), and subsequently numbered. The attribute databases were linked to the polygon coverages using the common field, POLY_NO. This allowed individual coverages to be created using ARC/INFO 8.1 software.

A map mosaic layout was developed for the mapping base. Each mosaic covers up to 6 to 8 km of road length with a 0.5 km overlap at each end (Table 4). Each mosaic is accompanied by a legend that provides an explanation of the codes used in the mapping. An example of an individual label is provided so that the user can quickly use the maps. An index map that allows the user to quickly reference each mosaic accompanies each mosaic. In addition, kilometer markers are provided for quick reference.

The mosaics are presented as follows:

Table 4. Mosaics for the Road Corridor

Route Segment	Mosaic Numbers	Note
Bathurst Inlet to Contwoyto Lake	1 – 29	Mosaic 1 starts at Contwoyto Lake

Plot files of the mosaics are available upon request.

2-2. Results of Quaternary (Surficial) Geology Inventory and Mapping

As one would suspect, various types of surficial materials occur along the Bathurst Inlet to Contwoyto Lake route. Surficial materials can be broken into two categories including glacial and post-glacial deposits. Glacial deposits include moraine and glaciofluvial deposits while post-glacial (recent) deposits include marine, lacustrine, and fluvial deposits, residual bedrock, and organic accumulations. The following provides summaries of each type of material based upon field investigations and existing information.

2-2.1. Marine Sediments – defined as sediments deposited in salt or brackish water bodies by settling from suspension and submarine gravity flows, or that have accumulated at their margins through shoreline processes such as wave action and longshore drift; may contain shells and the remains of other marine organisms (Howes and Kenk 1988). These sediments are found between Bathurst Inlet and the Amagok River up to 80 m in elevation. Well-exposed marine strandlines are visible within this area, especially along the peninsula; strandlines represent the level at which a body of standing water meets the land (i.e., shoreline).

These marine sediments are composed mainly of loamy sand to coarse sand with silt loams and loams being more common at higher elevations along the route. Colors vary from grayish brown (10YR5/2) to dark yellowish brown (10YR4/6) where poorly drained conditions are found. These sediments vary from medium acidic (pH 5.5) on the surface layers to very slightly acidic (pH 6.5) to neutral (pH 7.0). They vary in thickness from less than 50 cm (overlying bedrock) to greater than 10 m within the recently exposed marine basin west of the Bathurst Port site. For the most part, these sediments were free of coarse fragments (0 – 10%), however, at one site (Site 12), up to 80% subangular and angular fragments were found, possibly suggesting a remnant beach. Any boulders found on

the surface are suspected to be ice-rafted. Drainage is highly variable and strongly reflects topographic position with moderately well to well drained sediments being found on 2 – 15% slopes and imperfect to poorly drained sediments being found where slopes are less than 2% or where seepage was prevalent. These materials are considered to be highly pervious due to their coarse-textured nature; it is common for soil pits to fill in with water on lower slope positions. In addition, permafrost features such as solifluction were not noted – it is suspected that this is the result of the coarse-textured nature of these materials combined with the relative youthfulness of the materials.

From an engineering perspective, these sediments may pose concerns where they are greater than 1 m in thickness or where they are poorly drained. For example, along the unnamed stream west of Bathurst Inlet where sediments are greater than 10 m in thickness, pronounced gullying and some small scale natural failures were noted within the marine sediments. On lower slope positions where the marine sediments are poorly drained, consideration should be paid to reducing any channeling of waters resulting from road construction.

2-2.2 Lacustrine Sediments – defined as sediments that have settled from suspension, and occasionally by underwater gravity flows, such as turbidity currents, in bodies of standing fresh water, or sediments that have accumulated at their margins through the action of waves (Howes and Kenk 1988). Lacustrine sediments are found along the entire length of the route. These sediments are generally found in low-lying areas or depressional topography where slopes are generally less than 5%.

Figure 9. Silty clay lacustrine sediments.

East of the Mara River, lacustrine sediments are somewhat finer with textures ranging from varved clay, silty clays to silt loams; loams to fine sand are more typical west of the Mara River (Figure 9). Many of the sites investigated east of the Mara River showed strong evidence of varving, a distinct structure generally associated with lacustrine materials – a varve is defined as a sedimentary bed, layer, or sequence of layers deposited in a body of still water within a year's time, and usually during a season (Parker 1997). Like marine sediments, these sediments are generally free of coarse fragments. It is suspected that any boulders on the surface are the result of ice rafting rather than frost-heaving. These materials vary from moderately well to poorly drained, with imperfect to poorly drained conditions being the norm. They vary in color from gray (10YR5/1) to grayish brown (10YR5/2) to light yellowish brown (10YR6/4), dark yellowish brown (19YR6/4), and light olive brown (2.5Y5/2) where materials are poorly drained. pHs range from slightly acidic (pH 6.0) to alkaline (pH 8.0) where materials have been saturated with water for prolonged periods of time. Thin organic veneers may be found overlying lacustrine sediments.

East of the Mara River these finer-textured sediments may present significant issues regarding road construction and maintenance. Because of the fine-textured nature of these sediments, combined with imperfectly to poorly drained conditions, these sediments are highly susceptible to compaction and rutting. Proper beds must be constructed to ensure that existing hydrological patterns are not negatively impacted. In addition, clays and silty clays are characterized by high shrink-swell potentials which will also result in issues related to frost-heaving and other permafrost related processes (i.e., solifluction, cryoturbation).

Of particular note to the lacustrine sediments was the occurrence of "jelly-like" conditions. These "jelly-like" conditions were characterized by having imperfectly to poorly drained silty textures, no coarse fragments in the soil matrix, groundwater seepage, and permafrost processes including both cryoturbation and solifluction. These materials appear to be super-saturated and tend to flow when disturbed – natural moisture contents are very near the liquid limits so that the muds liquefy and flow readily in response to slight changes in moisture content or slight internal or external stresses (Shilts 1978). Attention needs to be paid to the occurrence of these materials, as any disturbance results in the materials immediately liquefying.

2-2.3. Fluvial Sediments – defined as materials transported and deposited by streams and rivers (synonymous with alluvial) (Howes and Kenk 1988). These sediments have been deposited in a variety of topographic positions, including landscapes adjacent active stream channels (i.e., Amagok River), low-lying topography found between shallow lakes (common near Concession Lake), and areas exhibiting flowing water.

Fluvial deposits vary from well to poorly sorted sands and gravels with the percentage of sands and gravels varying significantly between sites. These deposits varied from coarse sand with less than 10% rounded gravels and cobbles to rounded gravels in a sand matrix; in the latter case, coarse fragment content may be as high as 75 to 80%. Pea-sized gravels were common within the sandy fluvial deposits where very little gravel or cobbles were found. These sediments vary from rapidly to poorly drained depending upon the presence of groundwater flow. pH ranges from medium to slightly acidic (pH 5.5 – 6.5) with occasional alkaline (pH 8.0) deposits. Colors are highly variable due to coarse fragment content, but generally vary from light brownish gray (10YR6/2) to brown (10YR5/3).

From an engineering perspective, many of the fluvial deposits represent potential aggregate sources, however the mapping presented within is not to the level required to properly quantify aggregate potential. As mentioned above, these sediments are generally well drained, however, where drainage is poor or where springs are noted, care must be taken not to impact these areas as they will be prone to compaction, rutting, etc. Permafrost processes may or may not be present due to the coarse-textured nature of the materials.

2-2.4. Glaciofluvial Outwash – defined as sand and gravel transported away from a glacier by stream of meltwater and either deposited as a floodplain along a preexisting valley bottom or broadcast over a preexisting plain (Parker 1997). These deposits occur on a variety of landforms, but generally are found on level to near level topography where slopes are less than 2%.

Drainage in most instances is well to rapid, however imperfect to poorly drained outwash materials are found where groundwater seepage is pronounced. Textures are quite variable and range from silt loams with up to 25% rounded and subrounded gravels and cobbles to sandy gravel with up to 85% rounded and subrounded gravels. In some instances, no gravels or cobbles were found within the sandy matrix. The percentage of coarse fragments, if present, generally increases with depth. pH values are quite variable ranging from extremely acidic (ph 4.3) to alkaline (pH 8.0). Like most coarse-textured materials, color values are quite variable and range from grayish brown (10YR5/2), pale brown (10YR6/3), light brownish gray (10YR6/2) to dark brown (7.5YR4/4). Frost-heaved boulders and stones are common on the surface. Cryoturbation is quite common within these outwash materials as soil profiles commonly show extensive cryoturbation. For example cryoturbated colors are generally a reddish brown (5YR4/4) as compared to a matrix color of light brownish gray (10YR6/2).

At one area "jelly-like" conditions were observed similar to those described above for lacustrine sediments. Textures were somewhat finer (sandy loam versus sands and sandy gravel) and drainage varied from moderately well to poor; once dug, the soil pit in-filled with liquified sandy material within minutes.

From an engineering view, some of these outwash deposits may provide good aggregate sources, however, a quantitative assessment of these materials as a source of aggregate was not part of the terms of reference for the project. In most instances, outwash materials will provide a suitable bed for potential roads as drainage is generally well to rapid.

Figure 10. Classic esker - kettle complex found at kilometer 194 (polygon 1312).

2-2.5. Glaciofluvial Eskers – defined as a sinuous ridge of constructional form, consisting of stratified accumulations, glacial sand and gravel (Parker 1997); formed by deposition from meltwater running through a channel beneath or within glacier ice (Howes and Kenk 1988). In a study of the Keewatin area of Northwest Territories (and Nunavut) Aylsworth and Shilts (1989) suggest that extremely large esker complexes are rare – contrary to this, a number of large, significant esker complexes occur within the Bathurst Inlet to Contwoyto Lake area (Figure 10). Some of the eskers are up to 30 m in thickness and extend for over 10 km in length.

Eskers were sampled within the one-kilometer corridor. Figures 11, 12 and 13 show the location of major and minor esker complexes identified from the 1949/50 1:60 000 scale aerial photographs; the purpose of these figures is to show the extent of eskers within the general corridor area and their extent. Major esker complexes are identified as those that are significantly large and can be delineated as a polygon at 1:60 000. Minor esker complexes are too small to delineate as a polygon at 1:60 000, but are nonetheless, easily observed on the aerial photographs; these minor esker complexes generally tend to be narrow sinuous ridges of variable length.

For the most part, eskers along the route had side slopes of 30 – 50%, however esker slopes within the Amagok River valley range up to 70%. Well-defined kettle holes were noted at a number of the eskers; kettles are defined as bowl-shaped depressions with steep sides in glacial drift deposits that are formed by the melting of glacier ice left behind by the retreating glacier and buried in the drift (Parker 1997).

One of the most significant features of the eskers found along the route is that most are armored with gravels, cobbles, stones and boulders; coarse fragment content on the surface varies in most instances, from 35 to 85% thereby preventing excavation with a shovel. Research by Mueller (1995) suggests that many of the eskers along this route may be ice-cored rather than consisting of traditional sands, gravel, cobbles, stones, and boulders (i.e., large esker complexes immediately west of road between 90 – 94 km; numerous kettle holes have formed within esker as a result of melting of buried ice).

Figure 11. Major and Minor Esker Complexes Contwoyto Lake to Kilometer 75

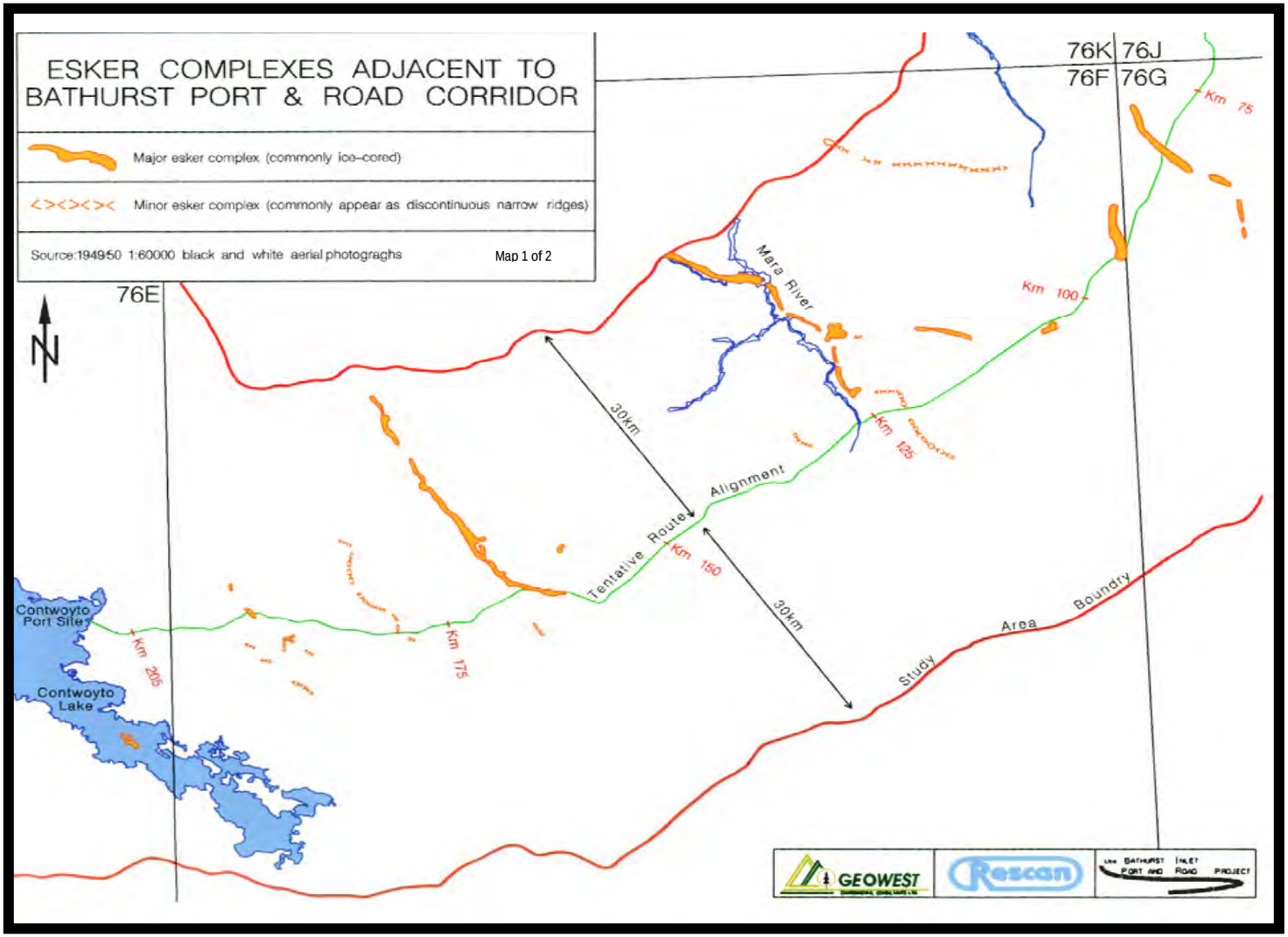


Figure 12. Major and Minor Esker Complexes Between Bathurst Inlet and Kilometer 75.

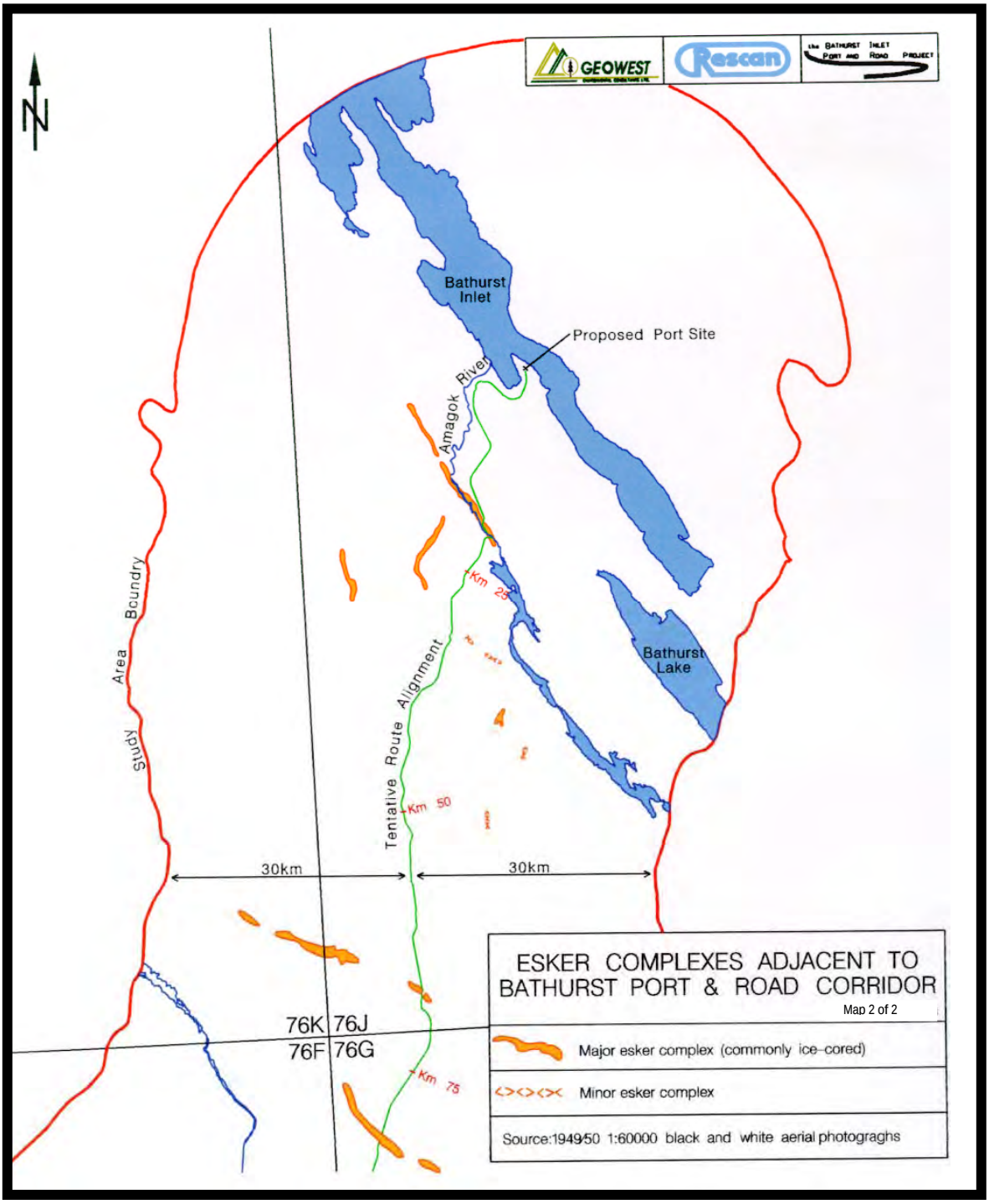


Figure 13. Exposed esker materials adjacent to the Amagok River.

Where eskers could be excavated by shovel, textures generally varied from coarse sand to sandy gravel with up to 70% rounded gravels and cobbles (Figure 14). Because of the coarse-textured nature of these materials, drainage is generally rapid. pH values are generally slightly to very slightly acidic (pH 6.0 - 6.5) to alkaline (pH 8.0) (along the Amagok River). Colors vary from dark grayish brown (10YR4/2), light brownish gray (10YR6/2) to yellowish brown (10YR5/6). Because of the coarse-textured nature of these deposits, combined with their ridged form, thin aeolian sediments were found overlying these eskers at a number of sites. Permafrost processes such as cryoturbation are not common within the upper 100 cm of these landforms.

Although it was not the intention of this study to provide a quantitative assessment of aggregate potential within these eskers, it would appear that most of the eskers (and associated kettle complexes) provide excellent aggregate sources for road construction. Of note however, is that eskers provide valuable habitat for many of the wildlife species in the area, including wolves, grizzly bear, wolverines, etc. (Mueller 1995).

2-2.6. Morainal Deposits – also known as "till"; generally consists of well-compacted to non-compacted material that is non-stratified and contains a heterogeneous mixture of particle sizes, often in a matrix of sand, silt and clay (Howes and Kenk 1988); defined as an accumulation of glacial drift deposited chiefly by direct glacial action and possessing initial constructional form independent of the floor beneath it (Parker 1997).

Textures are quite variable, ranging from silty clays to gravelly sand; however, the majority of tills were loamy sands. Table 5 provides a breakdown of textural classes..

Table 5. Textural Breakdown for Morainal Materials Sampled along Route

Texture Class
Silty clay
Silty loam
Sandy loam
Loamy sand
Sand
Gravelly sand

These materials vary in thickness from lithic (< 10 cm) to veneers and blankets (> 100 cm) overlying bedrock to thick morainal deposits (i.e., drumlins) in excess of 20 m in thickness. As would be expected with tills covering an area of approximately 300 km in length, coarse fragment content is quite variable; coarse fragment content varied from 5% subrounded and subangular gravels and cobbles to greater than 75% subrounded boulders and stones. 60% of the tills sampled had less than 25% coarse fragment content while 27% had between 25 – 50% coarse fragment content. An analysis of the drainage suggests that the majority of these morainal materials are moderately well to

well drained with approximately 25% of the tills sampled having imperfect to poor drainage. These imperfect to poorly drained tills are generally found on lower slopes where seepage may be present. Well-drained tills vary from grayish brown (10YR5/2), light yellowish brown (10YR6/2) to pale brown (10YR6/3) in color. Where tills are poorly drained, colors vary from dark brown (10YR4/3) to dark grayish brown (2.5Y4/2). pH generally is very slightly acidic to neutral (pH 6.5 – 7.0), however, slightly more acidic tills (pH 5.3) are also found.

Figure 14. Boulder belt within morainal plain.

Permafrost processes have resulted in many of these till deposits showing strong evidence of patterned ground. In areas where patterned ground is common, up to 50% of the mineral materials are exposed at the surface. Frost heaving is quite common as subangular cobbles and stones commonly extrude from the mineral surface. Much of the till materials show strong evidence of both solifluction and cryoturbation.

Nearly 10% of the total morainal sites investigated were characterized by the occurrence of "jelly-like" conditions. Unlike the lacustrine sites where these conditions were found, textures range from silt and silt loams to loamy sand and drainage varied from moderately well to poor with significant amounts of groundwater seepage. The sites sampled all tended to have approximately 25% coarse fragments. Solifluction was observed at all of the six sites sampled.

Figure 15. Boulder field found on lower morainal slope positions; appears that all fines have been eroded away by water.

Two morainal landforms of significance that occur with a high degree of regularity include boulder belts (Figure 15) and boulder fields (Figure 16); both were sampled along the Bathurst Inlet to Contwoyto Lake corridor. A boulder belt is a long, narrow accumulation of boulders elongately transverse to the direction of glacier movement. These boulder belts are generally found on upland topography and may take the form of non-sorted stripes. Highly eroded boulder fields are common on lower slope positions adjacent to lakes or in depressional topography. In these areas, finer sediments (i.e., sands, silts, and clays) have been eroded away mainly by fluvial processes resulting in extensive areas of boulders without any apparent surficial materials. Snow accumulates between these boulders resulting in small ponds being common between boulders during the summer months.

For the most part, the morainal materials sampled along the corridor provide a good source bed for the road. Moderately well to well drained loamy sands occurring on slopes of less than five percent are highly favored. On these materials, permafrost processes, although common, are not as significant as those found on steeper slopes where solifluction is more pronounced. Care should be taken to avoid low-lying morainal area where groundwater seepage and seasonally high water tables contribute to poorly drained conditions. If the road is to pass through these wetter areas then proper drainage systems will have to be developed so that natural hydrological regimes are not disturbed.

2-2.7. Residual Bedrock – defined as unconsolidated or partly weathered parent materials of soil, presumed to have developed in place (by weathering) from the consolidated rock on which it lies (Parker 1997). While residual materials are common within the project area, it was only sampled at a site located between the Bathurst Port site and the Amagok River. It is assumed that these materials are found mainly in areas underlain by sedimentary bedrock, as sedimentary rocks are more easily weathered and subject to cryogenic weathering (i.e., ice wedging, frost shattering, etc.). Residuum is not anticipated to occur in areas dominated by igneous bedrock; although frost shattering is certainly common in areas of igneous bedrock, igneous rocks do not weather to the same extent as sedimentary rocks and results in basically shattered bedrock.

Figure 16. Thick organic accumulations occurring adjacent to small lakes; organics commonly underlain by sand.

In the case of the site sampled, the residuum consisted of up to 90% platy cobble-sized fragments in a sandy matrix. Bedrock was noted in a side cut within 75 cm of the mineral surface. The weathered bedrock materials occurred parallel to the surface and consisted mainly of red shale materials. These materials are rapidly drained and commonly overlain with only a thin layer of litter.

Because bedrock is generally found within 100 cm of the mineral surface, these residual materials provide suitable bed materials for any proposed road.

2-2.8. Organic Accumulations – consists of peat deposits containing greater than 30% organic material by weight that may be as thin as 10 cm if they overlie bedrock but are otherwise greater than 40 cm and generally greater than 60 cm thick (Agriculture Canada 1987).

Organic soils are associated with low-lying, poorly to very poorly drained depressional topography where the water table is at or near the surface for most of the year. This results in highly saturated conditions and the accumulations of sedge and sphagnum peats. Most of the peats were fibric to mesic in nature (Figure 17). Ice and clay lenses are common. These accumulations are generally less than 50 cm in thickness, but may exceed 100 cm. They are generally found overlying lacustrine and morainal materials or bedrock. Frost heaving is common as boulders and stones commonly are found on the surface of many organics. Any disturbance to organic accumulations will result in significant impacts to the local hydrological regime.

2-3. Evaluation of Parent Materials for Road Location

Each parent material has a set of different limitations for road construction and hence certain materials are more preferred than others. Table 6 provides soil limitation classes for all-weather roads. They consist of:

- Underlying local parent material (either cut or fill) called subgrade;
- The base material of gravel, crushed rock or soil cement stabilized soil called the subbase; and
- The actual road surface, either flexible or rigid.

Priorities that affect design and construction of roads are:

- Those that affect the load supporting capacity and stability of the subgrade; and
- Those that affect the workability and amount of cut and fill.

The Unified Classifications (Table 7), and the shrink-swell potential give an indication of the traffic supporting capacity. Wetness and flooding affect stability. Slope, depth to bedrock, stoniness, rockiness, and wetness affect the ease of excavation and the amount of cut and fill required to reach an even grade.

Table 6. Materials Limitations for Road Location (adopted from Greenlee 1981)

Properties Affecting Use	Degree of Limitation			
	None to Slight	**Moderate**	**Severe**	**Very Severe**
Flooding	None	Infrequent (Once in 5 years)	Occasional (Once in 2 – 4 years)	Frequent (Every year)
Wetness	Rapid to moderately well; no seepage or ponding; seasonal water table greater than 150 cm.	Moderately well drained; occasional seepage or ponding; imperfectly drained with no seepage or ponding; seasonal water table 100 – 150 cm.	Imperfectly drained soils; seepage or ponding, poorly and very poorly drained materials; seasonal water table 50 – 100 cm.	Permanently wet materials; water table less than 50 cm.
Slope	0 – 9%	10 – 15%	15 – 30%	> 30%
Shrink-Swell Potential	Low – Unified Groups GW, GP, SW, SP, GM, GC, SM, SC	Moderate – Unified Groups CL with plasticity index < 15, ML	High – Unified Groups CL with plasticity index $\geq$ 15, CH, MH, OH, OL, Pt.	

[1] from United States Army Corps of Engineers (1962).

Table 7. Unified Soil Classification System (adopted from Portland Cement Association)				
Major Divisions			**Group Symbols**	**Typical Names**
a) Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Gravels	Clean Gravels	GW	Well-graded gravels, gravel – sand mixtures, little or no fines.
			GP	Poorly graded gravels, gravel – sand mixtures, little or no fines.
		Gravels with appreciable fines	GM	Silty gravels, gravel – sand – silt mixtures.
			GC	Clayey gravels, gravel – sand – clay mixtures.
	Sands	Clean sands	SW	Well-graded sands, gravelly sands, little or no fines.
			SP	Poorly graded sands, gravelly sands, little or no fines.
		Sands with appreciable fines	SM	Silty sands, sand-silt mixtures.
			SC	Clayey sands, sand – silt mixtures.
b) Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silts and clays (Liquid limit < 50)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity.
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL	Organic silts and organic silty clays of low plasticity.
	Silts and clays (Liquid limit > 50)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
			CH	Inorganic clays of high plasticity, fat clays.
			OH	Organic clays of medium to high plasticity, organic silts.
	Highly organic soils		Pt	Peat and other highly organic soils.

Table 8 provides a summary of the limitation by parent materials. It should be stressed that the comments provided are for general conditions described for each material and any detailed planning will require additional field sampling. Adverse terrain type has been highlighted in red.

Table 8. Limitations for Road Location based on Parent Material Type	
Parent Material Type	**Limitations For Road Location**
Moraine	For the most part, morainal materials provide suitable conditions for road location; morainal materials are moderately well to well drained and are moderately coarse with between 10 – 50% subrounded and subangular cobbles and gravels; except in areas where slopes are ≥ 15% or where drainage is poor, they present very few limitations to road construction; Unified Groups include SM to ML with none to moderate limitations for shrink-swell potential (the later where silty clays are found) and moderate to severe limitations for potential frost action; the more severe limitations are associated with silty clays rather than the loamy sands. **Jelly-like Conditions** – although these morainal materials cannot be distinguished from other morainal deposits (on aerial photographs), they present a significant limitation to road construction and maintenance; these materials are super saturated and tend to flow when disturbed – natural moisture contents are very near the liquid limits so that the muds liquefy and flow readily in response to slight changes in moisture content or slight internal or external stresses; if noted in the field, these types of deposits should be avoided - any disturbance results in the materials immediately liquefying; Unified Groups include CL to OH with severe limitations for shrink-swell potential and potential frost action.

Table 8. Limitations for Road Location based on Parent Material Type

Parent Material Type	Limitations For Road Location
	Boulder Belts – these features represent favorable areas for road construction as they area generally found on well drained upper slope and crest positions; the high percentage of coarse fragments on the surface represent good bed material for road construction; Unified Groups include GW to GC and hence none to slight limitations for both shrink-swell potential and potential frost action. **Boulder Fields** – these conditions present obstacles to road construction in that, where extensive, they may have to be avoided or filled in with finer materials; in lowland areas, frost heaving is common as these areas represent snow accumulation areas and the development of ponds in the summer months; Unified Groups include GW.
Glaciofluvial Outwash	From an engineering perspective, most outwash materials provide a suitable bed for potential roads as drainage is generally considered to be well to rapid; in addition, some of these outwash deposits may provide good aggregate sources; Unified Groups include GW to SP resulting in none to slight limitation for both shrink-swell potential and potential frost action. **Jelly-like Conditions** – although not common, one site was sampled where "jelly-like" conditions were found; although these "jelly-like" sediments cannot be mapped, care should be taken to avoid these conditions (see above).
Glaciofluvial Eskers	A number of significant esker complexes are found in the project area; while topography (30 – 70% slopes) commonly limits the use of these landscape features for potential road location, they provide suitable aggregate resources for road construction; unfortunately, none of the eskers were sampled (within the context of this study) to determine their suitability for aggregate; Unified Groups include GW to GP, hence there are no limitations for road location regarding wetness, shrink-swell potential or potential frost action; slopes present very severe limitations for road location; low and flat-topped eskers provide better road bed.
Lacustrine	East of the Mara River, lacustrine sediments present severe limitations for road construction and maintenance due to their fine-textured nature; these sediment types are generally found on lower slope positions adjacent existing shallow lakes; Unified Groups include ML to CH with severe limitations for road location due to high shrink-swell potential and potential frost action and moderate to severe limitations due to wetness. West of the Mara River, coarser-textured sediments present lesser limitations for road location; Unified Groups include SP to SC with none to slight limitations due to shrink-swell potential and potential frost action; where textures are somewhat heavier, moderate limitations may be experienced. **Jelly-like Conditions** – as discussed above, the occurrence of these types of sediments will pose significant limitations for road construction and maintenance; although these "jelly-like" sediments cannot be mapped, care should be taken to avoid these conditions (see above).
Marine	Marine sediments on upland slopes should not pose any major issues for road construction or maintenance; Unified Groups include SW to SP and hence there are none to slight limitations for both shrink-swell potential and potential frost action; on upper elevations where textures are somewhat finer (i.e., SiL), Unified Groups include SM to ML and hence there may be moderate limitations due to shrink-swell potential and severe limitations due to potential frost action. **Stream Crossing** - in the unnamed stream (Bathurst km 2.5) west of Bathurst Inlet where sediments are greater than 10 m in thickness, pronounced gullying and some small scale natural failures were noted within the marine sediments; while the sediments have Unified Groups of SW to SP, active erosion of the stream channel will present issues that need to be addressed for road construction; because these sandy to loamy sand sediments are relatively recent, they tend to be highly erosive and subject to small -scale failures.

Table 8. Limitations for Road Location based on Parent Material Type	
Parent Material Type	**Limitations For Road Location**
	Lower Slopes - on lower slope positions where the marine sediments are poorly drained, two problems may occur; (1) because of the coarse-textured nature, these sediments, especially where thick) are easily rutted and hence a proper roadbed of crushed gravels will be needed; and (2) consideration should be paid to reducing any channeling of waters resulting from road construction.
Rock	The use of rock surfaces for potential roadbeds is highly dependent upon slope and rock type. Where rock surfaces are polished and slopes are less than 10%, very few limitations are present. **Highly Fractured Sedimentary Bedrock** – highly fractured sedimentary bedrock was noted along the steep valley walls of the Amagok River; these fractured shales do not provide favorable foundation materials for either bridges or roads; sedimentary bedrock is highly susceptible to ice wedging and subsequent frost-shattering. **Escarpments** – many small bedrock escarpments have been mapped along the route; these escarpments are generally less than 10 m in height and can be blasted to allow the road to cut through the escarpment. **Steep Slopes** – where slopes are in excess of 15%, bedrock slopes become unfavorable topography for road location; slopes commonly exceed 30% and are as high as 70% $^{+}$.
Fluvial	**Flooding** - Although fluvial materials have favorable Unified Groups (i.e., GW to GP) for road locations, these sites should be avoided wherever possible due to flooding (and sensitive habitats).
Residual	Residual materials, although a form of weathered, fractured bedrock, appear to provide favorable foundations for roadbed as these materials are generally less than 75 cm in thickness overly more favorable bedrock structures.
Organic	**Organic materials** – should be avoided as much as possible as disturbance to these accumulations results in significant rutting, compaction and severe alterations to existing hydrologic conditions.

2-4. Soils

Soils of the Cryosolic Order are widespread within the Bathurst Inlet to Contwoyto Lake area. These soils have formed in either mineral or organic materials having permafrost either within 1 m of the surface or, if the soil is strongly cryoturbated, within 2 m of the surface, and having a mean annual soil temperature of below 0 ^{o}C (Agriculture Canada 1987). Three Great Groups have been identified within the Cryosolic Order during the field-sampling program, including Turbic Cryosols, Static Cryosols, and Organic Cryosols. The following descriptions are taken from the *Canadian System of Soil Classification, 2nd Edition* (Agriculture Canada 1987).

Figure 17. Brunisolic Turbic Cryosol.

2-4.1. Turbic Cryosols

The Turbic Cryosol Great Group are soils that have developed primarily in mineral material and have marked evidence of cryoturbation. They generally occur on patterned ground, which includes such cryogenic forms as sorted and nonsorted circles, nets, polygons, stripes, and steps in stony or coarse-textured materials and nonsorted units such as earth hummocks in medium and fine-textured materials. Processes include sorting of different sized particles and mixing of both mineral and organic material from different horizons. Organic (Oy) or organic-rich, mineral horizons (Ahy) are characteristically present. Turbic Cryosols have marked evidence of cryoturbation as indicated by broken horizons and displaced material in more than one-third of the pedon and permafrost within 2 m of the surface.

Four subgroups have been identified within this Great Group, including (1) Orthic Turbic Cryosols, (2) Brunisolic Turbic Cryosols (Figure 18), (3) Regosolic Turbic Cryosols, and (4) Gleyed Turbic Cryosols. Each is described below.

Orthic Turbic Cryosols (O.TC) – these soils occur extensively throughout the Bathurst Inlet to Contwoyto Lake area and are characterized by the following:

(i) Having a Bm horizon less than 10 cm thick or a Bmy horizon or both;
(ii) The horizons are strongly disrupted by cryoturbation; tongues of mineral and organic horizons, organic and mineral intrusions, and oriented stones occur commonly; and

(iii) The surface horizons are not strongly gleyed, but there is usually a gleyed horizon immediately above the permafrost table.

Orthic Turbic Cryosols usually have a Bmy horizon and subsurface organic (Omy, Ohy) or organic-rich, mineral horizons (Ahy). Common horizon sequence: Om, Bmy, Bcy, Cgy, Omy, Cz.

Brunisolic Turbic Cryosols (BR.TC) – these soils have the general properties specified for the soils of the Cryosolic order and the Turbic great group (Figure 18). They differ from Orthic Turbic Cryosols by having a Bm horizon more than 10 cm thick and continuous over the imperfectly to well drained part of the pedon that is relatively unaffected by cryoturbation. Common horizon sequence: Om, Bm, Bmy or Bcy, Cgy, Omy, Cz.

Regosolic Turbic Cryosols (R.TC) – these soils have the general properties specified for the soils of the Cryosolic order and the Turbic great group. They differ from Orthic Turbic Cryosols by lacking Bm and Bmy horizons. Usually these soils do not have sufsurface Ahy or Oy horizons, or intrusions. Common horizon sequence: Om, Cy, Cgy, Cz.

Gleyed Turbic Cryosols (GL.TC) – these soils have the general properties specified for the soils of the Cryosolic order and the Turbic great group. They differ from Orthic Turbic Cryosols by having evidence of gleying in the form of low chromas or mottling to the mineral surface. Layers thinner than 40 cm may overlie the surface mineral horizon, Bgy or Cgy. Common horizon sequence: Om, Bgy or Cgy, Cz.

2-4.2. Static Cryosols

Figure 18. Orthic Static Cryosol developed in rapidly drained outwash sands.

Soils of the Static Cryosols Great Group either show no evidence of cryoturbation or have features indicative of cryoturbation in less than one-third of the pedon, and they have permafrost within 1 m of the surface. Four subgroups have been identified within this Great Group, including (1) Orthic Static Cryosols, (2) Brunisolic Static Cryosols, (3) Regosolic Static Cryosols, and (4) Gleyed Static Cryosols. Each is described below.

Orthic Static Cryosols (O.SC) – these soils occur extensively throughout the Bathurst Inlet to Contwoyto Lake area and have the general properties specified for the Cryosolic Order and the Static Cryosol great group (Figure 19). They have a Bm horizon less than 10 cm thick. The surface horizons are not strongly gleyed, but gley features occur immediately above the permafrost table. Common horizon sequence: Om, Bm, BCgj, Cz.

Brunisolic Static Cryosols (BR.SC) – these soils have the general properties specified for the soils of the Cryosolic order and the Turbic great group. They differ from Orthic Static Cryosols by having a Bm horizon more than 10 cm thick. Common horizon sequence: Bm, BCgj, Cz.

Regosolic Static Cryosols (R.SC) – these soils have the general properties specified for the soils of the Cryosolic order and the Turbic great group. They differ from Orthic Static Cryosols by lacking Bm horizons. They may have thin peaty organic layers and a thin Ah horizon. Common horizon sequence: C, Cz.

Gleyed Static Cryosols (GL.SC) - these soils have the general properties specified for the soils of the Cryosolic order and the Turbic great group. They differ from Orthic Static Cryosols by having evidence of gleying in the form of low chromas or mottling to the mineral surface. Organic layers thinner than 40 cm may overlie the surface mineral horizon, Bg or Cg. Common horizon sequence: Om, Bg or Cg, Cz.

2-4.3. Organic Cryosols

These are Cryosolic soils that have developed principally from organic material. Landforms associated with Organic Cryosols include palsas, peat polygons, and high center polygons. An Organic Cryosol has a surface layer that contains more than 17% organic carbon by weight, about 30% organic matter. It is more than 40 cm thick, or

more than 10 cm thick over a lithic contact (i.e., rock), or more than 10 cm thick over an ice layer that is at least 30 cm thick. Permafrost occurs within 1 m of the surface.

Four subgroups of Organic Cryosols were identified, including Fibric Organic Cryosols, Mesic Organic Cryosols, Terric Fibric Organic Cryosols and Terric Mesic Organic Cryosols. Each is described below.

Fibric Organic Cryosol (FI.OC) – These soils have the general properties specified for the Cryosolic order and the Organic Cryosol great group. Also, they have organic layers thicker than 1 m, and the material is dominantly fibric in the control section below a depth of 40 cm. Common horizon sequence: Of or Om, Of, Ofz.

Mesic Organic Cryosol (ME.OC) – These soils have the general properties specified for the Cryosolic order and the Organic Cryosol great group. Also, they have organic layers thicker than 1 m, and the material is dominantly mesic in the control section below a depth of 40 cm. Common horizon sequence: Of or Om, Om, Omz.

Terric Fibric Organic Cryosol (TFI.OC) – These soils have the general properties specified for the Cryosolic order and the Organic Cryosol great group, however, they have a mineral contact within 1 m of the surface and are composed dominantly of fibric material above the contact. Common horizon sequence: Of, Ofz, Cz.

Terric Mesic Organic Cryosol (TMI.OC) – These soils have the general properties specified for the Cryosolic order and the Organic Cryosol great group, however, they have a mineral contact within 1 m of the surface and are composed dominantly of mesic material above the contact. Common horizon sequence: Om, Omz, Cz.

2-4.4. Discussion of Soils Mapping

An analysis of the 119 detailed plots suggests that Turbic Cryosols are more common on upland sites than Static Cryosols. Turbic Cryosols have developed in a variety of parent materials, including moraine, and lacustrine. In many of the morainal and lacustrine materials, somewhat finer-textured sediments (sandy loams, loams, silty clays, etc vs. loamy sand, sand, gravelly sands) tend to result in pronounced cryoturbation; disrupted and broken horizons incorporating materials from other horizons are common within the soil profile. All four subgroups may be present on the landscape with Regosolic Turbic Cryosols occurring on crest positions (where materials are shallow), Orthic and Brunisolic Turbic Cryosols on mid slope positions, and Gleyed Turbic Cryosols on lower slopes where seepage is common. Gleyed Turbic Cryosols also develop in level to nearly level areas where water may be at or near the mineral surface for a portion of the year; in these cases, thin organic materials (Om, Ah) are common. Figures 19 and 20 are schematic diagrams showing typical landscape positions for many of the soils types.

Static Cryosols are common within coarser-textured materials, including marine, glaciofluvial (outwash, eskers, etc.) and fluvial sediments. These soils generally have well-developed Bm horizons and show no evidence of cryoturbation. These sediments tend to be well to rapidly-drained with significant interstitial space between mineral particles (i.e., sand). These soils, especially within coarse-textured esker, outwash and marine landforms, tend to be transitional to Eutric Brunisols, as permafrost is commonly not found within 1 m of the surface; many of these soils that appear to be transitional to the Brunisolic Order tend to have well-developed Ae and Bm horizons.
All four subgroups have been identified in the field. Brunisolic Static Cryosols occur extensively on sandy to gravelly glaciofluvial materials while Regosolic Static Cryosols are common on fluvial sediments. Gleyed Static Cryosols are found on lower slope positions were groundwater seepage is common.

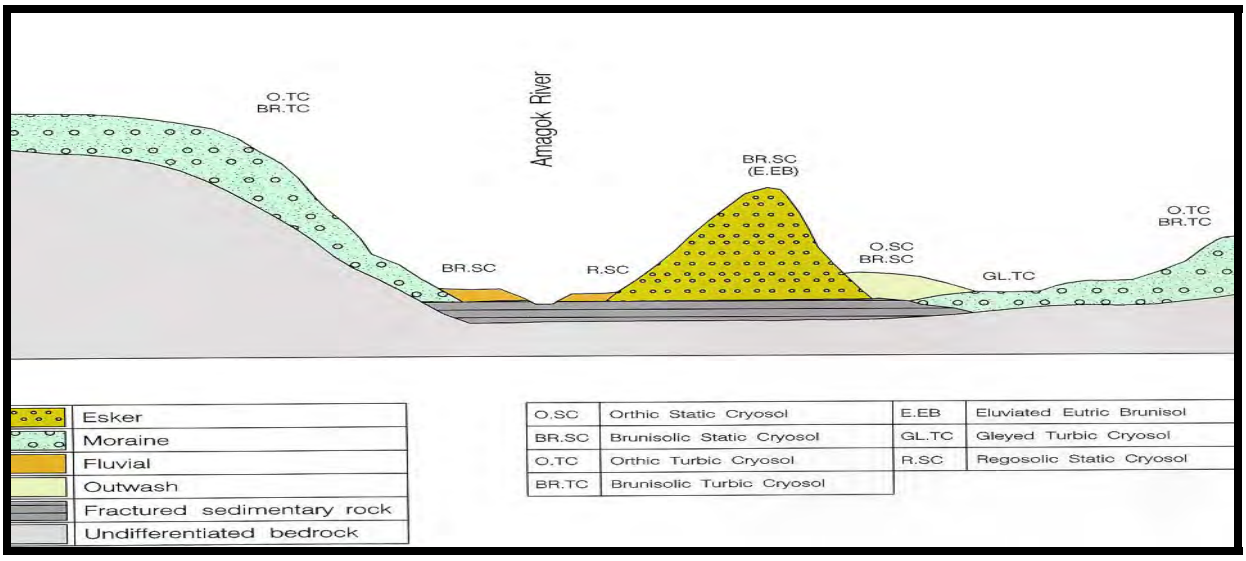


Figure 19. Schematic diagram of soils and parent materials within and near the Amagok River valley.

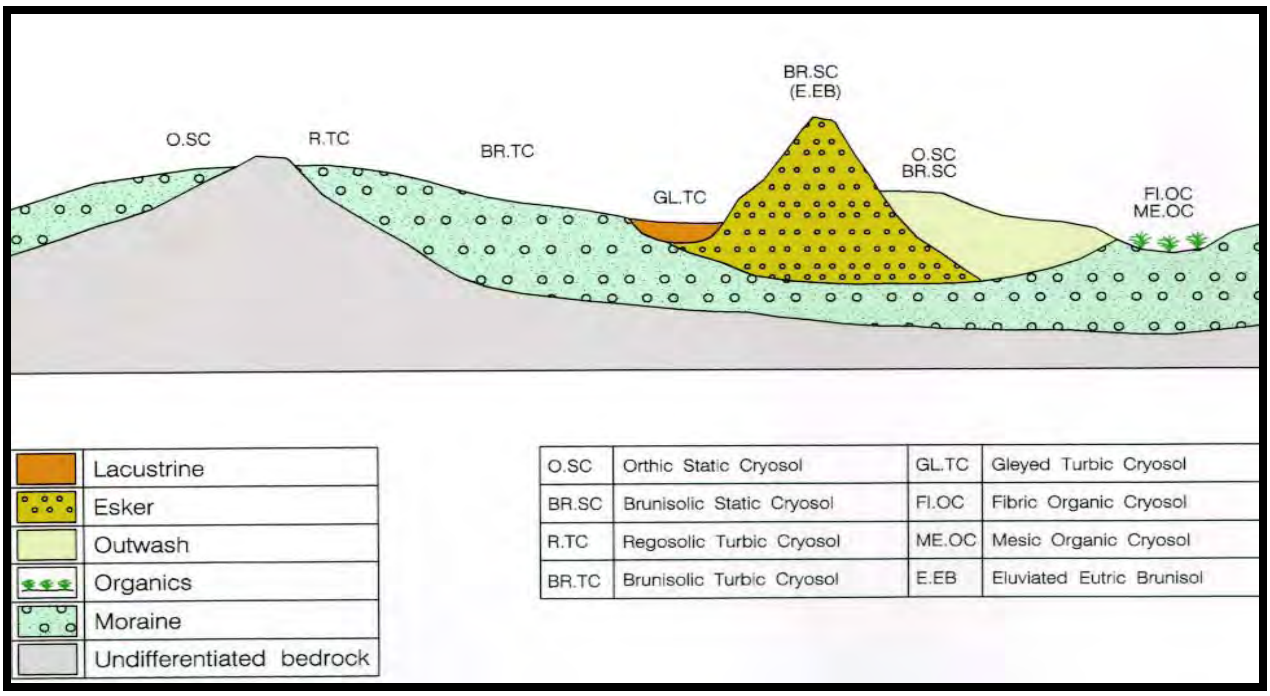


Figure 20. General schematic diagram of soils and parent material relationships.

Organic soils occur on lower slope and valley bottom positions. These soils tend to grade in composition between fibric and mesic materials. Both Terric subgroups are found where there is a mineral contact within 1 m of the surface.

2-5. Recommendations

Two assumptions are made to provide the following recommendations:

- The proposed route is to be a winter-road only; and
- The exact road location will be the result of alignment changes in the field (during construction).

1. It is recommended that the attached surficial geology maps be used to assist in the final route alignment. Not only is surficial geology information provided for each unit, but limitations for road location are also provided. By reviewing the labels for each polygon, the user will be able locate where obstacles are found that may result in increased costs. For example, in some polygons no limitations are presented, as the topography is favorable for road location; conversely, other units may have between one to three limitations for constraints such as fractured bedrock, steep slopes, flooding, excessive boulders, etc.

2. In the event that the road becomes an all-season road, it will be very important to determine the extent and location of the "jelly-like" materials (described above). The super-saturated nature of these materials results in them liquefying rapidly when disturbed, hence there will be significant difficulties in using such terrain for a potential all-season roadbed. The sampling conducted as part of this study has not provided sufficient detail on where these materials are found. It was noted that these highly sensitive sediments were found on lacustrine and morainal materials, and to a lesser extent, outwash materials. Consistent road traffic, thawing of the mineral surface, and continuous vibration of soil particles (from road traffic) will ultimately result in liquification of materials and significant maintenance issues. During the construction phase, field technicians should probe surficial materials ahead of the road construction to determine if, in fact, these "jelly-like" materials exist.

3. Silty clay lacustrine materials were noted adjacent a number of ephemeral lakes and in low-lying areas where imperfectly to poorly drained conditions occur. These fine-textured materials have a high shrink-swell potential which will ultimately be strongly affected by frost penetration and, if thawed, by rutting. These areas should be avoided, if possible. It should be noted, however, that many of the lacustrine sediments sampled tended to be coarser-textured (i.e., sandy loams). Likewise, all organic materials should be avoided if possible as these are negatively impacted by road activities.

4. The bridge crossing the Amagok River will need to be constructed with the knowledge that the area is underlain with highly fractured clastic sedimentary rock of the Goulburn Group (Figure 21). Not only is this bedrock easily weathered, but it also provides poor foundation rock for construction and pilings (relative to intrusive igneous rocks). It is also believed that over the long-term, constant truck traffic will result in negative vibrations within the bedrock, thereby weakening its properties. This may have implications on the span of the bridge; it is recommended that a detailed study be undertaken of this area to determine the best possible location for

construction. Because of the steep slopes immediately adjacent to the river, solifluction is common and hence the surface materials are already "flowing" downhill (to some extent).

Figure 21. Highly fractured sedimentary shales along Amagok River.

In addition to the highly fractured sedimentary bedrock, it is also recommended that construction activities avoid the strongly sloping materials found immediately south of the proposed Amagok River crossing on the west side of the river. It appears that the proposed bridge will occur immediately north of materials that have failed (Polygon 4280) and are actively slumping. In addition, although the road does not currently appear to cross polygons 4136, 4137 and 54136, any attempt to relocate the road in these areas should be undertaken with great care as many of the strong slopes show strong evidence of instability.

5. Erosion control structures are recommended in the vicinity of the bridge that will cross the unnamed stream (Bathurst km 2.5) running south from Bathurst Inlet immediately adjacent to the port site. The proposed crossing is approximately 2,250 m west of the road terminus. This stream has eroded through coarse-textured sandy marine sediments resulting in a number of naturally occurring small-scale slump failures and deeply incised gullies along the stream course. The installation of erosion control structures in this area should result in a more stable environment. The bridge should be located to avoid these failures and gullies.

3. VEGETATION COMMUNITIES AND ECOSYSTEM MAPPING

CHAPTER 3

Vegetation Communities & Ecosystem Mapping

CHAPTER 3 – VEGETATION COMMUNITIES & ECOSYSTEM MAPPING

3-1. History of Vegetation Studies in the Central Arctic

The first plant specimens collected from the Bathurst Inlet area were colleted by John Richardson, the Surgeon – Naturalist from the Franklin Expedition in 1820-1821. W.J. Hooker used this collection in writing the Flora Boreali – Americana. Richardson's specimens are preserved in the herbarium at Kew (Porsild and Cody, 1980). The Canadian Arctic Expedition of 1913 – 1918 completed the next extensive biological work. On this expedition, Johanson, Anderson, Cox, and O'Neill collected plants, and their collections, along with material collected by Reverends Stringer, Girling, and Captain Joseph Bernard, were recorded in a report by Macoun and Holm (1921). However, the Canadian Arctic Expedition did not travel far inland, certainly not to the area included in this study. In the very important work, *Vascular Plants of Continental Northwest Territories, Canada*, Porsild and Cody (1980) summarize the history of collecting in what is now the continental portion of the Northwest Territories and Nunavut. Because this reference is readily available, material in it is not further summarized here.

When the Bathurst Inlet area was under consideration as a national park, a survey of the natural resources of the area was done. This includes much information on the plants of the area (Zoltai *et al*., 1980). Also in the late 1980s, an environmental assessment of the Lupin Mine was completed, and a report including information on the vegetation was produced (Mary Collins Consultants, 1980). A follow-up paper on the effects of road and tailings pond dust around Lupin Mine should be of use in this project (Svoboda, 1997). However, up until about 1989, the flora of the area commonly called the *"Central Barrenlands"* was very poorly known, as is evident in the gaps in the range maps in Porsild and Cody.

During the past 12 years however, due to the huge expansion of exploration and development of the diamond mines and several other mineral properties, a considerable amount of environmental baseline work has been produced in the area extending from the Coppermine River to the Western River, and from the coast at Bathurst Inlet, south to the Lac de Gras area. In addition, work completed for the Bathurst Inlet Lodge has resulted in the publication of a color field guide based on the plants of the central Arctic and specifically, Bathurst Inlet (Burt, 1991, 2000).

Plans for development of a territorial park at Bloody Falls on the Coppermine River resulted in a literature survey and assessment of environmental work required for the development of the park (Burt and Hubert, 1996).

Once the development work on the diamond mines was initiated, vegetation studies were completed, tremendously increasing the knowledge of the vegetation and habitats of the central barrenlands. The Environmental Impact Statement for BHP's Ekati Diamond Mine (BHP/Diavik, 1996) and a 1995 baseline study update (BHP Diamonds, 1995) are both applicable. Vegetation baseline work undertaken for Diavik Diamond Mines (Burt, 1997) and for Tahera Corporation's Jericho Diamond Project (Burt, 1999b) further helped to establish plant association descriptions for the region.

The Government of the Northwest Territories has established a research station at Daring Lake, located about 300 km north of Yellowknife, at 64°52' N, 111° 35' W. Plant studies at this research station are ongoing, and include work on plant phenology, following a modification of the International Tundra Experiment (ITEX, 2000) in which individual plants or branches are tracked, with data kept on the opening of buds, maturation of seeds, etc. (Matthews and Clark, 1999). The Daring Lake station is also an EMAN-North study site. EMAN-North (the northern Ecological Assessment and Monitoring Network) is a network for the coordination of ecological monitoring in northern Canada, a partnership of the federal and territorial governments, and research institutes. Further information is available on their website (EMAN-North, 2002), but no papers are currently available.

The West Kitikmeot Slave Study Society was formed to encourage "environmental, socio-economic and traditional knowledge research focused on a mineral-rich area that stretches north of Yellowknife to the coast of the Arctic Ocean" (West Kitikmeot Slave Study Society, 2002). A number of papers have been produced on the southern Kitikmeot and northern North Slave regions, and are currently available in digital form on the WKSS website. Of particular interest to this work is an uncompleted study, establishing a vegetation classification for the region based on remote sensing (Epp *et al.*, 2000). Another report of interest is an analysis of esker use by wolves (Cluff *et al.*, 1998).

Additional ongoing studies include work being done for DeBeers at their Snap Lake project, and for Miramar Mining in the Hope Bay Belt on Melville Sound in northeastern Bathurst Inlet. As far as we have been able to tell, these are not published yet.

This section of the report provides a discussion of the rationale and methods used to inventory and classify the vegetation, as well as descriptions of the plant associations found in the study area, a literature survey, and recommendations for minimizing damage.

The study involved identification of as many plant species as possible, estimates of cover by each species, and edaphic data for 332 plots, as well as mapping of the surficial geology, soils and vegetation (Appendix F). Survey methods are described below.

A discussion of the vegetation classification follows, and several species lists were developed and are appended. Appendix A is a list of the plant species observed or collected and identified during this project. Appendix B is a list of the name changes since the publication of Porsild and Cody (1980), Vascular Plants of Continental Northwest Territories, Canada, which has in the past been the main authority for botanical work done in the NWT and Nunavut south of the Arctic coast. Appendix C lists potential plant species in addition to those identified, which likely occur in the Bathurst Inlet graben. Appendix D is a list of plant species sorted by community in which they usually occur, and Appendix E is a collection of representative photos that illustrate the classifications. Appendix F includes samples of the data sheets used.

3-2. Vegetation Inventory and Mapping Procedures

Data collection methods were adapted and modified from those described in the International Tundra Experiment (ITEX, 1996), from Research and Management Techniques for Wildlife and Habitats (Bookhout, 1994), especially the chapter on vegetation sampling (Ch. 22, Higgins, Oldemeyer, et. al.), and from Standards for Terrestrial Ecosystems Mapping in British Columbia (Ecosystems Working Group, 1998).

3-2.1 Pre-Field Activities

Field data sheets were developed based on field data forms used in other baseline studies in Nunavut and the NWT, and on ecosystem field forms developed in British Columbia for the Ministry of Forests. General classifications for the vegetation were developed, so that all field teams were analyzing the vegetation in a similar manner. Table 9 provides a comparison of the classifications developed for this project with those used for BHP's Ekati project, for Diavik, and for Tahera's Jericho Project.

Table 9. Comparison of Previous Vegetation Classifications Completed in Nunavut and Northwest Territories

Bathurst Inlet Port and Road Project	Jericho Diamond Project	Diavik Diamond Project
Submergent Communities	-	-
Sedge Communities Emergent sedge association Non-tussock sedge association Tussock sedge association	Sedge Communities Emergent sedge association Sedge association, non tussock Sedge association, tussock	Sedge Communities Emergent zone Non tussock zone Tussock zone
Moss Communities Moss shore associations Mossy cliff base associations	-	-
Riparian Shrub Communities Birch riparian association Willow riparian association Heath riparian association Alder/willow riparian association	Birch Communities Birch riparian association Birch/willow riparian	Riparian Shrub Riparian birch seeps Riparian shoreline shrub
Birch Shrub/"Seep" Communities	Birch "Seeps"	Birch hummocks
Heath Tundra Communities Upland heath tundra Heath tundra on frost scars Heath tundra on solifluction slopes Heath tundra, hummocks/tussocks Lichen-heath associations Lowland Arctic coast heath tundra	Heath Tundra Community Upland heath tundra Heath tundra on frost scars Heath tundra, solifluction slopes Transitional assn., hummock zone	Heath Tundra Upland heath tundra Frost boils Solifluction Tussock to hummock transition
Esker Complex Esker crest Esker slopes Pond margins in eskers	Ridge Complex Ridge crest communities Ridge slope communities	Esker Complex Esker crest Esker slopes Esker pond margins
Avens Community	Avens association	-
Saxifrage-Blueberry Community	-	-
Snowbank Communities	Snowbank Communities	Snowbank Communities
Lichen-Rock Communities Boulders in heath tundra Boulder field/felsenmeer association Bedrock association Polished bedrock outcrops Fractured bedrock ledges Cliff faces	Lichen-Rock Communities Boulders in heath tundra Boulder field association Bedrock association	 Boulder streams/boulder fields Cliffs and scree outcrops
Disturbed Sites Animal dens Nesting islands	Disturbed Sites Nutrient-enriched sites	Disturbed Sites

Table 9. Comparison of Previous Vegetation Classifications Completed in Nunavut and Northwest Territories		
Solifluction lobes Trails Arctic roads Camps		
Marine (Littoral) Communities Sandy beaches Gravel beaches Rocky points Estuaries	-	-

Since large-scale color aerial photographs were not to be available during the field portion of this study, it was essential to carefully plan the activities and to pre-select possible plot locations under good lighting in the lab using black and white 1:60 000 aerial photographs (from 1949/50). The 1:60 000 scale photographs became the field tools for plot location; the proposed road route was plotted on these photographs and general plot locations were selected to ensure that as many associations as possible were sampled. The selection of these plot locations was constantly evaluated throughout the study.

3-2.2 Field Inventory Program

Aerial (helicopter) surveys are helpful in ensuring that any unusual plant communities within (and in some cases outside, but in the vicinity of) the study area are not missed. In addition, it is important to identify any areas being used by animals, either as denning areas, or major travel routes, so that the vegetation in those areas can be sampled. Team members constantly surveyed the ground during any flight, looking for evidence of "different" plant communities, communities not identified in the preliminary classification list, and evidence of heavy use by animals.

No specific reconnaissance flights were completed to examine vegetation alone; the size of the area made this cost prohibitive. Field crews depended on incidental but constant observation of the ground cover and response to animal use of the area as observed from the helicopter.

Once a general area was selected for each set of plots, the helicopter landed and dropped off the field team (usually a senior scientist plus one field assistant). Once on the ground, the field team selected the precise location for each plot, trying not to have it straddling two plant associations.

The intent was to set up 10 m x 10 m plots, marked off by plastic tent pegs with flagging tape attached, so that the corners were visible in each photo. In actuality, the sizes and shapes of the plots varied considerably, but attempts were made to keep each plot at approximately 100 sq. m.

Once the plot was established, GPS readings were taken, and the orientation and slope of the land was recorded. A soil pit was dug, and the horizons and type of soil were recorded. A general survey of the terrain yielded information on the substrate, and the percentage of exposed bedrock, boulders, mineral soil, water, or plants in the plot area.

Species present were listed and the percent of cover for each was estimated and recorded. Collections were made of the following: representatives of all sedge, cottongrass, grass, rush, and willow species, samples of as many mosses and lichens as possible, and any plants of uncertain identity.

Observations were made regarding any animal use of plants (nests, feeding damage, or evidence that caribou or musk oxen had used woody plants to release tension or remove velvet from antlers). Most species of plants (other than grasses, sedges, willows, and mosses or lichens) can be identified in the field, even if the plant is not in bloom. All species observed at each plot were recorded; collections were made of any species that were uncertain. For each plot an attempt was made to collect a sample of each species of grass, willow, cottongrass, Carex sedge, and rush. Samples of moss or non-crustose lichens were also collected as time permitted. Plants collected were placed in plastic bags, a field label prepared and inserted in the bags, and all possible identifications were recorded on the data sheet.

After returning to camp, all specimens were removed from the plastic bags and all vascular plants were pressed, replicating field labels and keeping them with each collection. Mosses and lichens were placed along with field labels, in egg cartons, and allowed to air dry.

In camp, identification of any non-graminoid species was confirmed using Porsild and Cody (1980), and other references. Photographs in In-Cho Chung's photographic records of the Arctic flora of North America were helpful (Chung, 1989). Lichens, mosses, liverworts and ferns were identified as far as possible (by non specialists) using Mosses, Lichens, and Ferns of Northwest North America (Vitt, Marsh, and Bovey, 1998). Barrenland Beauties (Burt, 2000) was used in training field assistants.

3-2.3 Post-Field Activities

Groups of plants such as the grasses, sedges, willows, mosses, and lichens are notoriously difficult to identify, especially within the limited time periods available for this project. Far more reliable identifications are obtained if these are sent to specialists.

The grasses, rushes, and cottongrasses were sent to Dr. John Thieret, Dept. of Biology, Northern Kentucky University, Highland Heights, Kentucky, and the Carex sedges were sent to Dr. Robert Naczi, Claude E. Phillips Herbarium, Delaware State University, Dover, Delaware. Willows were sent to Dr. George Argus of the National Museums of Canada, Ottawa, Ontario. Mosses were sent to Dr. Martina Krieger, Department of Botany, University of Alberta, Edmonton, Alberta. Lichens were not forwarded to a lichen specialist because none were willing to take on the identification task, so the field crew did their best with photographic field guides.

In the past, for vegetation baseline studies in the Northwest Territories and Nunavut, Porsild and Cody's Vascular Plants of the Continental Northwest Territories, Canada (1980) was the taxonomic reference but for this project a number of tools have recently emerged that assist the botanists in tracking correct names.

British Columbia's VENUS database program [used for this project] produces a "validation" of all scientific names, but many species encountered in this study do not occur in British Columbia, so were not found in the database. A combination of methods was used to ensure the current names were used, including Kartesz' (1999) *Synthesis of the North American Flora* and the PLANTS Database (2001), provided by the U.S. Department of Agriculture, as well as the expertise of the specialists, Dr. John Thieret, Dr. Rob Naczi, Dr. George Argus, and Dr. Martina Krieger. All scientific names are, as far as the authors were able to determine, correct as of 2001.

After fieldwork was completed, vegetation and environment data were tabulated and analysed, and ecosystem units are finalized for the study area. Vegetation and environment data from full plots were computer coded in the VENUS (Vegetation and Environment NexUS) program (BC Ministry of Forests and BC Ministry of Environment 1997). Microsoft Windows-based VENUS is the standard for entering data and vegetation analysis in British Columbia.

After data was entered, tables summarizing vegetation and environment data were generated for classification and review purposes. VENUS produces basic tables for data from full plots, or more sophisticated (e.g., hierarchical) tables were prepared by exporting the data to VTAB (Kayahara 1992, Britton et al., 1995). Vegetation and environment summary tables were produced for each ecosystem unit.

3-2.4 Ecosystem Classification and Mapping

A tentative classification of data into plant communities and associations was developed prior to commencing field studies, based on the author's experience at Bathurst Inlet and with baseline work for Diavik (Burt 1997) and Tahera (Burt 1999). This classification was refined and modified as studies proceeded.

Two levels of ecosystem classification were developed - mapping units and descriptive units. The mapping units are larger and tend to coincide with terrain features. They can be delineated on 1:15 000 scale aerial photographs. Ecosystem mapping units are described below in Table 10.

Table 10. Ecosystem Mapping Unit Codes and Descriptions

Map Unit Code	Map Unit Name	Map Unit Description
AC	Avens Communities	Mountain avens is dominant species; typically occurs on level, well-drained sites with gravelly to sandy soils; often occurs on exposed tops of ridges that are more stable than esker crests; includes various small sedges and grasses.
BS	Birch Seep Communities	Dwarf birch is dominant species; generally low-growing, but not prostrate; occurs on solifluction lobes and hummocks, but rarely on boulders; usually on gentle slopes where moisture seeps downslope on top of permafrost.
EC	Esker Complex	Complex of plant communities associated with esker or dumlinoid landforms including associated terrain features (crests, slopes, pond margins, streamcuts, etc.); substrate may consist of boulders, cobbles, gravels, or sand; plant composition varies with slope position, aspect and substrate.
HT	Heath Tundra Communities	Dominated by a mixture of plant species of the Ericaceae (Heath) family, including Labrador tea, blueberry, Arctic heather, Alpine azalea and bearberry, as well as species such as dwarf birch, crowberry and sedges; the "climax community" for this area, covering large areas of tundra upland.
LR	Lichen Rock Communities	Mixture of crustose and fruticose lichens on rocks of various sizes; rocks about 80% covered with lichens on exposed surfaces; includes boulder fields, bedrock outcrops, cliff faces and ledges; lichens include map lichen, sunburst lichen, rock tripe and bloodspot lichen.
RS	Riparian Shrub Communities	Dominant species is dwarf birch, with several species of willow common in more active fluvial areas; occurs in drainage channels with a high percentage of boulders, usually little or no soil; grasses and sedges occur under birches and at margins.
SA	Saxifrage- Blueberry Community	Patches of vegetation on xeric sites with thin or relatively unstable (wind blown) soil; mostly on the crests of eskers or drumlins; may include blueberry, prickly saxifrage,

Table 10. Ecosystem Mapping Unit Codes and Descriptions		
Map Unit Code	**Map Unit Name**	**Map Unit Description**
		pussy-toes, bearberry, snow cinquefoil, dwarf fireweed and moss campion.
SB	Snowbank Communities	Occurs on south or southeast-facing slopes where deep snowbanks accumulate and remain into mid-summer; characterized by presence of least willow, grey mealy lichen, Labrador tea, and blueberry; in the northern part of the study area, pygmy buttercup, and in the southern part, bog laurel and mountain heather also occur.
SE	Sedge Communities	Sedges and cottongrasses dominate; occurs on poorly drained depressional sites with peaty materials overlying mineral soils and gradually sloping margins; several types, usually grading from emergent and non-tussock associations in wetter areas to tussock associations at the margins.
DF	Disturbance Features	Vegetation shows evidence of being significantly disturbed by animals, man or natural processes; types of disturbance features are identified.

Ecosystem mapping was done utilizing standards and guidelines established for Terrestrial Ecosystem Mapping in British Columbia (Ecosystem Working Group 1998), although modifications were necessary to reflect the treeless nature of the northern landscape and the differing climatic regime of the central Arctic.

Polygons delineated on the 1:15 000 aerial photos during the terrain-mapping component of the project were utilized as the baseline map units for ecosystem mapping. The final ecosystem classification for each polygon was produced through examining each unit in stereo while incorporating the final terrain and soil polygon attributes, field data and 35mm photographs of field inspection sites. Ecosystem map units are either simple, containing one ecosystem unit, or compound, containing up to three ecosystem units. The proportion of ecosystem units is indicated with "deciles", estimated to the nearest ten percent. Occasionally it was necessary to subdivide terrain polygons to reflect the more homogenous nature of a portion of the polygon. If this occurred, a "9000" numbers was assigned to the newly created polygon.

Non-vegetated polygons, or non-vegetated portions of polygons, were also mapped using a two-letter code, similar to ecosystem unit codes. Standardized codes and definitions for these are listed in Table 11.

In addition to ecosystem unit codes, site modifiers, if applicable, were used to provide additional descriptors for an ecosystem unit. Up to two site modifiers can be used in defining an ecosystem unit in the polygon labels. Site modifier codes and definitions are listed in Table 12.

Site modifiers were used for mapping the entire range of sites that do not meet the "typical" situation for that ecosystem unit. For example, a map unit comprised primarily of vegetation classified as Heath Tundra (HT), but having greater than 30% surface boulders with a thin veneer of soil materials over bedrock, would be mapped as HTbv.

Table 11. Non-Vegetated Map Unit Codes and Description		
Map Code	**Name**	**Definition**
BE	Beach Materials	Sorted sediments reworked by wave action; formed at the edge of fresh or saltwater bodies.
BF	Boulder Field	Level or gently sloping; covered with various sized angular blocks of rock derived from bedrock or drift; no significant downslope movement.

Table 11. Non-Vegetated Map Unit Codes and Description		
Map Code	**Name**	**Definition**
CL	Cliff	A steep, vertical or overhanging rock face.
ES	Exposed Soil	Includes areas of recent disturbance with vegetation cover less than 5%.
GB	Gravel Bar	An elongated landform generated by waves and currents and usually running to the shore; composed on unconsolidated small rounded cobbles, pebbles, stones and sand.
LA	Lake	A naturally occurring static body of water greater than 2 m deep; larger than 50 ha in size.
OW	Open Water	A wetland composed of permanent shallow open water and lacking extensive emergent plant cover; water is less than 2 m deep.
PD	Pond	A small body of water greater than 2 m deep but less than 50 ha in size.
PS	Permanent Snow	Snow or ice that is not part of a glacier but is found during summer months on the landscape.
RI	River	A watercourse formed when water flows between continuous, definable banks; flow may be intermittent or perennial.
RO	Bedrock Outcrop	A gentle to steep bedrock escarpment or outcropping; little soil development and sparse vegetation cover.

Table 12. Map Unit Site Modifier Codes and Descriptions	
Modifier Code	**Description**
b	ground surface >30% boulders
g	ground surface >30% gravels
r	ground surface >30% bedrock exposure
k	cool aspect >15% slope
w	warm aspect >15% slope
p	patterned ground resulting from various frost processes
h	tussocks or low hummocky microtopography
e	unit occurs within an esker complex
v	very shallow soils over bedrock
o	peaty (organic) materials over mineral materials

Disturbance features, although not common in the study area, were also identified during the mapping process. Disturbance feature codes (modifiers) and definitions are listed in Table 13.

Table 13. Disturbance Feature Site Modifier Codes and Descriptions	
Disturbance Code	**Description**
t	caribou migration trails
d	den site (wolf, grizzly bear, Arctic fox)
s	slumps or mass wastage
c	camps
l	winter road
x	excavations
a	airstrip
D	permanent road
m	mine site

Polygon attributes identified during aerial photo interpretation were entered on coding sheets and then input digitally into a polygon database using the same polygon numbers as the terrain attribute database. The following polygon attributes were included in the database:

- polygon number
- data source (ground plot or aerial photo)
- ecoregion
- percentage (decile) of ecosystem unit 1
- ecosystem unit 1
- site modifier (s) - up to 2
- percentage (decile) of ecosystem unit 2
- ecosystem unit 2
- site modifier (s) - up to 2
- percentage (decile) of ecosystem unit 3
- ecosystem unit 3
- site modifier (s) - up to 2

A map mosaic layout was developed for the terrestrial ecosystem-mapping base that coincided with the mapping base developed for the surficial geology and soils mapping. Each mosaic covers up to 8 km of road length with an approximate 0.5 km overlap at each end. Each mosaic is accompanied by a legend that provides an explanation of the codes used in the mapping. An example of an individual label is provided so that the user can quickly use the maps. An index map that allows the user to quickly reference each mosaic accompanies each mosaic. In addition, kilometer markers are provided for quick reference. The mosaics are presented in Table 14 for the applicable route segments.

Table 14. Mosaics for the Road Corridor

Route Segment	Mosaic Numbers	Note
Bathurst Inlet to Contwoyto Lake	1-29	Mosaic 1 starts at Contwoyto Lake

Plot files of the mosaics are available upon request.

3-3. Results of Vegetation Inventory and Mapping

The vegetation along the road corridor can be categorized into plant "communities" and "associations". The term "community" was used to refer to the larger, more distinct categories, most of which are mappable. The term "association" has been used to refer to subgroups of the communities, such as the "Non-tussock sedge association" as a subgroup of the "Sedge community".

Many of the associations are not easily mapped, either because they are too small, or because their delineations are not clear enough to map. Mapping codes for the communities that can be mapped appear to the right of the name of the community. A summary of these codes also appears on the legends of the maps themselves.

This chapter describes the plant communities found in the study area. The communities described below are arranged roughly from wetter communities to the drier ones, with those that do not fit, such as disturbed sites and marine communities being added at the end.

3-3.1 Submergent Plant Communities

The submergent plant community (Plate 2, Appendix E) occurs in standing or slowly flowing water, and consists of plants rooted in the bottom of the pond, and floating in the water column. Usually this community occurs in ponds that are less than a meter in depth. It is rare in the study area, especially inland, where most shallow ponds are temporary, drying up in summer, or too deep to allow rooted vegetation to extend to the surface. Submergent communities can occur in ponds with a variety of bottoms, as long as boulders are covered with a layer of silt.

Usually, the vegetation consists of *Sparganium (*either *S. angustifolium or S. hyperboreum;* no flowers were found*)*, rooted in the bottom of pond, with floating leaves lying on top of the water.

In the Bathurst Inlet port area, small tundra ponds or ponds located in estuarine areas may also include submergent buttercups (*Ranunculus gmellini*), bladderwort (*Utricularia intermedia*) and *Potomogeton filiformis*, as well as *Sparganium*. These ponds also may include submergent/emergent species like mare's tail (*Hippuris vulgaris* and *H. tetraphylla*), and *Ranunculus aquatilis var. eradicatus*. "Amphibious" buttercups like *Ranunculus hyperboreus* and *R. pallasii* may be found in brackish or freshwater ponds, or on mudflats at the edges of these ponds.

3-3.2 Sedge Communities

Sedge communities (Plate 3, Appendix E) occur where there is abundant water, usually flowing over the surface of the ground or standing in shallow ponds (depth less than 30 cm). The substrate is usually sand or silt (as opposed to boulders). These communities consist mostly of members of the sedge family, *Carex* or *Eriophorum.*

3-3.2.1 Emergent sedge association

This association occurs in shallow ponds or shallow areas in lakes where the water depth is less than 30 cm. (Plate 4, Appendix E). It consists almost entirely of sedges or related genera, mostly *Carex aquatilis*, *Eriophorum angustifolium*, and others (Figure 22)

Figure 22. Sedge community

3-3.2.2 Non-tussock sedge association

This association usually occurs in the middle of a drainage basin, where there may be some standing water, but where there is normally some flow, and intermittent drying (Plates 5 and 6, Appendix E). Water depths are usually no more than 10 cm. The non-tussock association usually includes sedges such as *Carex bigelowii*, *C. membranacea*, *C. rariflora*, and cottongrasses like *Eriophorum angustifolium* and *E. scheuchzeri*. These also may include forbs such as Sudetan lousewort (*Pedicularis sudetica*), marsh five-finger (*Comarum palustre*), and bistort (*Polygonum viviparum*).

At the Arctic coast, additional forbs such as yellow marsh saxifrage (*Saxifraga hirculus*), or cuckoo flower (*Cardamine pratensis*), red bladder campion (*Melandrium apetalum*), or the small white fireweed (*Epilobium palustre*) often occur in this association.

3-3.2.3 Tussock sedge association

The tussock association occurs in areas with less standing or slow-flowing water than that of the non-tussock ones, usually at the edges of a drainage basin (Plates 7 and 8, Appendix E). Tussocks are thick clumps of cottongrass or sedges, with individual stems growing from the same place, forming a flexible brush-like mound that collects silt and vegetation and becomes thicker and larger as time passes. In this area, tussocks usually are made up of *Eriophorum callitrix*, *E. vaginatum*, and *E. brachyantherum* (in the southern part of the study area). *Carex* sedges may include *Carex aquatilis*, *C. scirpoidea*, and *C. chordorrhiza* (Plate 9, Appendix E). Non-tussock sedges and cottongrasses may occur in the interstices between the tussocks.

This is a transitory association, as it seems to be quickly invaded by heaths, which take root in or around the cottongrass tussocks. With colonization by heaths, tussocks lose their shape and become mounds, generically called “hummocks”. The main difference between these plant-formed hummocks and ice-cored

hummocks is the fact that tussocks have root systems, and thus are somewhat flexible. Ice-cored hummocks are quite solid to the touch and do not wiggle when kicked or stumbled over. Plant associations on these mounds are similar, but there are a higher percentage of sedges in the tussock mounds, due to the persistence of some plants from the original tussocks.

3-3.3 Moss Communities

Moss communities occur where there is abundant moisture at the surface for all of the growing season. The vegetation consists of a preponderance of mosses, with woody vegetation or forbs rooted below or in the mossy blanket.

Moss communities usually occur at the base of banks or cliffs. Moisture runs through the active layer or down the bank and accumulates at the bottom where it can be utilized by the plants. Mossy shore communities are not common, but are distinct. They are small, and not mappable at the scale at which we were working.

3-3.3.1 Mossy shore associations

The mossy shore community occurs along lakeshores (and sometimes pond or stream margins) where the land bordering the lake/pond is only slightly higher than the water level (Plate 10, Appendix E). The substrate is covered with a thick blanket of moss, usually predominantly *Sphagnum*, often *S. imbricatum* or *S. russowii*, but including other mosses such as *Polytrichum commune* var. *jensenii*, *Calligeron stramineum*, and *Aulicomnium turgidum*.

Taller sedges (often *Carex aquatilis*) border the water, and other sedges, including *C. rariflora, C. rotundata)*, are established in the moss blanket, as well as a few grasses or woodrushes (*Poa* sp., *Calamagrostis canadensis, Luzula* sp.). A few plants of dwarf birch and small willows (*Salix fuscescens, S. arctophila*, and *S. tyrrellii*) may grow here, and small plants of least willow (*Salix herbacea*) are scattered in the mosses.

Heaths, including blueberry (*Vaccinium uliginosum*), lingonberry (*Vaccinium vitis-idaea*), bog rosemary (*Andromeda polifolia*), and white Arctic heather (*Cassiope tetragona*), occupy the edges of this community, but seem to occur only sporadically in the middle. Forbs like Sudetan lousewort and Lapland lousewort (*Pedicularis lapponicum)* also occur in this community. Cloudberry (*Rubus chamaemorus*) often occurs scattered throughout the moss.

The moss blanket retains water, so this area is constantly wet, even in dry weather. This association is often linear, extending in a narrow band along the edge of the lake or pond.

The mossy shore community (especially where it occurs on larger ponds or lakes) is often a preening place for waterfowl, probably because there is no impediment to their lines of sight for predators, and because the moss provides a stable platform for standing. Goose scat and feathers were often found in these associations.

3-3.3.2 Mossy cliff base associations

In a few places, such as in Kalvik Canyon near Nose Lake, moss associations were found at the bases of vertical cliffs, usually north-facing cliffs, as the south-facing cliffs have snowbank communities (Plate 11, Appendix E).

The cliff base moss associations are composed of thick *Sphagnum* moss with *Aulacomnium* and *Polytrichum* in lesser amounts. Labrador tea and white arctic heather occurred in mats within the moss blanket, and small plants of *Poa*, *Luzula*, *Salix planifolia*, and *Spiraea stevenii* were scattered throughout.

3-3.4 Riparian Shrub Communities

Riparian associations occur in drainage basins with boulder (as opposed to silt) substrates. These usually have a relatively constant flow of water, and often occur between lakes, especially where there is a gradient of more than 2% (Figure 23).

In this study area, riparian communities are usually characterized by the presence of "trees"; usually dwarf birches (*Betula nana*) and sometimes willows, as well as other species usually associated with the boreal forest. These may include shrubby cinquefoil (*Pentaphylloides floribunda*), and violets (*Viola ajunca* var. *minor*).

The riparian shrub communities, especially the taller willow and alder communities, are very attractive to wildlife. Caribou, musk ox, and grizzlies' shelter in these on hot days, and they provide nesting areas for small passerine birds, especially warblers, redpolls, and American tree sparrows. The larger trees provide attachments for hornet nests; which are usually made in rock crevices north of the treeline; a 15 cm (diameter) hornet nest was found in one riparian community near the Mara River.

Figure 23. Riparian shrub community

3-3.4.1 Birch riparian association

The birch riparian association occurs in the drainages between lakes, invariably on a boulder substrate, although plants may be rooted in perched material on the boulders (Plate 12, Appendix E). True "soil" is at a minimum.

Vegetation is low; small birches to about one meter in height, often so thick that the ground is covered with leaf litter and have little other vegetation. Low growths of crowberry (*Empetrum nigrum*) and lingonberry may occur under these birches.

3-3.4.2 Willow riparian association

The willow riparian association includes tall willows (sometimes up to 3 m), probably due to a more reliable source of water (Plate 13, Appendix E). In the study area, these occur in the midst of some birch riparian associations, possibly in a more protected environment, or where there is more water available. The substrate is bouldery, as opposed to silty or peaty. Willows may include *Salix glauca*, *S. planifolia*, and *S. tyrellii* and others (Figure 24).

Figure 24. Willow riparian association

3-3.4.3 Heath riparian association

The heath riparian association occurred only rarely in the study area but is a distinct subgroup. It consists of low heath in a drainage basin, usually between or downstream from willow riparian associations (Plate 14, Appendix E).

The dominant plant is bog rosemary (*Andromeda polifolia*), growing not as it usually does, on mounds, but as low vegetation with mosses underneath. Scattered willows (*Salix planifolia* intergrade with *S. tyrrellii*, and *S. fuscesens*) and a few sedges (*Carex rotundata*, *C. rariflora*), as well as *Eriophorum angustifolium*, and *Scirpus caespitosus*, also occur here, but are not as thick as the bog rosemary.

3-3.4.4 Alder/willow riparian association

At the Arctic coast, another riparian association occurs in protected stream valleys such as the Amagok (more correctly, "Amaguk") Creek valley just north of the port site on Bathurst Inlet (Plate 15, Appendix E). This is a green alder (*Alnus viridis* ssp. *crispa*) and willow community. The alder reaches the limit of its range at the Arctic coast, but forms dense thickets in some areas along Bathurst Inlet, especially near the mouth of the Burnside River. This community does not seem to occur inland, probably due to the rapid increase in elevation south of the port site at Bathurst Inlet.

In places, these thickets are so dense that there is little ground cover at all, just leaf litter and the trunks of alders, willows, with dwarf birches at the edges. Willows include Alaska willow (*Salix alaxensis*), *S.*

planifolia, and *Salix glauca*. In some places, grass, mostly *Calamagrostis canadensis*, grows thickly under the willows, and more sparsely under alders. Stands of large-flowered wintergreen (*Pyrola grandiflora*) and leggy stands of crowberry, Labrador tea, lingonberry, and blueberry also occur in the shade of the alders and willows.

3-3.5 Birch Shrub/Birch "Seep" Communities

The birch shrub or birch "seep" community is similar to the riparian birch shrub association, but usually does not occur on boulders, and there is seldom any visible water flow involved. In the study area, it occurs mostly on sandy loam soils, and, though boulders, cobbles, or gravel were often present, they were not predominant. It seems to occur where there is an increased level of moisture in the soil, possibly where the moisture seeps to the surface after flowing downhill through the active layer on top of permafrost (Plate 16, Appendix E).

The extent of the extra moisture controls the size of the birch shrub community. Where the terrain limits the outflow of water, the shrub area is small. However, where there is abundant moisture, (but not enough for a sedge community to develop) the birch shrublands are much larger, sometimes extending over hundreds of square metres.

Typically, this looks like a low birch "forest", with the bushes forming a low flattened canopy, but not prostrate, as they are in more exposed situations. An understory/herbaceous layer occurs under the birches, but can be quite sparse. In some areas under dense birch, the only plants on the ground are mosses, and there is a distinct leaf litter composed of dead birch leaves. Small willows may also occur here, including *Salix arctophila*, *S. arctica*, *S. glauca* ssp *callicarpaea*, and *S. planifolia*, sometimes as an intergrade with *S. tyrrellii*. *Salix tyrrellii* is, in places, very common in this community (Figure 25).

Figure 25. Birch seep community

Where more sunlight penetrates, the understory consists of Labrador tea (*Ledum palustre* ssp. *decumbens*), crowberry, lingonberry, blueberry, bog rosemary, and sometimes bearberry (*Arctostaphylos* sp.) and white Arctic heather. Sedges and grasses may be thick under the birches, or may occur sparsely, including *Poa arctica*, *Calamagrostis neglecta* and *Festuca saximontana*. Lichens (mostly *Hypnogymnia physodes*) grow on the stems of the birches, and *Cetraria nivalis*, *Nephroma*, *Peltigera* and other lichens often occur on the ground, along with dense mosses, including *Racomitrium lanuginosum*, *Aulicomnium turgidum*, *Dicranum elongatum*, and *D. fuscescens*, *Sphagnum* sp., and *Bryum alpinum*. If the birch shrub is on old tussocks, there is a higher percentage of cottongrass, usually the tussock-forming species like *Eriophorum callitrix* or *E. vaginatum*.

3-3.6 Heath Tundra Communities

"Heath" refers to plants of the family Ericaceae, and is used as a collective common name for this community, which forms the climax community for our area. Given sufficient time, it is likely that most of the drier terrains gradually acquire a larger percentage of heaths. In several variations, this community covers huge areas of land all along the road corridor. All low rounded hills and ridges with sufficient soil support a heath tundra community, characterized by heaths, forbs, small xeric sedges, and scattered grasses.

Several members of the Ericaceae and related families are characteristic of this community (Plate 17, Appendix E): blueberry (*Vaccinium uliginosum*), lingonberry (*Vaccinium vitis-idaea*), Labrador tea (*Ledum palustre* ssp. *decumbens*), and white Arctic heather (*Cassiope tetragona*). Crowberry (*Empetrum nigrum*), alpine azalea (*Loiseleuria procumbens*), and black bearberry (*Arctostaphylos alpina* ssp. *alpina*) occur on drier heath tundra areas. More sedges, bog rosemary (*Andromeda polifolia*), red bearberry (*Arctostaphylos alpina* ssp. *rubra*), Lapland lousewort (*Pedicularis lapponica*) and bistort (*Polygonum viviparum*) occur in the wetter areas. South of the coastal areas at Bathurst Inlet, the dwarf birch (*Betula nana*) is an important member of the heath tundra community, adopting an almost prostrate growth form, or growing in depressions in the tundra (Figure 26).

Variants of heath tundra occur on different terrain features: on frost boils, solifluction ridges, slopes and lobes, hummocks, and patterned ground. These variants are sufficiently different to warrant separate descriptive categories, but are mapped together as one community. Terrain features, especially those that affect the amount of water available to plant roots or those that cause the soil to be more exposed to winter winds, also affect the type of community that develops.

Figure 26. Heath tundra community

Heath tundra is important to wildlife. Its wealth of flowers attracts many insect pollinators, which in turn provide food for small tundra birds, many of which normally feed on seeds, but which feed insects to their nestlings. In the spring, the previous year's berries, exposed by melting snow, also attract wildlife, including many migrating birds (including geese and gulls). In fall, ripening berries are food to many animals, bears, foxes, and many birds. In the past and today, berries are an important food source to Inuit across the North. The buds of dwarf birch and willows provide food for ptarmigan, and Arctic hares, lemmings, and voles feed on the bark of many woody plants in tundra areas.

3-3.6.1 Upland heath tundra association

This is the basic heath tundra association, which occurs over much of the level or rolling uplands in the central barrenlands (Plates 18 and 19, Appendix E). A blanket of snow generally protects this association in winter, minimizing the erosional effects of wind and blowing snow.

Heath species are mostly as described above, with minor variations due to moisture levels. Alpine azalea (*Loiseleuria procumbens*) and crowberry occur in more exposed, drier sites, and white Arctic heather occurs where there is slight protection due to ground contours. Grasses and sedges include alpine holygrass (*Hierochloe alpina*), and *Arctagrostis latifolia, Calamagrostis neglecta, Carex bigelowii,* and *C. supina* in dry areas, and *Carex capitata* and *Eriophorum callitrix* where there is more moisture,

Over much of the road route, dwarf birch and small willows are an important part of the upland heath tundra association, but does not form an unbroken cover on the land. Instead, the birches are scattered and often stunted, growing almost prostrate, seldom exceeding 15 cm in height. Willows in this association are mostly low or prostrate, and include *Salix arctica, S. glauca* ssp. *callicarpaea, S. planifolia* and *S. tyrrellii*.

The moss and lichen component of the upland heath tundra varies according to protection and moisture, with hair lichens (*Alectoria* sp.) where there is less moisture, and a complex mixture of *Cetraria nivalis, Dactylina arctica, Stereocaulon tomentosum, Thamnolia subuliformis,* and various *Cladina* and *Cladonia* species in moister areas. Antler lichen (*Masonhalea richardsonii*) often occurs in this association in large quantities, but is not attached to the ground; it blows around and accumulates in depressions. The mosses *Aulacomnium turgidum, Racomitrium lanuginosum, Dicranum elongatum,* and various *Polytrichum* species are also components of this association.

3-3.6.2 Heath tundra on frost scars

In this report, we have used the term “frost scar” to include small scale terrain features created by cryoturbation and local downslope movement of the active layer, especially frost boils and small solifluction lobes. The freeze-thaw cycle in Arctic soils creates these terrain features, which are more completely described in the surficial geology and soils part of this report. The vegetation on frost scars creates a mosaic, with several associations mixed together and impossible to separate at any practical mapping level (Plates 20 and 21, Appendix E). Within a single 10 m x 10 m plot there may be as many as three frost scars.

Heath associations can occur on the drier tops of small solifluction ridges in sedge associations, and the raised edges of low-center polygons (patterned ground). In addition to the heaths listed in the general heath tundra above, a variety of other heaths occur on the surface of the boils, or on the ridge that surrounds it.

The centers of frost boils are often composed of a mixture of fine mineral soil, pebbles, and small rocks brought to the surface by the mixing of the soil that occurs due to freeze-thaw convection currents in the boil. This soil is constantly being worked; individual particles often moving too swiftly to allow the establishment of rooted vegetation. In these cases, there are only isolated small plants, or no plants at all.

In frost scars with slower convection currents, there are plants that are typical of these centers, especially tiny plants of Lapland rosebay (*Rhododendron lapponicum*), alpine azalea (*Loiseleuria procumbens*), false

asphodel (*Tofieldia pusilla*), alpine milkvetch (*Astragalus alpina*), Arctic crazyweed (*Oxytropis arctica*), *Carex bigelowi,* woodrush *(Luzula* sp.*)* and occasionally, *Diapensia lapponica.* Most are stunted, often prostrate. Occasionally, the least willow (*Salix herbacea*) occurs sparsely in the center of the boil, as well as patches of the lichen *Stereocaulon tomentosum*.

A mixture of heaths, dwarf birch, and sedges more typical of upland heath tundra occurs on the raised margins of the frost scars and between these structures. If there is enough moisture, Sphagnum mosses also become established in the interstices between frost scars. Yellow oxytrope (*Oxytropis maydelliana*), mountain avens, *Salix arbusculoides, S. arctica,* and grasses such as *Arctagrostis latifolia, Trisetum spicatum, Poa* sp. and *Hierochloe alpina* may also occupy the ridges.

3-3.6.3 Heath tundra on solifluction slopes

Frequently, solifluction slopes are quite large, with a thick active layer sliding downslope over a more stable bottom layer, creating a steep face that may extend for hundreds of meters along a slope. The top of these large lobes usually is occupied by typical upland heath tundra. However, the faces of the lobes, which may be as much 1.5 to 2 m thick, often support birches and other plants more typical of a birch seep. These rim the face of the lobe, and, due to downslope movement, are physically consolidated into a fringe that is often thicker, the plants more crowded, than would be the case if there were no soil movement (Plates 22 and 23, Appendix E).

The species occupying the faces of the lobes always includes dwarf birches, sometimes much taller than those occurring on the surrounding tundra. It usually includes taller willows than in the surrounding area, mostly *Salix arctica, S. arctica* intergrades with *S. glauca* ssp. *callicarpaea*, and *S. planifolia* intergrades with *S. tyrrellii*. Grasses such as *Poa arctica*, *P. alpina*, and *Arctagrostis latifolia*, occur amidst the birches and willows. There is often an understory of heaths, including lingonberry, blueberry, and Labrador tea under the birches as well.

See “Disturbed sites” for additional information on this type of plant association; essentially it contains elements of both birch shrub/seep associations and heath tundra.

3-3.6.4 Heath tundra on hummocks or tussocks

At the edges of most sedge basins, hummocks form a distinct band that varies in width from less than a meter to hundreds of meters. These hummocks may be colonized tussocks or mounds with a small core of ice (Plates 24 and 25, Appendix E).

Despite different origins, these support similar plant associations. Those of tussock origin usually retain their flexibility, and will show more of the original plant structure, i.e., a framework of *Eriophorum* or *Carex*, with heaths and other plants colonizing the mound or growing in the interstices between mounds.

When there is a lot of water available, the heaths usually grow *on* the mounds, and sedges *between* them. However, as the level of the ground is raised by the accumulation of organic debris, more and more heaths become established between mounds, until the entire association resembles heath tundra. In our opinion, this is a successional stage to heath tundra.

Bog rosemary (*Andromeda polifolia*) and cloudberry or akpiks (*Rubus chamaemorus*) are typical of this moist hummock community, and are often joined by Lapland lousewort (*Pedicularis lapponica*). Dwarf birch may also occur thickly in this association, mostly growing on the tops of the mounds, and it also includes grasses like *Hierochloe alpina* and *Poa* sp., as well as sedges, including *Carex rotundata* and *C. holostoma*.

Mosses, especially *Sphagnum subsecundum*, often begin to grow at the bases of tussocks, slowly surrounding the tussocks and spreading out from there. Where there are ice-cored mounds, sphagnum mosses become established between the mounds, and gradually fill the interstices. Other mosses, including *Aulacomnium turgidum*, *Rhizomnium magnifolium*, and *Drepanocladus revolvens* also occupy this area. The mosses in turn provide a secure spot for seeds to become established, and soon are colonized by many different species.

3-3.6.5 Lichen-heath associations

In drier areas where a sandy or gravelly substrate provides good drainage, lichens dominate, and the heaths are scattered throughout this lichen "carpet". This type of association generally occurs on ridges, terraces along the sides of ridges, and on peninsulas (Plate 26, Appendix E).

Cetraria nivalis, hair lichens (*Alectoria* sp.) and the grey mealy lichen (*Stereocaulon* sp.) provide the major ground cover, but this is studded with small heaths growing through the lichen carpet. These include lingonberry, Labrador tea, blueberry, and black bearberry. Crowberry mats also occur in these areas.

3-3.6.6 Lowland Arctic coast heath tundra

The heath tundra association at the Arctic coast on Bathurst Inlet exhibits some major variations from that over the rest of the road route. Bathurst Inlet is geologically a graben, a downdrop block once flooded by the sea, but over geological time filled by sediments washing in over the steep edge of the graben. This, along with the fact that the rough terrain provides some protection from winds, creates somewhat of an Arctic "oasis" where the flora is comparatively lush and more diverse than in surrounding areas.

Arctic coast heath tundra supports a rich flora characterized by all the previously mentioned heath species, plus a number of additional species, all growing profusely with individual plants attaining larger sizes than they do inland (Plates 27 and 28, Appendix E). Lapland rosebay (*Rhododendron lapponicum*) achieves dwarf shrub size, up to 25 cm. at the coast. Inland, it is prostrate; usually less than 3 cm. Alpine milkvetch (*Astragalus alpina*) also is much larger at the coast.

In addition, a number of species occur in much higher densities in heath tundra at the Inlet than they do even 5 km inland in this area. These include mountain avens (*Dryas integrifolia*), liquorice root (*Hedysarum alpinum*), wild sweet pea (*Hedysarum boreale* ssp. *mackenzeii*), Arctic lupine (*Lupinus arcticus*), net-veined willow (*Salix reticulata*), groundsel (*Senecio atropurpurea*), fireworks flower (*Saussurea angustifolia*), the false asphodels (*Tofieldia pusilla* and *T. coccinea*), both coralroot (*Corallorhiza trifida*) and small northern bog orchid (*Platanthera obtusata*). Several louseworts, including woolly lousewort (*Pedicularis lanata*), Arctic lousewort (*P. arctica*), crowned lousewort (*P. capitata*), and

flame-tipped lousewort (*P. flammea*), as well as paintbrush or painted-cup (*Castilleja* sp.) also occurs here. The paintbrushes readily hybridize in the area, and are not readily identifiable as to species.

A number of saxifrages also are much more common in the Bathurst Inlet graben than they are inland, including *Saxifraga oppositifolia* (though we may have missed this one, as it is not conspicuous when not in bloom), *S. foliolosa*, *S. aizoides*, *S. cernua*, and *S. rivularis*. Even *Saxifraga tricuspidata*, though present inland, grows much more profusely at the Inlet.

Some species occur *only* at the coast; they were not encountered on the inland portion of the road. A separate list, "Potential Vascular Plant Species at the Northern Port Site" (Appendix C) details some of the species to be found at the coast, but seldom inland. Included in this list are *Cardamine digitata*, *Draba alpina*, *D. glabella*, *D. lactea*, Richardson's milkvetch (*Astragalus richardsonii*), *Oxytropis glutinosa*, harebell (*Campanula uniflora*), and others.

3-3.7 Esker Complex

The term "esker" is used in a generic context here, with no attempt being made to separate these terrain features into eskers, drumlins, or "drumlinoid ridges" (Figure 27).

Eskers are long ridges, often branched, winding across the surface of the land. They may include enclaves of sedges, streams, snowbank communities, small ponds, or even larger lakes. The crests of eskers may be composed of boulders, cobbles, pebbles, sand and gravel, or even aeolian (wind laid) deposits, and may be criss-crossed with small ravines (patterned ground or polygons).

An esker complex is truly that, a complex mixture of microhabitats, each with a unique signature, and typical plants that occur in those situations.

Due to the small size of some of these microhabitats, it is best to map eskers as units, instead of trying to resolve the differences between crests, slopes, stream cuts, ponds, etc.

Figure 27. Esker Complex

Drumlins are esker or morainal deposits that have been established, and then overridden by another ice advance. These are usually molded hills of varying material, but shorter and less complex than eskers.

Moraines are usually long ridges, material pulled off another ridge or the shoulder of a "mountain" or hill by the passage of the ice sheet. Moraines in our area are ice-laid deposits, unsorted (though some "sorting" may appear to have occurred through wind removal of the fine materials from the surface), and generally do not show the winding

or branching characteristics that are shown by the eskers. Moraines are usually large enough that their associated communities can be mapped separately.

3-3.7.1 *Esker crest*

The plant associations on the crest of an esker are determined by the substrate and exposure to the wind. In all cases, this is a xeric (dry) environment, and plants must adapt to desert like conditions (Plates 29 to 34, Appendix E).

Where there are boulders and cobbles, the plant association is usually thin heath tundra with a high percentage of hair lichen (*Alectoria* sp.). In these areas, since most fine soil either was not present or has blown away, the substrate is relatively stable, and plants can find a secure foothold. In places, cobbled esker crests were found with very few plants except a dark lichen (*Pseudephebe pubescens*) growing on the rocks, and scattered small plants of prickly saxifrage between the cobbles (Figure 28).

Figure 28. Esker crest community

Where the substrate is sandy, this low, often prostrate, plant association usually consists of individual plants such as dwarf birches, *Trisetum spicatum*, *Festuca* sp., dwarf fireweed, *Potentilla nivea*, *Arabis arenicola*, and moss campion (*Silene acaulis*). Or, mats of individual plants (blueberry, crowberry, black bearberry, lingonberry, Labrador tea) likely have developed by layering from a parent plant; these mats increase in diameter if conditions are favorable. Tufted plants such as *Antennaria* sp., prickly saxifrage, sandwort (*Minuartia rubella*), also develop; their deep taproots allow them to exist even if wind removes some of the sand.

Lichens are uncommon on sandy esker crests, but when they occur, they are mostly confined to hair lichens (*Alectoria nigricans*, *A. ochroleuca*), and small mats of *Stereocaulon tomentosum* in depressions protected by adjacent plants.

This sandy substrate is very unstable, and the grains of sand are constantly being rearranged, so the species that exist here are usually those that can quickly establish a deep root system. (See section 9 for a description of the Saxifrage-Blueberry association, which may occur on an esker crest.)

Several interesting esker crests deserve special attention. One, in a large esker system west of Nose Lake (near KM 166.5 of the proposed road corridor) sports a variety of crests, from patchy vegetation on small gravel substrates to lichens on large cobbles, to gravel with virtually no vegetation at all, to heath tundra, and one interesting crest with patterned ground (plot PB 671). This area has almost no vegetation on the high centers of the polygons (a little black *Alectoria*, and a few tiny *Dryas integrifolia*), but has deep channels in the patterned ground (some almost 20 cm deep). These are densely vegetated with a mat of *Alectoria*, crowberry, Labrador tea, lingonberry, and blueberry.

Snow does not accumulate on the crests of ridges and eskers, so all plants there are subject to intense wind and snow erosion in winter. They are invariably prostrate or show the cushion or mat growth form.

3-3.7.2 Esker slopes

The slopes of eskers exhibit some differences due to their orientation to the prevailing winds. Windward (in the study area, north or northwest-facing) slopes do not accumulate large snowdrifts (Figure 29), and are more exposed, so have lower and sparser vegetation (Plates 35 and 36, Appendix E). Leeward (south or southeast-facing) slopes do accumulate snow as a result of the drifts accumulating in the lee of the ridge.

The lee slopes of eskers show two very different types of plant associations – a slope association with a high percentage of relatively tall birch, and a snowbank community with very low vegetation and a unique association of species (the snowbank association was dealt with as a separate community, as it occurs on any leeward slope with soil, not just on eskers.).

Figure 29. Windward slope of esker

Where dwarf birches fringe the esker's upper slope, the community superficially resembles a narrow birch seep, with an understory of heaths (blueberry, lingonberry, Labrador tea), crowberry, *Poa* sp., large-flowered wintergreen, and, often, alpine arnica (*Arnica angustifolia* ssp. *angustifolia*) beneath the birches. *Cetraria nivalis, Cladina* sp., some *Cladonia* sp. and antler lichen, along with *Aulicomnium* and *Polytrichum* mosses cover the ground. The birch fringe can be so thick that there is little ground cover, just leaf litter.

Where there is no distinct fringe of birches, the esker slope bears an upland heath tundra association, which may be somewhat affected by the steepness of the slope. This assemblage includes small birches, but consists mostly of blueberry, lingonberry, Labrador tea, black bearberry, and crowberry, with a substantial amount of *Cetraria nivalis*, and hair lichens. *Hierochloe alpina*, *Trisetum spicatum*, *Arctagrostis latifolia*,

Luzula wahlenbergii, and *Carex bigelowii* often occur as scattered individual plants within the heath association. In more protected areas at the base of the slope, there may be patches of white Arctic heather.

Windward slopes of eskers usually have a typical wind-pruned upland heath tundra community, low birches, Labrador tea, lingonberry, blueberry, crowberry, alpine azalea, and black bearberry, plus some small willows, and scattered small sedges (*Carex bigelowii*) and grasses (*Hierochloe alpina* or *Trisetum spicatum*). In this area, the lichens *Cetraria nivalis*, *Alectoria*, glove lichen, antler lichen, and worm lichen are joined by a number of mosses (usually *Aulicomnium* sp. and *Polytrichum* sp.).

3-3.7.3 Pond margins in eskers

Ponds in eskers can be quite small, or can be large lakes, as many eskers extend into the lakes (Plates 37 and 38, Appendix E). Where the esker is low, these margins resemble surrounding lake margins but on the taller eskers, they are quite different. Snowbank communities occupy most south-facing steep pond margins (Figure 30).

Those with other orientations usually include a band of dwarf birch (with willows, usually *Salix planifolia*, intermingled, especially in the southern part of the area) with an understory of boreal forest plants, and a band of grasses and sedges or mosses at the pond edges.

Figure 30. Pond margin within esker complex

A profile often includes:

a) Top band of heath tundra with lichens.
b) Steep slope with a fringe of birches with understory of Labrador tea, blueberry, lingonberry, crowberry, and some grasses, especially *Poa* sp.
c) At the base of the slope, a band with *Calamagrostis neglecta* and other *Calamagrostis*, *Agrostis borealis*, *Carex aquatilis* and other sedges, woodrush (*Luzula wahlenbergii*), blue-green chickweed (*Stellaria longipes*) and sometimes red bearberry (*Arctostaphylos alpina* ssp. *rubra*).
d) A flat area with *Poa* sp., bog rosemary, bog-laurel, mountain heather (*Phyllodoce coerula*), white Arctic heather, bistort, violets, cloudberry, *Anemone richardsonii*, and occasionally *Saxifraga nelsoniana*, *Pyrola minor*, and *Sibbaldia procumbens.*
e) Actual pond border with sedges and mosses, and often cloudberry. This can be similar to a mossy lakeshore association, or to an emergent sedge association.

A few esker ponds exhibited typical riparian associations at their ends if there was sufficient drainage into the pond, and if there were boulders in the drainage channel.

Some pond margins are grassy slopes, possibly developing in areas with a higher component of mineral soil, mostly sand. These offer a lush growth of grasses including *Arctagrostis latifolia* and *Calamagrostis canadensis*, and, at the base of the slope, a band of sedges, including *Carex saxatilis* and other *Carex* sp., rushes (*Juncus filiformis*), with occasional tall fireweed (*Epilobium angustifolium*) and small willow plants (*Salix planifolia*, *Salix tyrrellii*, intergrades of these, and *Salix glauca* ssp. *callicarpaea*.

The grassy slopes may reflect sites that have been disturbed more than simple pond margins. Not enough of these types were observed.

3-3.8 Avens Community

This community occurs on wide and dry ridge tops and is often surrounded by heath tundra (Plate 39, Appendix E); however, it includes such a high percentage of mountain avens that it really cannot be called heath tundra. The avens community is not common in the study area and covers only limited areas.

Mountain avens (*Dryas integrifolia*) is the dominant species in this association, but is often accompanied by a few plants of other species, such as lingonberry, blueberry, *Potentilla nivea*, alpine azalea, black bearberry, *Antennaria* sp., alpine milkvetch, *Rhododendron lapponicum*, Silene acaulis, prickly saxifrage, and others. Lichens include hair lichens, *Cetraria nivalis*, worm lichen, and grey mealy lichen (*Stereocaulon tomentosum*).

The avens community is much more common at Bathurst Inlet, especially on high glacial rebound beaches on calcareous gravels, but is not common in the area of the port. *Oxytropis arctica, O. arctobia,* and rarely, Arctic bladderpod *(Lesquerella arctica)* are often part of this association at the Inlet.

3-3.9 Saxifrage-Blueberry Community

This community is similar to the avens community in that it occurs on ridge tops (Plate 40, Appendix E). It represents a more mappable esker crest community, as its margins are usually well defined, mostly a sharp transition to heath tundra (Figure 31).

The substrate is usually sand, often with blowouts due to strong winds. Plants occur in dense mats, probably by layering or expansion from a common root system. These mats are usually blueberry, lingonberry, alpine azalea, crowberry, black bearberry, *Antennaria* sp. or *Saxifraga tricuspidata*, in each case some, but not all, of these. There may be additional scattered plants of moss campion, *Potentilla nivea*, *Hierochloe alpina* or *Trisetum spicatum*, *Calamagrostis purpurescens*, and sometimes a few xeric sedges like *Carex supina*. Lichens are sparse, usually hair lichens and *Cetraria nivalis*. Larger pebbles may be coated with rock wool (*Pseudephebe pubescens*).

Both the avens community and the Saxifrage-blueberry community are important in the stabilization of esker crests. Exposure to strong winds in winter ensures that a snow cover never develops; the area is constantly exposed to the bitter winds and blowing ice crystals, so a contiguous plant community seldom develops. The plants that grow here are the survivors; those that can become established in an unstable substrate, under very dry conditions. As expected, many show adaptations for water retention: the waxy leaf surfaces of lingonberry and prickly saxifrage, the hairy leaves of *Antennaria* and *Potentilla nivea*, succulent growth form of the saxifrage, and very low growth of blueberry.

Figure 31. Saxifrage-blueberry community on esker crest

3-3.10 Snowbank Communities

Over most of the road route, the prevailing winds in winter are from the northwest or north. These cause snow to pile up on the southeast or south side of any ridge or structure that blocks the wind. The higher the bank or steeper the slope, the deeper the snowbank and more pronounced effect on the vegetation (Figure 32).

Figure 32. Snowbank community

Snowbank communities become established where snow accumulates to sufficient depths in winter that its mass is large enough to remain into mid to late summer. In the fall, the accumulation process begins with the first snows, usually in early October. The resultant short growing season reduces the number of plant species that can survive in this community.

Over most of the road route south of the coast, most snowbank communities occur in the lee of eskers, as these are generally the highest structures on the land (Plates 41 and 42, Appendix E). Still, west of Nose Lake, we found

distinct snowbank communities in the valley locally known as "Kalvik Canyon". These were at the base of the south-facing cliffs that form the north wall of the canyon.

There are a number of species that are typical of or even somewhat limited to these snowbank communities, including least willow (*Salix herbacea*), *Antennaria angustata*, pygmy buttercup (*Ranunculus pygmaeus*), cordate-leaved saxifrage (*Saxifraga nelsoniana)*, and brooklet saxifrage (*Saxifraga rivularis).*

In the southern part of the region, other species are common in these snowbank areas: bog laurel (*Kalmia polifolia*), mountain heather (*Phyllodoce coerula*), *Viola ajunca* var. *minor*, and *Sibbaldia procumbens*. In the northern part, at Bathurst Inlet, the few-flowered anemone (*Anemone parviflora*) blooms in profusion in snowbank communities.

Still other species occur in these areas in more or less pure stands, blooming later than the same species in the surrounding areas: mountain sorrel (*Oxyria digyna)*, Richardson's anemone, cloudberry, Labrador tea, blueberry, lingonberry, crowberry, white Arctic heather, *Poa arctica*, *Saxifraga nivalis*, Lapland lousewort, and some Carex sedges.

There are usually few non-vascular plants in true snowbank communities, but often there are patches of *Aulicomnium, Stereocaulon tomentosum*, and liverworts, mostly *Marchantia polymorpha*.

3-3.11 Lichen-Rock Communities

Large areas of the land north of Contwoyto Lake are covered with boulder fields, boulder streams, and felsenmeer (fractured bedrock).

Figure 33. Lichen - rock community

Most exposed rock surfaces are about 80% covered with crustose lichens (Figure 33; Plate 43, Appendix E), which include rock tripe (*Umbilicaria vellea*), map lichen (*Rhizocarpon geographicum* and *R. geminatum*), sunburst lichen (*Arctoparmelia centrifuga*) (Plate 44, Appendix E), bloodspot lichen (*Ophiopharma lapponica*), *Tremolecia atrata*, and grey and black crustose lichens (*Aspilicea cinerea* and *Umbilicaria hyperborea*). Hair lichens, including *Alectoria nigricans, A. ochroleuca*, and *Pseudophebe pubescens*, often also become established on these rocks.

In places, the rocks show bright orange patches of lichens, especially on prominent boulders or outcrops. This is due to the jewel lichen (*Xanthoria elegans*), a calciphile, which does not occur widely on the acidic rocks of this area. Here, it is growing where the ground squirrels use boulders and outcrops for lookouts, or where raptors or gulls perch. It becomes established on rocks enriched by the urine and feces of the Arctic ground squirrels or the whitewash from the birds.

In other areas, bright red-orange patches in the felsenmeer were observed, in damp areas where snow may have remained or where water percolating through the rocks keeps the area wet. This is not jewel lichen, but may be a slime mold.

Small variations in the plant associations occur on different kinds of rock surfaces, depending on the type of rock, the exposure to sunlight or weathering, and the plant communities surrounding the rocks.

3-3.11.1 Boulders in heath tundra

These are usually glacial erratics, transported into the area by the continental ice sheets, and stranded at varying distances from their origins (Plates 45, 46 and 47, Appendix E). These are also almost completely covered with crustose lichens.

Each of these boulders is covered with a lichen flora typical of that described above, and the surrounding tundra is typical of the heath tundra described above.

Since some boulders can come from distant areas, their chemical composition may vary, and thus their lichen flora. Calcareous boulders will have lichens like jewel lichen (*Xanthoria elegans*) or *Lessidea tessellata.*

In some places, increased plant growth can be seen around scattered boulders, due to a higher moisture level in the immediate vicinity because of runoff and a higher nutrient level due to animal activity on or around the boulders.

Most areas with boulders in heath tundra are mapped as heath tundra, but when the area covered with boulders exceeds that of the rooted vascular vegetation, they become more of a lichen-rock association. Often one grades into the other.

3-3.11.2 Boulder field/felsenmeer associations

Although the terrain features are quite different, the plant communities on boulder streams, boulder fields, and felsenmeer are all similar. The lichen species are determined by the composition of the rocks on which they occur.

Most of these rocks have not traveled far, if at all, and therefore bear the lichens typical of basic rocks in our area, as described above.

Boulder fields often have inclusions of heath tundra, “perched” on a boulder substrate (Plate 48, Appendix E). These likely develop from thick growths of lichens that capture dust and organic material, enough to harbour seeds that finally fall into the lichen mat. Some plants, like prickly saxifrage, are able to establish themselves in very little soil, so often start the process of colonization of the boulders.

Plants typical of vegetation mats in boulder fields include lingonberry, blueberry, and Labrador tea. Crowberry is often present, as is white Arctic heather, and occasionally small birches. Usually, there are a high percentage of foliose lichens, including *Cetraria nivalis, C. islandica*, *Cladonia cornuta, C. pixidata*,

and *Cladina mitis, C. rangiferina,* and *C. stellaris*. Fragrant shield ferns (*Dryopteris fragrans*) are also sometimes present, and are more common up at the Arctic coast than inland (Plate 49, Appendix E).

Frost boils in boulder fields bring finer soils to the surface, and are usually inhabited by a heath tundra association, although the center is often almost bare.

3-3.11.3 Bedrock associations

Bedrock associations occur on bedrock that is in place, not highly fractured into blocks that permit water to drain through the structure. Bedrock formations are rare in the northern part of the road, except in the edge of the Bathurst Inlet graben.

The composition of the bedrock will determine the plants that occupy it, but most in the study area tend to be acidic (Plate 50, Appendix E).

3-3.11.4 Polished bedrock outcrops

Bedrock outcrops vary in size from a few square meters to large ridges covering more than a hectare. These may barely clear the ground vegetation, or may be large ridges with steep cliffs or slopes.

For the most part, the bedrock is polished by the passage of the continental ice sheet during the Laurentide Glaciation, but fractures and small faults permit rooted vegetation to become established.

Most of the bedrock is of acidic composition, and the lichen flora reflects this – rock tripe, map lichens, bloodspot lichen, sunburst lichen, fine rock wool (*Pseudephebe pubescens*) and several black and grey crustose lichens are common. Mats of foliose lichens develop where the wind erosion is less than on the open rock, including *Cladina rangiferina, C. stellaris, Cetraria nivalis, C. islandica, Cladonia cornuta,* and other Cladonia lichens.

Rooted vegetation begins in depressions and crevices, with plants like prickly saxifrage, *Antennaria* sp., lingonberry, black bearberry (*Arctostaphylos alpina*), *Potentilla nivea, Saxifraga nivalis,* and small grasses. Fragrant shield ferns often become established in fissures in the rocks. Dwarf birches develop where there is more protection from the wind.

3-3.11.5 Fractured bedrock ledges

Ledges develop along cliffs, especially in the area at the western terminus of the road corridor. These are due to fracturing and large pieces of the bedrock slipping down or falling away from the cliff itself.

A thick layer of foliose lichens (*Cetraria nivalis, Cladonia* sp., and *Cladina stellaris*), mosses (*Aulicomnium, Polytrichum,* and a grey moss), plus a few plants of *Hierochloe alpina,* develops on many of these ledges, and is eventually invaded by heaths (mainly blueberry, lingonberry, and Labrador tea), becoming a lichen-heath association (Plate 51, Appendix E).

3-3.11.6 Cliff faces

Cliff faces may be sheer rock, or may involve a mixture of sheer rock and talus. The vegetation on the talus slopes is usually similar to that on felsenmeer, but not as lush, due to the fact that the surface layer of rock has not been in place as long, and is constantly being renewed, and due to shading and snowbanks (Plate 52, Appendix E). The talus rocks below cliffs are usually occupied by crustose and a few foliose lichens. The coverage of the rock by lichens is about 50%, rather than 85% as is usual for boulder fields.

The vegetation on cliff faces is limited due to the fact that there are few places where plants can gain a foothold. Sheer cliff faces usually support little more than a few crustose lichens and ferns clinging to small cracks in the cliff.

In the northern part of the study area, cliff faces may have *Dryopteris fragrans* in the sunny, dry areas, and *Cystopteris fragilis* and *Woodsia alpina* ferns in shaded crevices and overhangs. *Antennaria* sp., *Saxifraga tricuspidata, Silene acaulis* and *Dryas integrifolia* usually find a foothold in small cracks, and *Saxifraga oppositifolia* hangs from crevices where there is ample shade or a reliable source of moisture.

If there is fine soil material weathering out of the cliff face, then birches, grasses (usually *Poa* sp.), some xeric sedges (*Carex bigelowii, C. supina* or *C. vaginata),* heaths (usually blueberry is first), *Antennaria* sp., *Saxifraga tricuspidata,* and tall fireweed *(Epilobium angustifolium)* can gain a foothold.

3-3.12 Disturbed Sites (Disturbance Features)

Some plant associations seem to be typical of or somewhat limited to sites that have been disturbed due to natural or human activities. These differ according to the type of activity and the amount of nutrients added to the system.

We have labeled these “disturbed sites”, and have point-mapped examples with modifiers as to what caused the disturbance.

3-3.12.1 Animal den sites

Some animal dens (especially Arctic ground squirrel, wolf, and fox dens) usually are quite noticeable due to the piles of exposed subsoil, which the owners regularly dig out and distribute over surrounding vegetation (Plate 53, Appendix E). As well, these sites are recognizable by the lushness of the vegetation (Figure 34). This is due to enrichment by defecation, urination, and decomposition of prey items or the bodies of the den-makers themselves. One active Arctic fox den, with the residents inside, was identified and a large quantity of organic material, from bones to feces surrounded the den were observed. The vegetation was correspondingly fresh and green.

These enriched dens are characterized by thick grasses (*Arctagrostis latifolia, Calamagrostis neglecta, C. inexpansa, Festuca* sp. and *Poa* sp.), woodrushes (*Luzula* sp.), xeric sedges (*Carex vaginata, C. bigelowii*) and individual plants of *Hierochloe alpina*. A number of other plant species are often present, including alpine arnica, blue-green chickweed (*Stellaria longipes*), violets, *Saxifraga tricuspidata, Antennaria* sp., *Potentilla nivea, Dryas integrifolia*, and mats of heaths. Dwarf birches may overhang the site, probably there prior to the den being made. White Arctic heather and *Salix herbacea* often occur on the slopes

below the dens. Tall fireweed sometimes grows in profusion on old den sites, and small willows, including *Salix arctica*, and *S. glauca* ssp. *callicarpaea* may take root nearby.

Wolverine dens are much less obvious. These are usually in rocky areas, and grasses do not tend to become as clearly established around these dens. Wolverines do not use the dens year round, but only when they have young, hence do not seem to influence the plant communities as much as the ground squirrels or foxes do. Wolverines also use rock crevices and cliff bases as dens in winter, but their use of these areas also does not seem to affect the plants there, probably due to the fact that the use is sporadic and light. The only evidence is often only the presence of bones and a few feces.

Figure 34. Wolf den on esker slope

A single wolverine den was identified (PB 711, near KM 206) with some den openings in a rocky ridge, and a thick growth of *Hierochloe alpina*, Labrador tea, and black bearberry near the openings. Dwarf birches were scattered over the area, and there were several plants of *Stellaria longipes* in or close to each entrance. There were many piles of feces around this den site, offering enrichment for future plant development.

The crew did not have an opportunity to examine many bear dens, but the one den sampled (PB 712, to the west of the wolverine den, near KM 206, identifiable by bear hair caught in the rocks over the entrance) was a very small summer den under a rocky cliff, and did not show much evidence of excavation. Bears do not necessarily defecate in the vicinity of the den, nor do they tend to bring prey back to the den, so accumulation of nutrients is low. The sampled den did exhibit some enhanced growth of grasses, including *Poa* sp. around the entrance. There were patches of white Arctic heather and crowberry nearby, bulblet saxifrage (*Saxifraga cernua*) in a nearby rock crevice, and golden saxifrage (*Chrysosplenium tetrandrum*) under an overhang.

3-3.12.2 Nesting islands

Gulls tend to be colonial nesters, and to use islands in the middle of lakes or wide rivers, or on Bathurst Inlet. They contribute significantly to the nutrient levels of these islands due to defecation from the nests and from perches on prominent rocks (Plate 54, Appendix E).

Nutrients added due to nest defecation actually create small "gardens" around each nest site. At inland sites, *Potentilla nivea*, dandelions (*Taraxacum sp.*), and grasses (*Poa* sp., *Calamagrostis* sp.) are common around nests.

Bird islands in Bathurst Inlet demonstrate a much richer flora. In addition to *Potentilla nivea* and dandelions *(Taraxacum hyperboreum* and *T. lacerum)*, these often have lush growths of prickly saxifrage (*Saxifraga tricuspidata*), beach-rye grass (*Leymus mollis* ssp. *mollis),* foxtail (*Alopecurus alpinus*), Pallas' wallflower (*Erysimum pallasii*), star chickweed (*Stellaria humifusa*), blue-green chickweed (*Stellaria longipes*), and mouse-eared chickweed (*Cerastium alpinum*). Brooklet saxifrage (*Saxifraga rivularis)*, scurvy grass (*Cochlearia officinalis*), and Arctic poppies (*Papaver radicatum*) also occur on these islands, sometimes abundantly. Jewel lichen (*Xanthoria elegans*) encrusts most rock outcrops on these islands and all beaches to the storm tide line.

Due to limitations in helicopter time, gull-nesting islands were not visited in 2001 however, one botanist on the team has visited them prior to this study and is aware of the species involved.

3-3.12.3 Solifluction lobes

Solifluction is the slow downslope movement of parts of the active layer, which override other plant communities in some areas. Solifluction occurs on several different scales: small "frost boil" movement, and on a large scale where a lobe may extend over dozens or hundreds of metres.

On a small scale, frost boils and their solifluction create inclusions in heath tundra or the edges of sedge associations. These are discussed under "Heath Tundra".

Larger scale solifluction creates a unique type of disturbed site. Movement is circular at the face of the lobe, with soil particles being rolled over and over as the mass moves downslope. In addition, this movement allows seepage of water at the face of the slope, so the plants growing there have access to more water than those either above or below the actual lobe.

The presence of more water and the actual physical movement of plants tend to encourage the accumulation of woody plants at the face of the lobe. Birches and some willows, Labrador tea, and blueberries create a dense plant cover in this area, much denser than above or below.

3-3.12.4 Trails

Along the north shore of Contwoyto Lake, where there is an extremely high level of summer caribou migration movement, several areas were found with a characteristic plant association in heavily used trails (Plate 55, Appendix E).

This terrain, without the caribou traffic, would likely be heath tundra. However, the disturbance due to hooves and nutrient supplementation apparently encourages a plant community with a high percentage of low sedges (probably *Carex bigelowii*), blueberry, some mountain avens, *Antennaria* sp., least willow, a small amount of white Arctic heather, and grasses (*Poa* sp. and others). *Phyllodoce coerula* occurred in the edges of the trails on one site. *Aulacomnium* sp. was common, producing spores at the time.

Currently, it is not known why this distinct association develops in certain heavily traveled areas but not in others. In many other areas, heavy caribou use does not seem to produce this distinct plant community, but simply creates areas with deep trails where the vegetation is worn away, and the soil exposed.

Further study is needed to more completely define this association.

3-3.12.6 Camps

Several plots are located on old Inuit campsites, mostly on the crests of ridges along the road route. These are all likely more than 75 years old, and any transitory effect on the vegetation of the area is long past. The vegetation on the sites is the same as that of surrounding areas, only the boulders arranged in circles for tent rings, and little hearths provide any indication of human use.

More recently used Inuit campsites do have effects on the vegetation. Tall fireweed, dwarf fireweed, tansy mustard (*Descurainia sophioides*), and wormwood (*Artemisia tilesii*) all grow in profusion in the decade after a site is used.

Still, modern camps with buildings produce predictable effects on the vegetation in two ways, by erosion and by enrichment, either by water or nutrients.

The establishment of a camp and consequent heavy use of the land produces paths between buildings where the vegetation is worn away.

Enrichment can take the form of additional water. Buildings accumulate snow in the form of snowdrifts, and these produce a wetter microclimate as they melt in summer.

Greywater outflows from camps are high in phosphates and organic materials, and cause sedge associations to develop where the outflow is deposited on the ground. This results in lush growth of sedges and cottongrasses; the plants are much taller, thicker, and greener than normal for the area. No camps of this sort were found within the study area.

3-3.13 Marine (littoral) Communities

Marine communities occur only at the northern port site on Bathurst Inlet, so do not account for a large area in this study. However, these are among the most delicate communities, so protection of these communities will be important. The port site is located on a point, which does not adequately represent the great variety of littoral communities around the Inlet.

It is assumed that consideration will be given to the littoral communities on the islands and shores of Bathurst Inlet that will be exposed to increased ship traffic and potential pollution in the inlet.

3-3.13.1 Sandy beaches

The northern port location is on a point extending north into Bathurst Inlet just to the south of Amagok Creek. The shore of this port area is approximately 80% narrow sand beach.

Normal tides usually do not exceed 40 cm, so there is not much tidal effect on plant communities in the area. There is simply a zone along the shoreline where terrestrial plants do not grow.

The vegetation of sand beaches above the tidal zone varies with the exposure of the beach to storm tides. Exposed beaches have less vegetation and less diversity (Figure 35).

Figure 35. Marine beach community along Bathurst Inlet at port site.

Beach-rye grass (*Leymus mollis* ssp. *mollis*) is the most striking feature of the beaches along the Inlet. Under the beach-rye there is often a mat of beach pea (*Lathyrus japonicus*), and in areas where the sand is too unstable for the beach-rye to become established, there are mats of seabeach sandwort (*Honkenya peploides*). Seaside cinquefoil (*Potentilla egedii*) grows prostrate along the shores with a higher percentage of silt, close to the high tide zone. Two species of grass-of-Parnassus occur here, *Parnassia palustris* and *P. kotzebuei*.

On some more protected beaches, sedge communities extend almost to the salt water, with Sudetan lousewort, *Primula stricta*, and chamomile (*Matricaria ambigua*) and *Equisetum arvense* and *E. variegatum* growing amidst the sedges. Three gentians occur on these beaches, but are not common: *Lomatogonium rotatum*, *Gentiana propinqua*, and *Gentiana tenella* can occasionally be found behind protecting sandbars. (These gentians were not encountered in the study, but are located on the inlet.)

3-3.13.2 Gravel beaches

Many of the beaches around Bathurst Inlet are composed of gravel, mostly sandstone or algal limestone pebbles which vary tremendously in size and shape. On gravel beaches, seaside bluebells (*Mertensia maritima*) form small mats along the shore.

On algal limestone pebble beaches, scurvy grass (*Cochlearia officinalis*), dandelions (*Taraxacum* sp.), hawksbeard (*Crepis nana*), and sometimes *Saxifraga rivularis*, can manage to become established in protected spots.

Some gravel beaches are not littoral anymore, but are old glacial rebound beaches, now stranded far from the sea. These formed at sea level, and were carried up and away from the marine environment as the land rose after the retreat of the Laurentide ice sheet (clearing the coast some 8,000 years Before Present). These “strandlines” are common on the peninsula at the port site, and in a long strip parallel to the small meandering stream that flows into the bay immediately to the west of the point.

Glacial strandlines are a series of parallel ridges following the contour of a slope, each with a slight depression inland from the ridge. Close to the current sea level, these have no vegetation at all, but slightly inland (and upslope), they bear an accumulation of lichens, mostly a combination of *Cetraria nivalis*, other Cetraria lichens, some hair lichen, and small patches of white worm lichen (*Thamnolia subuliformis*). Further inland, these start to accumulate rooted vegetation, first patches of mountain avens, then some of the legumes, including *Hedysarum boreale* ssp. *mackenzeii*, *Astragalus richardsonii,* and *Astragalus alpina*. Still further inland, dwarf birches and willows become established, along with patches of typical heath tundra. All this progression of vegetation, a textbook example of plant succession, may happen in a distance of several hundred meters.

3-3.13.3 Rocky points

Virtually no plants grow within the salt spray zone on rocky points. There are also no lichens up to about 3 m elevation due to salt spray.

In some areas, *Potentilla nivea*, *Draba glabella*, Arctic poppies, or white bladder campion (*Melandrium affine*) become established in cracks in the rock.

3-3.13.4 Estuaries

Estuaries are uncommon around southern Bathurst Inlet, occurring where significant streams or rivers flow into the Inlet. There is a small estuary at the mouth of Amagok Creek, which enters the Inlet just north of the port site.

Shoreline features in estuaries are usually modified sandy beaches with more growth of sedges and thick beach-rye grass close to the high tide level. They can also be silty sand flats with heath tundra and assorted plants that are tolerant of high salt levels. Grasses may include beach-rye grass, *Dupontia fisheri*, and goose grass (*Pucinnellia phryganodes*). Sedges may include *Carex maritima*, *C. ursina*, and occasionally *C. subspathecea.*

Forbs in these areas include Sudetan lousewort, seaside chamomile, dwarf fireweed (*Epilobium latifolium*), small white fireweed (*Epilobium palustre*), wild sweet pea (*Hedysarum boreale* ssp. *mackenzeii*), Siberian aster (*Aster sibericus*), boreal wormwood (*Artemisia borealis*), and tall wormwood (*Artemisia tileseii*). Mare's tail (*Hippuris vulgaris* and *H. tetraphylla*), marsh marigold (*Caltha palustris* var. *arctica*), marsh five-finger (*Comarum palustre*), and several buttercups, including *Ranunculus gmellini* and *R. aquatilis* var. *eradicatus*, grow in small ponds or streams where they reach the salt water of the inlet.

3-4. Rare Plant Survey and Results

A "rare plant" is defined in *Rare Vascular Plants of the Northwest Territories* (McJannet et al., 1993) as:

> *"One that, because of its biological characteristics, or because it occurs at the edge of its main range, or, under some other reason, exists in low numbers or in very restricted areas in the region*

> *under consideration…. Our basic criteria for rarity were that the taxon either occurred in very few locations or was restricted to a very small area of the Northwest Territories*." (McJannet, Argus, and Cody, 1995) (To note that this was written before division of the Northwest Territories into Nunavut and the Northwest Territories.)

No plant species identified as "rare" in either the above paper or in *Rare Vascular Plants of the Canadian Arctic* (McJannet et al., 1993) were found in these studies.

As this project proceeded, the field crews were constantly on the lookout for any plant that could be considered "rare". A number of plants encountered were at the edge of their ranges, and thus uncommon. However, if their entire ranges were taken into consideration, they would not be uncommon.

Two species were inventoried that are considered to be range extensions. These include the following:

Salix pulchra

One collection of *Salix pulchra* at a site near the Mara River (plot PB 692) is an easternmost range extension for this species (Argus, personal communication, 2002). Argus writes:

> "*Salix pulchra* is part of the very complicated *Salix planifolia/ S. pulchra/ S. tyrrellii* complex. *Salix pulchra* usually occurs in Alaska and the Yukon, only overlapping slightly into the Mackenzie Delta, Tuktoyaktuk Peninsula, to the Anderson River delta (Argus, 1973). Argus writes, "This is an easternmost locality for this species. I have only seen one other specimen from south of Bathurst Inlet. It is the western phase of the *S. planifolia-pulchra-tyrrellii* complex. It has large narrow stipules, which are typically persistent for more than one year. The persistent leaves are red-brown compared to the yellow- or gray-brown in *S. planifolia*. In the Yukon, where the ranges of *Salix planifolia* and *S. pulchra* overlap, the two do not occur in the same habitats. *S. pulchra* is at higher elevations. I do not know of any Arctic habitats where they may well occur together."

In this case, there was one collection of *Salix planifolia* made within a few hundred meters of the willow riparian habitat of this example of *S. pulchra*. The two do occur near each other, but the *S. planifolia* example here was in heath tundra on the crest of a large rounded ridge.

Salix tyrrellii

Another willow, *Salix tyrrellii*, has, over the years of these baseline studies, been proven to be much more common than originally thought. Prior to studies at the WMC International Ltd. Meliadine West Gold Project near Rankin Inlet, *Salix tyrrellii* was known only from one locality in the Athabasca sand dunes. However, it proved to be quite common in the Meliadine West study (Burt, 1999a), and again in the work done at Tahera's Jericho Diamond Project at the western end of Contwoyto Lake (Burt, 1999b). As a result of the work at Rankin Inlet, *S. tyrrellii* was de-listed from the COSEWIC list of "threatened" species.

3-5. Recommendations/Conclusions

None of the plant communities or associations found in the proposed road corridor for this project is unique; all occur across the central barrenlands and Arctic coast wherever terrain conditions permit. Unfortunately, disturbance to the tundra caused by construction or transportation activity in an area may not merely damage the thin layer of tundra vegetation; it has the potential to destroy it. Recovery takes years, or decades. Therefore, to prevent unnecessary breaking of the plant cover on the land, it will be necessary to identify areas of concern, and to if possible, avoid damaging plant communities in the construction of the road.

Some communities or associations are of far more importance to wildlife than others, and, where these are limited in frequency or extent, care should be taken to avoid their destruction. These "communities of concern" include:

- Esker complexes over the entire road route; these landform features are important for denning of mammals like foxes, wolverine, ground squirrels, wolves;

- Riparian associations throughout the route; these communities are important nesting sites for small birds, and for foraging or resting spots for caribou and grizzlies;

- A major caribou travel route along the north shore of Contwoyto Lake; this migration pathway and associated nadloks has been in such intensive and continuous use by caribou that the animals seem to have modified the plant cover;

- Littoral communities in Bathurst Inlet itself; these communities are sensitive to marine pollution; in the case of bird nesting islands, any damage to the nesting environment could affect a population of birds over a large area.

Sedge communities are also of tremendous importance to wildlife, especially to grizzlies and caribou in the spring; they are however not limited in extent and are not perceived as requiring special protection. However, changes in the drainage patterns across the land can deprive sedge communities of the necessary groundwater flows necessary for their existence causing changes over time. Consideration needs to be taken in the design of the road with regard to the groundwater flows on a seasonal and yearly basis.

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APPENDIX A – PLANT SPECIES ENCOUNTERED IN THE STUDY AREA

Appendix A
Plant Species Encountered in the Study Area

Scientific Name	Common Name	Previous Name
POLYPODIACEAE	**FERNS**	
Dryopteris fragrans	Fragrant shield fern	
EQUISETACEAE	**HORSETAILS**	
Equisetum arvense	Common horsetail	
Equisetum sylvaticum var. pauciramosum	Wood horsetail	
LYCOPODIACEAE	**CLUBMOSSES**	
Lycopodium annotinum	Stiff clubmoss	
Lycopodium complanatum	Ground-cedar	
Huperzia selago	Shining clubmoss	*Lycopodium selago*
SCHEUZERIACEAE	**ARROW-GRASSES**	
Triglochin maritimum	Seaside arrowgrass	
GRAMINAE	**GRASSES; IVIK**	
Agrostis mertensii	Northern bentgrass	*Agrostis borealis*
Arctagrostis latifolia	Polargrass	
Calamagrostis canadensis	Bluejoint grass	
Calamagrostis inexpansa		
Calamagrostis stricta ssp. stricta	Slimstem reedgrass	*Calamagrostis neglecta*
Calamagrostis purpurascens	Purple reedgrass	
Calamagrostis sp.		
Dupontia fisheri		
Deschampsia caespitosa	Tufted hairgrass	
Festuca richardsonii	Richardson's fescue	*Festuca rubra ssp. richardsonii*
Festuca saximontana	Rocky mountain fescue	
Festuca sp.	Fescue	
Hierochloe alpina	Alpine holygrass; Alpine sweetgrass	
Leymus mollis ssp. mollis	Beach rye grass, dune wildrye	*Elymus arenarius ssp mollis*
Poa alpina	Alpine bluegrass	
Poa arctica	Arctic bluegrass	
Poa sp.	Bluegrass	
Trisetum spicatum	Spike trisetum	
CYPERACEAE	**SEDGES**	
Carex aquatilis	Water sedge	
Carex atrofusca		
Carex bigelowii		
Carex capillaris	Hairlike sedge	
Carex capitata	Capitate sedge	
Carex chordorrhiza	Cordlike sedge	
Carex holostoma		
Carex rariflora		
Carex rotundata		
Carex saxatilis	Russet sedge	
Carex scirpoidea	Single-spike sedge	
Carex supina	Spreading arctic sedge	
Carex tenuiflora	Sparse-leaved sedge	
Carex vaginata	Sheathed sedge	
Carex sp.	Sedges	
Eriophorum angustifolium	Narrow-leaved cottongrass	
Eriophorum brachyantherum	Short-anthered cottongrass	
Eriophorum callitrix	Arctic cottongrass	
Eriophorum chamissonis	Chamisso's cottongrass	*Eriophorum russeolum*
Eriophorum scheuchzeri	Scheuchzer's cottongrass	
Eriophorum vaginatum	Sheathed cottongrass	
Eriophorum sp.	Arctic cotton, cottongrass kangoyak	
Kobresia myosuroides	Bellard's kobresia	
Scirpus sp.	Rushes	
Trichophorum caespitosum	Tufted bulrush	*Scirpus caespitosus*
JUNCACEAE	**RUSHES**	
Juncus albescens	Whitish rush	
Juncus castaneus	Chestnut rush	
Juncus filiformis	Thread rush	
Juncus sp.	Rushes	
Luzula confusa	Confused woodrush	
Luzula wahlenbergii	Piper's woodrush	
Luzula sp.	Woodrush	

(continued)

Appendix A
Plant Species Encountered in the Study Area (continued)

Scientific Name	Common Name	Previous Name
LILIACEAE	**LILIES**	
Tofieldia coccinea	Northern false asphodel	
Tofieldia pusilla	Common false asphodel	
ORCHIDACEAE	**ORCHIDS**	
Platanthera obtusata	Small northern bog-orchid; one-leaved rein orchid	*Habenaria obtusata*
SALICACEAE	**WILLOWS; OKPEET**	
Salix arctica	Arctic willow	
S. arctica X S. glauca callicarp.	Hybrid	
Salix arbusculoides	Northern bush willow	
Salix arctophila		
Salix brachycarpa ssp. niphoclada	Snow willow	*Salix niphoclada*
Salix fuscescens		
Salix glauca	Blue-green willow; grey-leaved willow	
Salix glauca ssp. callicarpaea		
Salix herbacea	Least willow	
Salix lanata	Woolly willow	
Salix niphoclada		
Salix planifolia	Tea-leaved willow	
S. planifolia X S. tyrrellii	Intergrades	
Salix pulchra		
Salix reticulata	Net-veined willow	
Salix richardsonii	Richardson's willow	
Salix tyrrellii	Tyrrell's willow	
Salix sp.	Willows	
BETULACEAE	**BIRCHES; AVALAKIAK**	
Alnus viridus ssp. crispa	Green alder	*Alnus crispa*
Betula nana	Dwarf birch	*Betula glandulosa*
POLYGONACEAE	**BUCKWHEATS**	
Oxyria digyna	Mountain sorrel; sweetleaf heeknakotit	
Polygonum viviparum	Smartweed	
CARYOPHYLLACEAE	**PINKS**	
Cerastium alpinum	Mouse-ear chickweed	
Minuartia rubella	Sandwort	
Silene acaulis	Moss campion	
Stellaria longipes	Long-stalked starwort	*Stellaria monantha*
Stellaria sp.	Star chickweeds; starworts	
RANUNCULACEAE	**BUTTERCUPS**	
Anemone richardsonii	Richardson's anemone	
Ranunculus lapponicus	Lapland buttercup	
Ranunculus pygmaeus	Pygmy buttercup	
PAPAVERACEAE	**POPPIES**	
Papaver radicatum	Arctic poppy	
CRUCIFERAE	**MUSTARDS**	
Arabis arenicola	Rock-cress	
SAXIFRAGACEAE	**SAXIFRAGES**	
Chrysosplenium tetrandrum	Golden saxifrage	
Saxifraga cernua	Bulblet saxifrage; nodding saxifrage	
Saxifraga hirculus	Yellow marsh saxifrage	
Saxifraga nelsoniana	Cordate-leaved saxifrage	*Saxifraga punctata*
Saxifraga nivalis	Alpine saxifrage	
Saxifraga oppositifolia	Purple mountain saxifrage	
Saxifraga rivularis	Brooklet saxifrage	
Saxifraga tricuspidata	Prickly saxifrage; kakilahan three-toothed saxifrage	
ROSACEAE	**ROSES**	
Comarum palustre	Marsh cinquefoil; marsh five-finger	*Potentilla palustris*
Dryas integrifolia	Mountain avens	
Sibbaldia procumbens	Sibbaldia	
Spiraea stevenii	Steven's spirea	*Spiraea beauverdiana*
Pentaphylloides floribunda	Shrubby cinquefoil	*Potentilla fruticosa*
Potentilla nivea	Snow cinquefoil	
Rubus chamaemorus	Cloudberry, akpik	

(continued)

Appendix A
Plant Species Encountered in the Study Area (continued)

Scientific Name	Common Name	Previous Name
LEGUMINOSAE	**PEAS; LEGUMES**	
Astragalus sp.		
Astragalus alpinus	Alpine milkvetch	
Hedysarum alpinum	Liquorice-root; mahok; bear root; eskimo potato	
Hedysarum boreale ssp mackenzeii	Wild sweet pea	*Hedysarum mackenzeii*
Lathyrus japonicus	Beach pea	
Lupinus arcticus	Arctic lupine	
Oxytropis arctica	Arctic crazyweed	
Oxytropis maydelliana	Yellow crazyweed; Maydell's oxytrope	
Oxytropis sp.	Crazyweeds, locoweeds	
EMPETRACEAE	**CROWBERRIES**	
Empetrum nigrum	Crowberry; baongak	
VIOLACEAE	**VIOLETS**	
Viola ajunca var. minor	Early blue violet	
Viola palustris (probably)	Marsh violet	
Viola sp.	Violets	
ONAGRACEAE	**EVENING PRIMROSES**	
Epilobium angustifolium	Tall fireweed	
Epilobium latifolium	Dwarf fireweed; river beauty; broad-leafed willowherb	
PYROLACEAE	**WINTERGREENS**	
Orthilia secunda	Side-flowered wintergreen; one-sided wintergreen	*Pyrola secunda*
Pyrola grandiflora	Large-flowered wintergreen	
Pyrola minor	Wintergreen	
ERICACEAE	**HEATHS**	
Andromeda polifolia	Bog rosemary	
Arctostaphylos alpina ssp alpina	Black bearberry; kablak	*Arctostaphylos alpina*
Arctostaphylos alpina ssp rubra	Red bearberry; kablak	*Arctostaphylos rubra*
Cassiope tetragona	White arctic heather; eghotik	
Kalmia polifolia	Western bog-laurel	
Ledum palustre ssp. decumbens	Labrador tea	*Ledum decumbens*
Loiseleuria procumbens	Alpine azalea	
Vaccinium oxycoccos	Small bog cranberry	*Oxycoccus microcarpus*
Phyllodoce coerula	Mountain heather	
Rhododendron lapponicum	Lapland rosebay	
Vaccinium vitis-idaea	Lingonberry; kinminiak mountain cranberry	
Vaccinium uliginosum	Bilberry, blueberry kegotangenak	
DIAPENSIACEAE	**DIAPENSIAS**	
Diapensia lapponica	Diapensia	
PLUMBAGINACEAE	**LEADWORTS**	
Armeria maritima	Thrift	
BORAGINACEAE	**BORAGES**	
Mertensia maritima	Seaside bluebells	
SCROPHULARIACEAE		
Castilleja sp.	Paintbrush; painted-cup	
Pedicularis labradorica	Labrador lousewort	
Pedicularis lanata	Woolly lousewort	
Pedicularis lapponica	Lapland lousewort	
Pedicularis sudetica	Sudetan lousewort	
CAPRIFOLIACEAE	**HONEYSUCKLES**	
Linnaea borealis	Twinflower	
LENTIBULARIACEAE	**BLADDERWORTS**	
Pinguicula villosa	Small butterwort	
Pinguicula vulgaris	Butterwort	
Utricularia intermedia	Flat-leaved bladderwort	
COMPOSITAE	**DAISIES**	
Achillea sp. (prob. nigrescens)	Yarrow	
Antennaria alpina	Dwarf pussytoes	*Antennaria compacta*
Antennaria sp.	Pussytoes	
Arnica angustifolia ssp angustifolia	Alpine arnica	*Arnica alpina*
Artemisia tilesii	Wormwood	
Aster sp.	Asters	

(continued)

Appendix A
Plant Species Encountered in the Study Area (continued)

Scientific Name	Common Name	Previous Name
Leucanthemum integrifolium	Entire-leaved daisy	*Chrysanthemum integrifolium*
Saussurea angustifolia	Fireworks flower; northern sawwort	
Senecio atropurpurea	Purple-haired groundsel	
LIVERWORTS		
Barbilophozia sp.		
Marchantia polymorpha		
MOSSES		
Aulacomnuim palustre	Glow moss	
Aulacomnium turgidum		
Aulacomnium sp.		
Brachythecium sp.		
Bryum alpinum		
Byrum arcticum		
Bryum sp.		
Calliergon giganteum	Giant water moss	
Calliergon richardsonii		
Calliergon stramineum		
Campylium stellatum		
Dicranum elongatum		
Dicranum fuscescens		
Dicranum groenlandicum		
Dicranum montanum		
Dicranum spadiceum		
Dicranum sp.		
Didymodon johansenii		
Distichium capillaceum		
Drepanocladus aduncus		
Drepanocladus brevifolius		
Drepanocladus capillifolius		
Drepanocladus exannulatus		
Drepanocladus fluitans		
Drepanocladus revolvens		
Drepanocladus ucinatus		
Eurhynchium sp.		
Hylocomium splendens	Step moss	
Hylocomium umbratum		
Hypnogymnia physodes	Monk's hood moss	
Lepraria neglecta		
Leptodictyum riparium		
Philonotis americana		
Pleurozium schreberi	Red-stemmed feathermoss	
Polytrichum commune var. commune		
Polytrichum commune var. jensenii		
Polytrichum juniperinum	Juniper haircap moss	
Polytrichum piliferum		
Polytrichum strictum		
Polytrichum sp.	Haircap mosses	
Racomitrium canescens	Grey rockmoss	*Rhacomitrium canescens*
Racomitrium lanuginosum	Hoary rockmoss	*Rhacomitrium lanuginosum*
Rhizomnium magnifolium		
Rhizomnium nudum		
Sanionia uncinatus		
Sphagnum angustifolium		
Sphagnum capillifolium		*Sphagnum nemoreum*
Sphagnum compactum		
Sphagnum cuspidatum		
Sphagnum fuscum	Common brown sphagnum	
Sphagnum imbricatum		
Sphagnum platyphyllum		
Sphagnum pylaesii		
Sphagnum quinquefarium		
Sphagnum russowii		
Sphagnum squarrosum	Shaggy sphagnum	
Sphagnum strictum		
Sphagnum subsecundum		
Sphagnum subtile		
Sphagnum teres		
Sphagnum sp.		
Tomentyupnum nitens	Golden fuzzy fen moss	
Tortella tortuosa		

(continued)

Appendix A
Plant Species Encountered in the Study Area (completed)

Scientific Name	Common Name	Previous Name
LICHENS	**LICHENS, KAGIUYAT**	
Alectoria sp.	Hair lichen	
Alectoria nigricans	Grey witches' hair	
Alectoria ochroleuca	Green witches' hair	
Arctoparmelia centrifuga	Sunburst lichen	
Aspilicea cinerea		
Cetraria cucullata	Furled paperdoll	
Cetraria ericetorum	Icelandmoss	
Cetraria islandica	Brown icelandmoss	
Cetraria nivalis	Ragged paperdoll	
Cetraria tilesii	Limestone sunshine lichen	
Cetraria sp.	Brown lettuce lichen	
Cladina mitis	Lesser green reindeer lichen	
Cladina rangiferina	Grey reindeer lichen	
Cladina stellaris	Starred reindeer lichen	
Cladina sp.	Reindeer lichens	
Cladonia borealis	Boreal pixie-cup	
Cladonia chlorophaea	Mealy pixie-cup	
Cladonia coccifera or *C. bellidiflora*	Toy soldiers lichen	
Cladonia cornuta	Cup lichen	
Cladonia pixidata	Pebbled pixie-cup	
Cladonia squamosa	Dragon funnel lichen	
Cladonia sp.	Pixie-cup lichen	
Coelocaulon aculeatum	Spiny heath lichen	
Dactylina arctica	Glove lichen	
Dimelaena oreina	Mountain lichen	
Hypnogymnia physodes	Monk's hood lichen	
Icmadophila ericetorum	Peppermint drop lichen	
Masonhalea richardsonii	Antler lichen, arctic tumbleweed	
Nephroma arcticum	Green light lichen	
Ophioparma lapponica	Bloodspot lichen	*Haematomma lapponicum*
Peltigera aphthosa	Freckle pelt	
Peltigera sp.	Pelt lichens	
Pertusaria dactylina	White finger lichen	
Pseudephebe pubescens	Fine rock wool; brushcut lichen	
Rhizocarpon geographicum	Map lichen	
Rhizocarpon geminatum	Map lichen	
Stereocaulon tomentosum	Grey mealy lichen; eyed foam	
Stereocaulon sp.	Foam lichens	
Thamnolia subuliformis	Whiteworm lichen	
Tremolecia atrata	Halloween lichen	
Umbilicaria hyperborea	Blistered rock tripe	
Umbilicaria vellea	Frosted rock tripe	
Xanthoria elegans	Jewel lichen	

APPENDIX B – LIST OF VASCULAR PLANT TAXA WITH NOMENCLATURE REVISIONS SINCE PORSILD AND CODY (1980)

Appendix B
List of Vascular Plant Taxa with Nomenclature Revisions since Porsild and Cody (1980)

The following vascular plant species have had major revisions, and the scientific names are no longer the same as recorded in Porsild and Cody (1980).

The Vascular Plants of the Continental Northwest Territories, Canada. These are names as recorded in the VENUS system and checked in several sources, including the "PLANTS Database" (USDA, NRCS, 2001).

Current Name	Name in Porsild and Cody (1980)	Common Name
Huperzia selago	*Lycopodium selago*	Shining clubmoss
GRAMINAE		
Calamagrostis stricta ssp. stricta	*Calamagrostis neglecta*	Slimstem reedgrass
Festuca richardsonii (sometimes *F. rubra*)	*Festuca rubra ssp. richardsonii*	Richardson's red fescue
Leymus mollis	*Elymus arenarius ssp. mollis*	Beach rye, dune wildrye
Eriophorum chamissonis	*Eriophorum russeolum*	
Trichophorum caespitosum	*Scirpus caespitosus*	Tufted bulrush
ORCHIDACEAE		
Platanthera obtusata	*Habenaria obtusata*	Small northern bog orchid
SALICACEAE		
Salix brachycarpa ssp. niphoclada	*Salix niphoclada*	Snow willow
BETULACEAE		
Alnus viridus ssp. sinuate	*Alnus crispa*	Green alder, Sitka alder
Betula nana	*Betula glandulosa*	Dwarf birch
CAROYPHYLLACEAE		
Stellaria longipes var. monantha	*Stellaria monantha*	Blue-green chickweed
SAXIFRAGACEAE		
Saxifraga nelsoniana	*Saxifraga punctata*	Cordate-leaved saxifrage
ROSACEAE		
Comarum palustre	*Potentilla palustris*	Marsh cinquefoil
Spiraea stevenii	*Spiraea beauverdiana*	Steven's spirea
LEGUMINOSAE		
Hedysarum boreale ssp. mackenzeii	*Hedysarum mackenzeii*	Wild sweet pea
PYROLACEAE		
Orthilia secunda	*Pyrola secunda*	Side-flowered wintergreen
ERICACEAE		
Arctostaphylos alpina ssp. alpina	*Arctostaphylos alpina*	Alpine or black bearberry
Arctostaphylos alpina ssp. rubra	*Arctostaphylos rubra*	Red bearberry
Ledum palustre ssp. decumbens	*Ledum decumbens*	Northern Labrador tea
Vaccinium oxycoccos	*Oxycoccus oxycoccos, O. microcarpus*	Bog cranberry
COMPOSITAE		
Arnica angustifolia ssp. angustifolia	*Arnica alpina*	Alpine arnica
Laucanthemum integrifolium	*Chrysanthemum integrifolium*	Entire-leaved daisy
MOSSES		
Racomitrium canescens	*Rhacomitrium canescens*	Grey rockmoss
Racomitrium lanuginosum	*Rhacomitrium lanuginosum*	Hoary rockmoss
Sphagnum capillifolium	*Sphagnum nemoreum*	
LICHENS		
Ophiopharma lapponica	*Haematomma lapponicum*	Bloodspot lichen

APPENDIX C – POTENTIAL VASCULAR PLANT SPECIES AT THE NORTHERN PORT SITE

Appendix C
Potential Vascular Plant Species at Northern Port Site

The following list is a list of the potential plant species that likely occur in the vicinity of the port site on Bathurst Inlet and on adjacent islands in the inlet, but **were not collected during 2001**. This list is appended because the area is relatively sensitive, and because the field studies did not allow time to check islands.

This list is based on data provided by Bathurst Inlet Lodge, which has operated in the area since 1969. Taxonomy is based on Porsild and Cody (1980), Vascular Plants of Continental Northwest Territories Canada. If name changes were identified, these are inserted below the name as used in Porsild and Cody.

Scientific Name	Common Name	Notes
POLYPODIACEAE		
Cystopteris fragilis	Fragile fern	
Woodsia alpina	Northern woodsia	Deep niches in cliffs Shaded niches in cliffs
Woodsia glabella	Smooth cliff fern	Crevices and overhangs
Equisetum variegatum	Variegated horsetail	Sandy beaches
SPARGANIACEAE		
Sparganium hyperboreum	Bur-reed	Shallow delta ponds
POTOMOGETONACEAE		
Potomogeton filiformis	Pondweed	Shallow ponds
GRAMINAE		
Alopecurus alpinus	Foxtail	Nitrophilous, nesting areas
Arctophila fulva		Pond edges, marshes
Festuca brachyphylla	Fescue	Sandy, gravelly places
Poa glauca	Bluegrass	Sandy, gravelly places
Pucinnellia phryganodes	Marine goose grass	On stable, sandy shores
CYPERACEAE		
Carex amblyorhyncha		
Carex aquatilis var. stans	Water sedge	Mossy bog areas
Carex bigelowii	Bigelow's sedge	Edges of shallow ponds
Carex maritima	Marine sedge	Variable, wet and dry
Carex membranacea		Mostly, but not always, littoral
Carex microglochin		Dry, turfy tundra
Carex rupestris	Curly sedge	Wet calcareous soil
Carex subspathecea		Dry tundra, gravel ridges, rocky ledges
Carex supina		Littoral, wet clay beaches
Carex ursina		Noncalcareous, dry places
Eriophorum callitrix	Single-headed cottongrass	Littoral, sheltered s
ORCHIDACEAE		
Corallorhiza trifida	Coralroot orchid	Turfy lowlands, often with Dryas
SALICACEAE		
Salix alaxensis	Felt-leaf willow	Thickets, streambanks, lakeshores
POLYGONACEAE		
Koenigia islandica		Wet sand or silt, annual
CARYOPHYLLACEAE		
Honkenya peploides		
Melandrium affine	White bladder campion	Dry stony, gravelly places, densites
Melandrium apetalum	Red bladder campion	Edges of ponds
Stellaria humifusa	Star chickweed	Islands and shores
RANUNCULACEAE		
Anemone parviflora	Few-flowered anemone	Snowbanks, sheltered areas
Caltha palustris var. arctica	Marsh marigold	Pond edges, small streams, emergent
Ranunculus aquatilis var. eradicatus	White water buttercup	In small streams/ponds, submergent
Ranunculus gmelinii		Shallow ponds, submergent
Ranunculus hyperboreus		Fresh/brackish ponds, amphibious
Ranunculus lapponicus	Lapland buttercup	Moss under willows
Ranunculus pallasii	Pallas' buttercup	Meadows and sloughs, brackish, emergent
Ranunculus pedatifidus var. leiocarpus	Birdfoot buttercup	Calcareous soils

(continued)

Appendix C
Potential Vascular Plant Species at Northern Port Site (completed)

Scientific Name	Common Name	Notes
PAPAVERACEAE		
Papaver radicatum	Arctic poppy	Algal limestone islands, gravelly ridges
CRUCIFERAE		
Cardamine digitata		Hummocks and turfy tundra
Caradmine pratensis	Cuckoo flower	Wetlands near coast
Cochlearia officinalis	Scurvy grass	Bird nesting islands
Descurainia sophioides	Tansy-mustard	Disturbed sites, esp. near community
Draba alpina	Alpine draba	Moist turfy tundra
Draba glabella	Smooth draba	Rocky, grassy areas, nitrophilous
Draba lactea	Milky draba	Moist turfy tundra
Erysimum inconspicuum	Yellow wallflower	Islands in lakes, shores
Erysimum pallasii	Pallas' wallflower	Bird nesting islands, calcareous soil
Lesquerella arctica	Arctic bladderpod	Gravell
SAXIFRAGACEAE		
Chrysosplenium tetrandrum	Golden saxifrage	Moist spots in grassy areas, shores
Parnassia kotzebuei	Kotzebue's grass-of-Parnassus	Wet sand by lakeshores
Parnassia palustris	Northern grass-of-Parnassus	Moist sandy shores
Saxifraga aizoides	Yellow mountain saxifrage	Moist calcarerous clays
Saxifraga foliolosa		Wetlands, deltas
ROSACEAE		
Potentilla egedii	Seaside cinquefoil	Shores
Potentilla nivea ssp. nivea	Snow cinquefoil	Gravelly ridges, bird islands
LEGUMINOSAE		
Astragalus richardsonii	Richardson's milkvetch	Gravelly beach ridges
Oxytropis arctobia		Exposed gravel ridges
Oxytropis deflexa var. foliosa	Pendant-pod crazyweed	Moist sandy shores
ELAEAGNACEAE		
Shepherdia canadensis	Soapberry	Thickets at streams
ONAGRACEAE		
Epilobium palustre	Small white fireweed	Moist shorelines, pond edges
HALORAGACEAE		
Hippuris tetraphylla	Four-leaved mare's tail	Shallow saline pools or streams at the sea
PRIMULACEAE		
Androsace septentrionalis	Northern fairy candelabra	Sandy, gravelly areas
Primula stricta	Upright primrose	Wet seepages, along sea shores
GENTIANACEAE		
Gentiana propinqua	Four-parted gentian	Open herbmats, beaches
Now: *Gentianella propinqua ssp. propinqua*		
Now: *Gentianella tenella ssp. tenella*		
Lomatogonium rotatum ssp. rotatum	Felwort	Beaches
Pedicularis capitata	Crowned lousewort	Heath tundra, with lupines
Pedicularis flammea	Flame-tipped louseworts	Dry tundra. Rare.
Plantago canescens	Arctic plantain	Calcareous gravels
CAMPANULACEAE		
Campanula uniflora	Arctic harebell	Old glacial rebound beaches, dry tundra
COMPOSITAE		
Antennaria angustata	Pussytoes	Snowbank communities
Now: *Antennaria monocephala*		
Antennaria compacta	Pussytoes	Dry slopes, gravels
Artemisia borealis	Boreal wormwood	Sand dunes
Now: *Artemisia campestris ssp. borealis*		
Aster sibericus	Siberian aster	Sand dunes, gravel areas
Crepis nana	Dwarf hawk's-beard	Gravelly exposed ridges/ islands
Erigeron humilis	Daisy fleabane	Moist areas, shores, snowbanks
Matricaria ambigua	Wild chamomile	Sandy shores
Petasites sagittatus	Arrow-leaved coltsfoot	Moist areas by lakeshores
Taraxacum hyperboreum	Dandelion	Bird islands, esp. limestone
Taraxacum lacerum	Narrow-leaved dandelion	Moist tundra, bird islands

APPENDIX D – PLANT SPECIES BY COMMUNITY

Appendix D
Plant Species by Community

This list outlines plant species typical of each community, based on common occurrence in the plots. Those that seem to be limited to the Bathurst Inlet area are followed by *.

Sedge Community

Betula nana
Calamagrostis neglecta
Carex aquatilis
C. chordorrhiza
C. holostoma
C. rariflora
C. rotundata
C. scirpoidea
C. vaginata
Comarum palustre
Eriophorum angustifolium
E. brachyantherum
E. callitrix
E. scheuchzeri
E. vaginatum
Hierochloe alpina
Juncus albescens
Luzula confusa
L. wahlenbergii Melandrium
*Melandrium apetalum**
Pedicularis sudetica
Salix arctica
S. arctophila
S. fuscescens
S. glauca ssp. callicarpaea
S. herbacea
S. planifolia
S. tyrrellii
S. tyrrellii intergrade with S. planifolia
*S. hirculus **
Scirpus caespitosus

Mosses
Aulacomnium
Sphagnum sp.

In addition, invading members of the heath family (Ericaceae) and others, including *Andromeda polifolia*, *Rubus chamaemorus*, *Vaccinium uliginosum*, *V. vitis-idaea*, *Ledum palustre*, and *Polygonum viviparum*.

Moss Communities

Two very different types of moss communities occur, so are listed separately. Mosses are listed first, vascular plants second.

Mossy shore association

Aulacomnium turgidum
Calligeron stramineum
Polytrichum commune var. jensenii
Sphagnum imbricatum
S. russowii

Vascular plants:
Andromeda polifolia
Calamagrostis canadensis
Carex aquatilis
C. rariflora
C. rotundata
Kalmia polifolia
Luzula sp.
Pedicularis lapponica
P. sudetica
Poa sp.
Rubus chamaemorus
Salix arctophila
S. herbacea
S. tyrrellii
Spiraea stevenii
Vaccinium uliginosum
Viola ajunca var. minor

Mossy cliff base
Aulacomnium
Polytrichum
Sphagnum

Vascular plants:
Luzula sp.
Poa sp.
Salix planifolia
Spiraea stevenii

Riparian Shrub Communities

Arctagrostis latifolia
Betula nana
Calamagrostis canadensis
C. inexpansa
C. neglecta
Carex aquatilis
C. bigelowii
C. rariflora
C. rotundata
Empetrum nigrum
Eriophorum angustifolium
E. scheuchzeri
Juncus castaneus
Linnaea borealis Lycopodium annotinum
Pedicularis lapponica
Pentaphylloides floribunda
Pyrola grandiflora
Ranunculus lapponicus
Salix arctophila
S. fuscescens
S. glauca
S. herbacea
S. tyrrellii
S. tyrrellii intergrade with S. planifolia
Saxifraga cernua
Scirpus caespitosus
Stellaria longipes
Tofieldia pusilla

Mosses and lichens:
Polytrichum commune var commune
Sphagnum sp.

Plus assorted heaths: *Andromeda polifolia, Arctostaphylos alpina ssp. rubra, Cassiope tetragona, Vaccinium uliginosum, V. vitis-idaea, Ledum palustre ssp. decumbens.*

Birch Shrub/'Seep" Community

Arctagrostis latifolia
Arctostaphylos alpina
Betula nana
Calamagrostis neglecta
Empetrum nigrum
Eriophorum callitrix
E. vaginatum
Festuca saximontana
Ledum palustre ssp. decumbens
Loiseleuria procumbens
Poa arctica
Salix arctica
S. arctophila
S. herbacea
S. planifolia
S. planifolia intergrade with S. tyrrellii
S. tyrrellii
Vaccinium uliginosum
V. vitis-idaea

Mosses, liverworts, and lichens:
Aulicomnium turgidum
Barbilophozia sp.
Bryum alpinum
Cetraria nivalis
Dactylina arctica
Dicranum elongatum
Drepanocladus capillifolius
Hypnogymnia physodes
Nephroma
Peltigera
Racomitrium lanuginosum
Sphagnum subsecundum
Sphagnum sp.
Stereocaulon tomentosum
Tortella tortuosa

(continued)

Appendix D
Plant Species by Community

This list outlines plant species typical of each community, based on common occurrence in the plots. Those that seem to be limited to the Bathurst Inlet area are followed by *.(continued)

Heath Tundra Community

This list includes species recorded from heath tundra throughout the length of the proposed road corridor. Those typical of/restricted to the arctic coast are followed by *.

Andromeda polifolia
Arctagrostis latifolia
Arctostaphylos alpina ssp. alpina
A. alpina ssp. rubra (wetter sites)
Astragalus alpinus
*A. richardsonii**
Betula nana
Calamagrostis inexpansa
Calamagrostis neglecta
*Campanula uniflora**
*Cardamine digitata**
Carex bigelowii
C. capitata
C. holostoma
C. rotundata
C. vaginata
Cassiope tetragona
Diapensia lapponica
*Draba alpina **
*D. lactea **
Dryas integrifolia
Eriophorum callitrix
E. scheuchzeri
*Hedysarum alpinum **
*Hedysarum boreale ssp. mackenzeii **
Hierochloe alpine
Huperzia selago
Loiseleuria procumbens
*Lupinus arcticus **
Lycopodium annotinum
Oxytropis arctica
*O. glutinosa **
O. maydelliana
*P. capitata **
*P. flammea **
P. labradorica
*P. lanata **
P. lapponica
*Platanthera obtusata **
Poa arctica
Poa alpina
Polygonum viviparum
Rhododendron lapponicum
Rubus chamaemorus
Salix arctica
S. arbusculoides
S. glauca ssp. callicarpaea
S. planifolia
S. planifolia intergrade with S. tyrrellii
S. reticulata
S. tyrrellii
Saxifraga oppositifolia
*Senecio atropurpurea **
*Tofieldia coccinea **
T. pusilla
Trisetum spicatum
**Vaccinium uliginosum*
**V. vitis-idaea*

Mosses and lichens:

Alectoria nigricans
A. ochroleuca
Aulicomnium turgidum
Cetraria nivalis
Cladina stellaris
Cladonia sp.
Dactylina arctica
Dicranum elongatum
Drepanocladus revolvens
Masonhalea richardsonii
Peltigera sp.
Polytrichum commune var. commune
Racomitrium lanuginosum
Rhizomium magnifolium
Sphagnum subsecundum
Stereocaulon tomentosum
Thamnolia subuliformis

Snowbank Community

Anemone richardsonii
Antennaria angustata
A. eckmaniana
Anemone richardsonii
Arabis arenicola
Betula nana
Cassiope tetragona
Carex aquatilis
C. bigelowii
Diapensia lapponica
Eriophorum brachyantherum
Hierochloe alpine
Kalmia polifolia
Ledum palustre ssp. decumbens
Lycopodium annotinum
Oxyria digyna
Pedicularis lapponica
Phyllodoce coerula
Poa arctica
Ranunculus pygmaeus
Rubus chamaemorus
Salix herbacea
Saxifraga nivalis
S. nelsoniana
S. rivularis
Sibbaldia procumbens
Silene acaulis
Vaccinium uliginosum
V. vitis-idaea
Viola sp.

Aulicomnium turgidum
Drepanocladus aduncus
D. capillifolius
Marchantia polymorpha
Polytrichum commune var. commune
P. commune var. jensenii
P. piliferum
Racomitrium canescens
Sphagnum teres
Stereocaulon tomentosum

Avens Community

Species more typical of northern examples of this community are marked with *.

Antennaria sp.
Arctostaphylos alpina ssp. alpina
Astragalus alpinus
Betula nana
Calamagrostis purpurescens
Carex bigelowii
C. scirpoidea
Cassiope tetragona
Dryas integrifolia
Ledum palustre ssp. decumbens
Loiseleuria procumbens
Minuartia rubella
*Oxytropis arctica **
*O. arctobia **
Poa alpina
P. arctica
Potentilla nivea
Rhododendron lapponicum
Salix glauca ssp. callicarpaea
S. herbacea
*S. reticulata **
Saxifraga tricuspidata
Silene acaulis
*Tofieldia coccinea **
T. pusilla
Trisetum spicatum
Vaccinium uliginosum
V. vitis-idaea

(continued)

Appendix D
Plant Species by Community

This list outlines plant species typical of each community, based on common occurrence in the plots. Those that seem to be limited to the Bathurst Inlet area are followed by *.(continued)

Lichens:
Alectoria sp.
Arctoparmelia centrifuga
Aulicomnium
Cetraria nivalis
Cladonia sp.
Stereocaulon tomentosum
Thamnolia subuliformis

Saxifraga-blueberry Community

Antennaria sp.
Arctostaphylos alpina ssp. alpina
Carex supina
Calamagrostis pupurescens
Empetrum nigrum
Hierochloe alpina
Loiseleuria procumbens
Potentilla nivea
Saxifraga tricuspidata
Silene acaulis
Trisetum spicatum
Vaccinium uliginosum
V. vitis-idaea

Lichens:
Alectoria sp.
Cetraria nivalis
Pseudephebe pubescens

Lichen-Rock Communities

Since lichens dominate these communities, they have been included as part of the main list here.

On rocks
Antennaria sp.
Alectoria nigricans
A. ochroleuca
Arctoparmelia centrifuga
Arctostaphylos alpina ssp. rubra
Aspicilea cinerea
Cystopteris fragilis (cliffs, northern)
Dryopteris fragrans
Ophiopharma lapponica
Potentilla nivea
Pseudephebe pubescens
Rhizocarpon geminatum
R. geographicum
Saxifraga nivalis
S. tricuspidata
Tremolecia atrata
Umbilicaria sp.
Woodsia glabella (cliffs, northern)
Xanthoria elegans

Between boulders
Alectoria nigricans
A. ochroleuca
Arctostaphylos alpina ssp. alpina
Aulicomnium sp.
Betula nana
Calamagrostis neglecta
Carex rotundata
Cassiope tetragona
Cetraria islandica
C. nivalis
Cladina rangiferina
C. stellaris
Cladina sp.
Cladonia cervicornis
C. coccifera
C. cornuta
Empetrum nigrum
Hierochloe alpina
Ledum palustre ssp decumbens
Loiseleuria procumbens
Polytrichum sp.
Racomitrium lanuginosum
Salix arctica/S. glauca ssp. callicarpaea
S. planifolia
S. tyrrellii
Sphagnum sp.
Stellaria longipes
Thamnolia subuliformis
Tofieldia pusilla
Vaccinium uliginosum
V. vitis-idaea

Esker Complex

This section is divided into crest, lee slope, and pond margin sections as the different components of an esker complex are so distinct. See text for explanations.

Crest
Antennaria sp.
Arabis arenicola
Arctagrostis latifolia
Arctostaphylos alpina ssp. alpina
Betula nana
Calamagrostis purpurescens
Carex vaginata
Draba glabella
D. lactea
Dryas integrifolia
Empetrum nigrum
Epilobium latifolium
Festuca sp.
Hierochloe alpina
Ledum palustre ssp decumbens
Loiseleuria
Luzula sp.
Minuartia rubella
Poa sp.
Potentilla nivea
Rhododendron lapponicum
Salix glauca ssp. callicarpaea
S. planifolia
Saxifraga tricuspidata
Silene acaulis
Trisetum spicatum
Vaccinium vitis-idaea
V. uliginosum

Mosses and lichens:
Alectoria nigricans
A. ochroleuca
Cetraria nivalis
Cladonia sp.
Masonhalea richardsonii
Pseudephebe pubescens
Stereocaulon tomentosum
Thamnolia subuliformis

Lee slope
Arctagrostis latifolia
Arctostaphylos alpina ssp. alpina
Arnica angustifolia ssp. angustifolia
Betula nana
Carex bigelowii
C. vaginata
Cassiope tetragona
Empetrum nigrum
Hierochloe alpina
Ledum palustre ssp. decumbens
Loiseleuria procumbens
Luzula sp.
Lycopodium annotinum
Poa arctica
Pyrola grandiflora
Trisetum spicatum
Vaccinium uliginosum
V. vitis-idaea

Mosses and lichens:
Alectoria ochroleuca
Aulacomnium
Cetraria nivalis
Cladina stellaris
Cladina sp.
Cladonia sp.

(continued)

Appendix D
Plant Species by Community

This list outlines plant species typical of each community, based on common occurrence in the plots. Those that seem to be limited to the Bathurst Inlet area are followed by *.(completed

Dactylina arctica
Masonhalea richardsonii
Polytrichum
Stereocaulon tomentosum

Windward slope
Usually a heath tundra association, see "heath tundra" list.

Pond margins in eskers
Agrostis borealis
Anemone richardsonii
Andromeda polifolia
Arctagrostis latifolia
Arctostaphylos alpina ssp. rubra
Betula nana
Calamagrostis canadensis
C. neglecta
Carex aquatilis
C. saxatilis
Cassiope tetragona
Empetrum nigrum
Epilobium angustifolium
Juncus filiformis
Kalmia polifolia
Ledum palustre ssp. decumbens
Luzula wahlenbergii
Phyllodoce coerula
Poa alpina
Poa arctica
Polygonum viviparum
Pyrola grandiflora
P. minor
Rubus chamaemorus
Salix glauca ssp. callicarpaea
S. herbacea
S. planifolia
S. tyrrellii
Saxifraga nelsoniana
Sibbaldia procumbens
Stellaria longipes
Vaccinium vitis-idaea
V. uliginosum
Viola sp.

Mosses and lichens:
Alectoria nigricans
A. ochroleuca
Aulacomnium sp.
Cetraria nivalis
Dactylina arctica
Sphagnum sp.
Stereocaulon tomentosum
Thamnolia subuliformis

Disturbed Sites; Animal Den Sites
Antennaria sp.
Arctophila latifolia
Arctostaphylos alpina ssp. alpina
Arnica angustifolium ssp. angustifolium
Betula nana
Calamagrostis inexpansa
C. neglecta
Carex bigelowii
C. vaginata
Cassiope tetragona
Chrysosplenium tetrandrum
Dryas integrifolia
Epilobium angustifolium
E. latifolium
Festuca brachyphylla
Hierochloe alpina
Ledum palustre ssp. decumbens
Luzula sp.
Poa arctica
Potentilla nivea
Salix arctica
S. glauca var. callicarpaea
S. herbacea
Saxifraga cernua
S. tricuspidata
Stellaria longipes
Vaccinium uliginosum
V. vitis-idaea
Viola sp.

Marine Communities
Although there are a number of marine communities at Bathurst Inlet, most were not encountered in the study. We have dealt with several in the text, but are including only sandy beaches in the list, as this is the community that surrounds most of the poin

Sandy beaches:
Castilleja sp.
Epilobium latifolium
E. palustre
Equisetum arvense
E. variegatum
Gentiana propinqua
G. tenella
Honkenya peploides
Lathyrus japonicus
Leymus mollis ssp. mollis
Lomatogonium rotatum
Matricaria ambigua
Pedicularis sudetica
Potentilla egedii
Primula stricta

APPENDIX E - REPRESENTATIVE PHOTOGRAPHS

APPENDIX E

Representative Photographs

Plate 1. Aerial view of canyon near Nose Lake

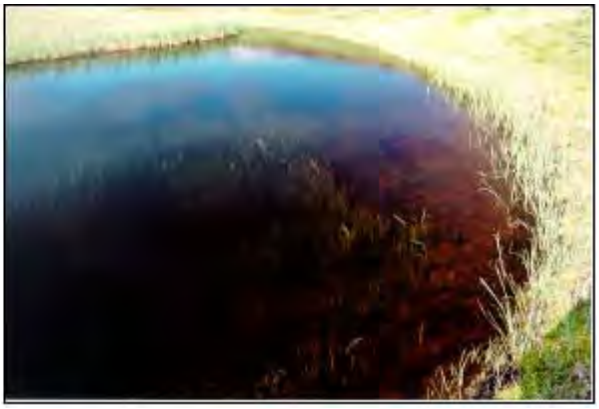

Plate 2. Submergent community, Plot 849

Plate 3. Sedge community, transect across drainage basin to illustrate changes in associations, near Plot 619.

Plate 4. Emergent sedge association, Plot 645.

Plate 5. Non-tussock sedge association, Plot 604

Plate 6. Non-tussock sedge association, at stream edges, Plot 762.

Plate 7. Tussock sedge association, Plot 846.

Plate 8. *Eriophorum* tussock, detail, Plot 723.

Plate 9. Clump of several species of *Carex* sedges, Plot 606A.

Plate 10. Mossy lakeshore association, Plot 606.

Plate 11. Moss community at base of cliff.

Plate 12. Riparian birch association in stream channel, note boulders, Plot 651.

Plate 13. Riparian willow association Plot 416.

Plate 14. Unusual heath riparian association with *Andromeda polifolia*

Plate 15. Riparian alder/willow association near Bathurst Inlet, Plot 412.

Plate 16. Birch shrub/seep community, Plot 644.

Plate 17. Heath tundra with blueberries, detail, Plot 691.

Plate 18. Upland heath tundra, Plot 612.

Plate 19. Melanie Panioyak with soil sample in heath tundra, Plot 01-06382.

Plate 20. Heath tundra on frost scars, Plot 710.

Plate 21. Detail of frost scar, note lack of vegetation in center, Plot 710.

Plate 22. Heath tundra on solifluction

Plate 23. Birch root showing extreme movement of active layer, Plot 840

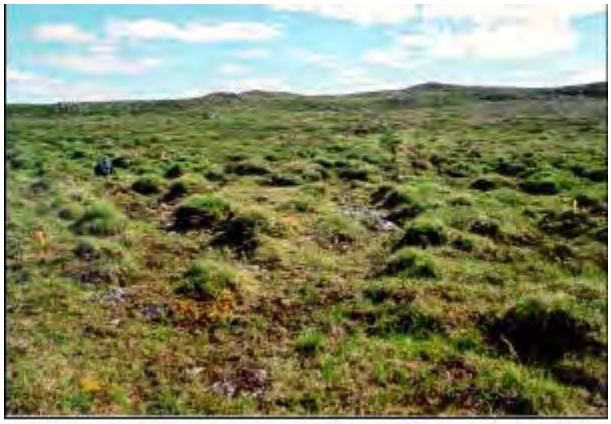

Plate 24. Heath tundra on tussock-based hummocks, Plot 626.

Plate 25. Hummocks, showing heath invasion of the cottongrass Tussock, Plot 626.

Plate 26. Lichen-heath tundra on edge of esker system, lichen veneer, Plot 848.

Plate 27. Lowland Arctic coast heath tundra with abundant lupins, Plot 464.

Plate 28. Detail of height bloom on Arctic coast heath tundra

Plate 29. Esker complex, crest with patterned ground, Plot 671.

Plate 30. Detail of esker crest with crowberry and blueberry mats in depressions, Plot 671.

Plate 31. Crowberry on sand esker, Plot 847.

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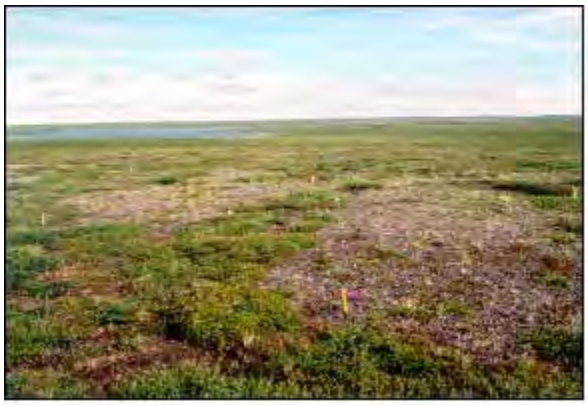

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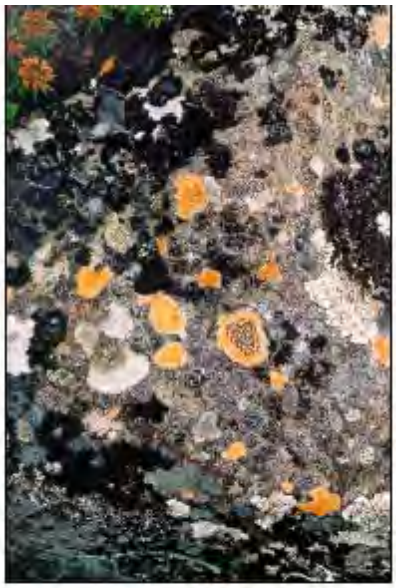

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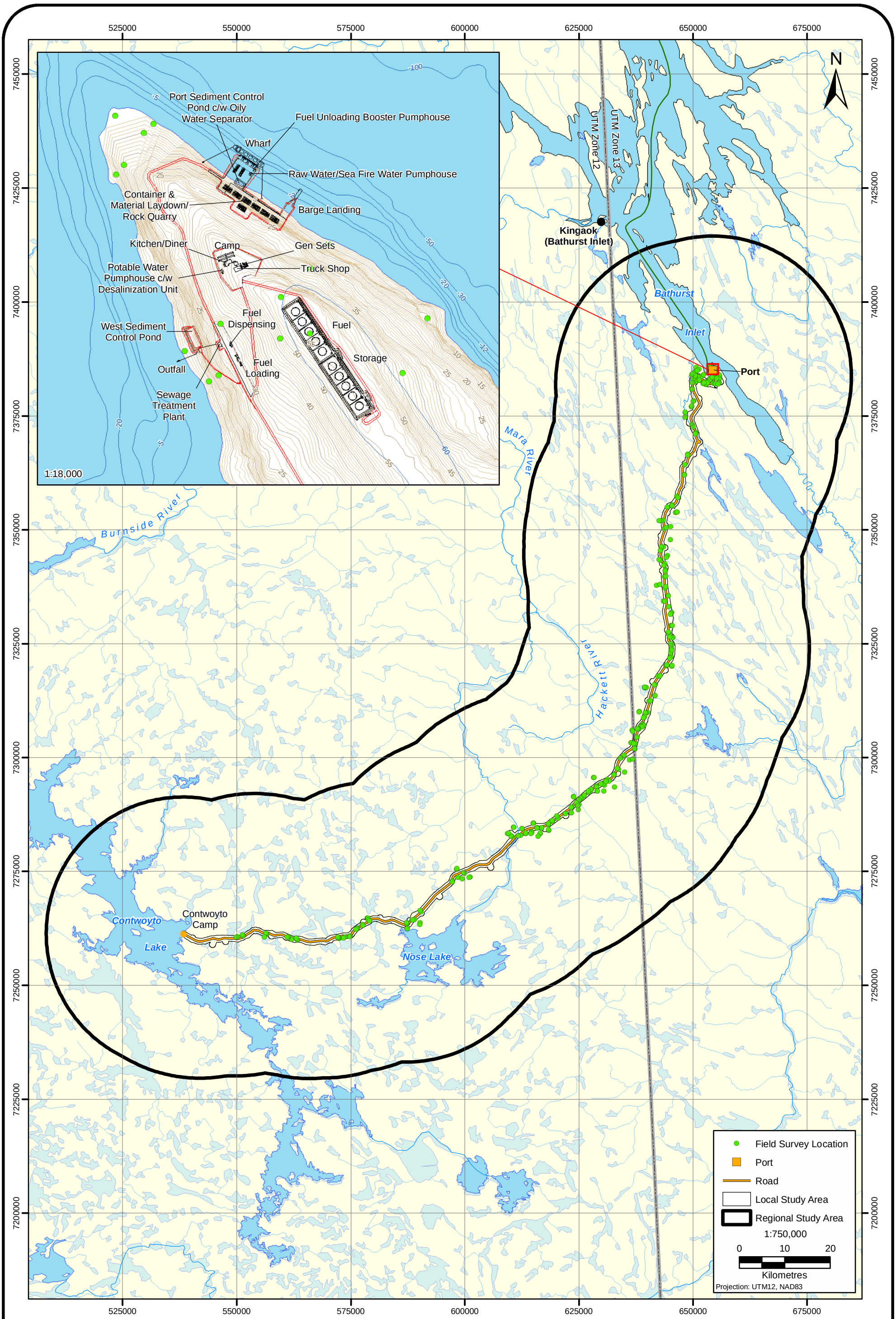

APPENDIX E

BIPR Field Survey Locations

the Bathurst Inlet Port and Road Project

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Appendix D-5
Preliminary Bedrock Geology Characterization

Author: **Rescan Environmental Services Ltd.**
Date: **October 2007**

the BATHURST INLET PORT AND ROAD PROJECT

Bathurst Inlet Port and Road Project

Nunavut, Canada

Preliminary Bedrock Geology Characterization

Prepared by:

Rescan™ Environmental Services Ltd.
Vancouver, British Columbia

October 2007

EXECUTIVE SUMMARY

Executive Summary

Rescan™ Environmental Services Ltd. (Rescan) was retained by the Bathurst Port and Road Project Technical Committee to undertake baseline environmental studies along the proposed road route during the 2001 field season. One component of the 2001 program was to conduct a reconnaissance level bedrock geology survey and sampling campaign along the proposed route. The program included the collection of bedrock samples for environmental analysis to evaluate potential acid formation concerns and provide a foundation for future work in this study area.

Geological mapping and sampling was undertaken at a reconnaissance level along a 1 km wide corridor spanning the length of the proposed road route. Bedrock was selected for sampling based upon presence of mineralization as well as a requirement to randomly sample representative lithologies. Bedrock geology was developed into an outcrop map with identifying lithologies, structural measurements, sample locations, proposed quarry sites and the route corridor boundaries superimposed onto air photo mosaics. Bedrock identified during the fieldwork consisted of granites, gneisses, mafic volcanics, schists, carbonaceous sediments, argillite, and diabase dikes. These lithologies are consistent with published geological mapping for this region.

Potentially mineralized amphibolitic iron formation is commonly found as very narrow bands and lenses within the quartz biotite schist unit, and is occasionally observed as wider zones of well-banded silicified amphiboles, haloed by bands of pink almandine garnets. Two shear zones were mapped between Bathurst km 102 and 104.5. The shears are comprised of a highly fractured rock with a strong fabric, which displays calc-silicate alteration, visible sulphides, and strong rusty oxidation staining. The first zone is at Bathurst km 102 and is 30 m wide, highly friable, and weathered. The second shear zone is at Bathurst km 104 and is 15 m wide. The potential for mineralized zones to change width and orientation quickly over short distances was observed in surface outcrop.

No occurrences of soapstone or other materials suitable for carving stone were identified along the proposed road route. Significant intervals of overburden void of outcropping bedrock were observed along the proposed road route.

A total of 26 bedrock samples were collected that best represented overall lithologies and displayed evidence of mineralization. Five samples, including one duplicate, displayed visual evidence of mineralization containing either sulphides, or having rusty oxidation staining. The remaining samples are considered to be typical representations of bedrock along the road route. Seven samples were taken from mafic volcanics, five from unmineralized meta-sedimentary units, three from diabase dike intrusions, three from granites, and three from sedimentary rocks. Environmental analysis of bedrock samples included acid base accounting in order to determine if any samples had a potential to generate acid rock drainage (ARD) concerns. Such predictive acid base accounting of samples from proposed rock excavations (*i.e.*, bedrock quarries) has become a best management practice endorsed by regulatory agencies such as the Water Board of the Northwest Territories and the British Columbia Ministry of Transportation.

Results of the ARD screening assessment determined that 24 of the 26 bedrock samples did not indicate a potential to generate acid. Two of the remaining samples were determined to have an uncertain potential to generate acid as compared to acid base accounting guidelines established by Indian and Northern Affairs Canada (INAC).

Potential quarry sites and road cut localities were established after completion of the field program. Screening of the proposed quarry sites indicated that 19 of the 37 sites were in the vicinity of bedrock sampling locations. Based on the bedrock mapping and ARD screening program it was determined that bedrock in these areas may include lithologies with a potential to generate ARD concerns if excavated. Bedrock samples from the proposed road cut near the port site did not indicate any potential ARD concerns.

It is anticipated that the eventual construction of the Bathurst Port and Road Project will include the implementation of a comprehensive environmental management plan. The plan should incorporate detailed ARD screening of potential bedrock quarries and road cuts thereby allowing project planners to avoid and mitigate (if necessary) potentially negative environmental effects.

ACKNOWLEDGEMENTS

Acknowledgements

This report was produced in 2003 by Rescan™ Environmental Services Ltd. (Rescan). Lara Woodhouse (B.Sc.) conducted the fieldwork and geology interpretations while Kyle Stanfield (B.A.Sc., P.Eng.) carried out the ARD screening assessment. Senior technical review was provided by Dr. George Poling (P.Eng., Ph.D.). Patsy Avakana provided invaluable assistance for the field component of the program. Geowest produced the photomosaics on which the bedrock geology mapping is superimposed.

Recent updates, 2007, were made to the report by François Landry (M.Sc., R.P.Bio.) and Rachelle Lalonde (M.Sc., A.Ag.). Laura Henderson (Word Processing), Francine Alford (Graphics), and Pieter Van Leuzen (GIS), were responsible for report production, figures, and maps respectively.

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1. INTRODUCTION

1. Introduction

The Bathurst Inlet Port and Road Project proposed road route lies entirely within the Slave Geological province of the Canadian Shield. The Canadian Shield geologic region occupies nearly one half of Canada. It was formed in the Precambrian Eon, 544 to 4,500 million years ago (mya), when two colliding tectonic plates converged pushing crustal rock into the interior of the earth where it melted, before rising to the surface and slowly cooling. Provinces and subprovinces were formed within the Canadian Shield through tectonic and volcanic activities that occurred subsequent to the formation of the Canadian Shield. The Shield is subdivided into seven such provinces and several subprovinces based upon geologic origin and structural history.

The Slave province is characterized by having underlying Archean Age (2,500 to 3,800 mya), and rocks of the Yellowknife Supergroup that are overlain by sediments of the Epworth and Goulburn groups (L.P. Tremblay, 1967; R.A. Frith 1987). The Slave province has been affected by numerous depositional and deformational events. Beginning in the Archean period the Slave structural province underwent multiple periods of deposition, intrusion, folding, faulting, regional metamorphism and erosion (L.P. Tremblay, 1976). Figure 1-1 presents a simplified geological map of the Slave province (modified from G.S.C. Memoir 417, R.A. Frith 1987).

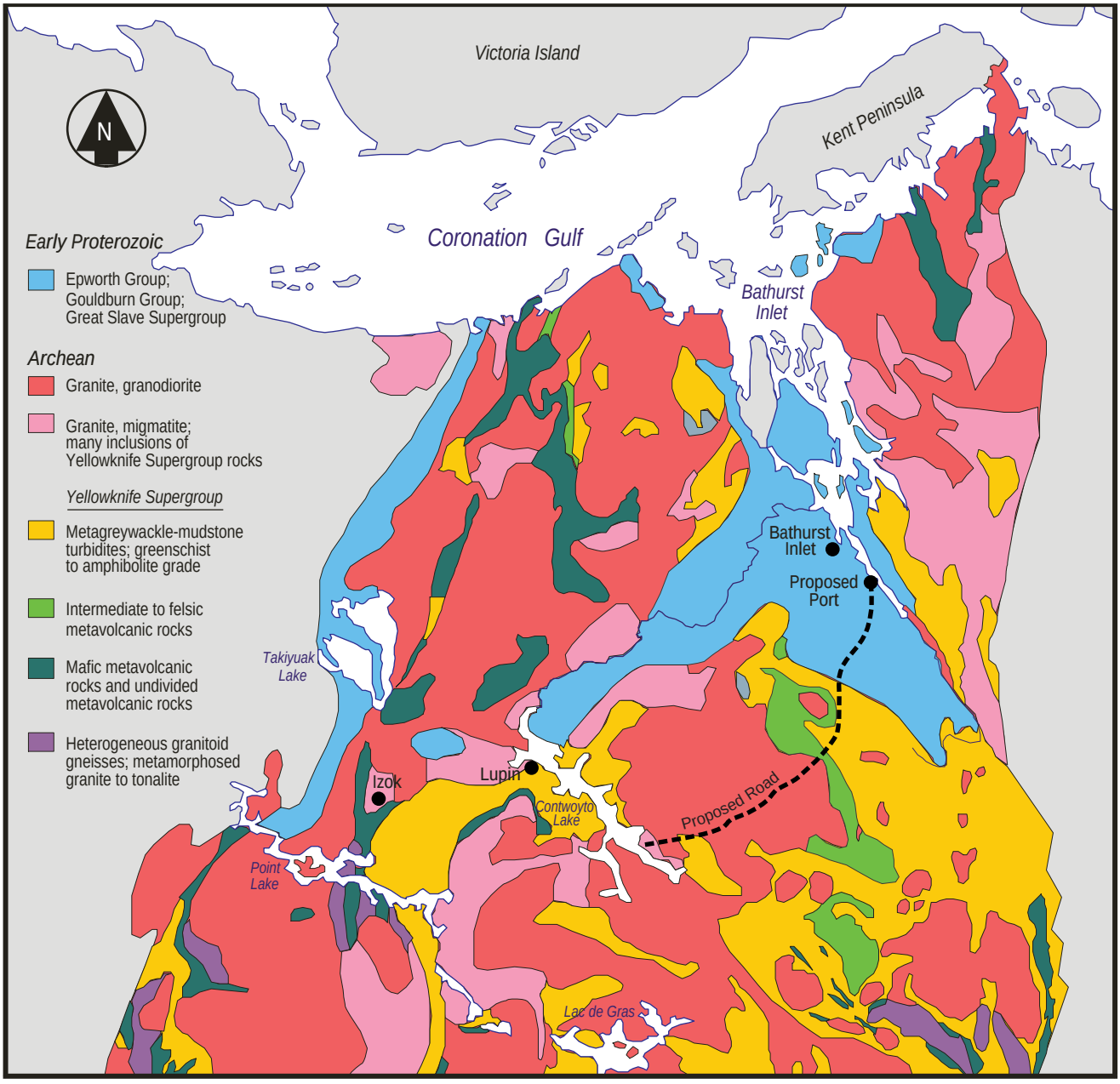
This geologic activity created regions of complex geology and abundant mineralization such as the many mineral and metal occurrences in pegmatites, shear zones, quartz veining, and skarn deposits. Polyphase deformation within the Slave created mineralized zones that frequently occur as small-scale pod or lens structures that are inclusions in unmineralized lithlologic units.

Since the 1950s numerous mineralized zones and showings have been identified and documented by the geologic exploration activities of private mining companies, as well as through mapping studies and research completed by the Geologic Survey of Canada. Mineralization occurrences vary greatly in composition and character and are commonly found containing sulphide group minerals, as well as other economic and non-economic metal bearing minerals.

Characterization of bedrock geology along the length of the proposed road route was identified as a study component of the 2001 Bathurst Baseline program. The characterization was designed to collect information on the occurrence and types of bedrock at the reconnaissance level in order to facilitate the development of bedrock geology maps. The study also included the collection of bedrock samples from various types of bedrock and subsequently subjecting them to environmental analysis to facilitate future road construction planning.

Construction of the proposed Bathurst Port and Road will require the excavation of bedrock from quarries developed within the vicinity of the road route. Depending upon road grading requirements, the engineering feasibility study may also determine a need to excavate additional bedrock in certain locations along the route. Quarry materials along with any other competent rock excavated from bedrock sources would then be used in the road construction process to both fill low-lying areas and provide a stable working base for construction equipment.

Scale
0 100 km



Simplified Geology of the Slave Geological Province

(modified from GSC Memoir 417, R. A. Frith, 1987)

the Bathurst Inlet Port and Road Project

FIGURE 1-1

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Environmental Concerns

In recent years, Canadian road construction projects have been required to adhere to certain environmental performance objectives developed by government regulatory agencies such as the Department of Fisheries and Oceans and Provincial Ministries of Environment. Best management practices such as the use of erosion controls and quarry reclamation techniques have reduced some of the negative environmental effects of road development. The Canadian north is a particularly sensitive environment due to the unique habitat for aquatic and terrestrial organisms inhabiting the region.

Exposure of sulphide-bearing bedrock to the atmosphere and drainage waters increases the rate of natural weathering. The weathering process includes oxidation of sulphides leading to the formation of sulphuric acid and often a concomitant release of metals from associated minerals. Collectively, the acid formation and metals leaching process is known as acid rock drainage or ARD, a process that has been the subject of extensive research over the past 25 years. Studies have led to the development of several types of predictive tests to evaluate the potential for a given bedrock material to produce ARD.

In light of potential ARD concerns, best management practices for projects involving large bedrock excavations should include ARD screening assessments. Such an assessment involves sampling of representative rock types followed by what is known as static analytical testing in the laboratory. Static tests are designed to evaluate the potential for a rock sample to both generate acidity as well as neutralize any acid that may form as a result of weathering processes. Where potentially acid generating materials are identified, the simplest management approach is to avoid excavation. Figure 1-2 presents a general overview of the proposed alignment of the Bathurst road along with each of the sampling locations.

In British Columbia, road construction proponents now typically retain consultants to conduct ARD screening and provide any mitigation planning advice where necessary. The Inland Vancouver Island Highway that opened in 2001 was subjected to ARD screening in several areas so that potential problems could be avoided (Price, 2002). An example of where such screening could have avoided a problem is that of the Coquihalla Highway project that opened in 1986. Acid formation in one road cut area resulted in a requirement to construct a water treatment plant to neutralize the drainage prior to its entry into the receiving environment (Price, 2002).

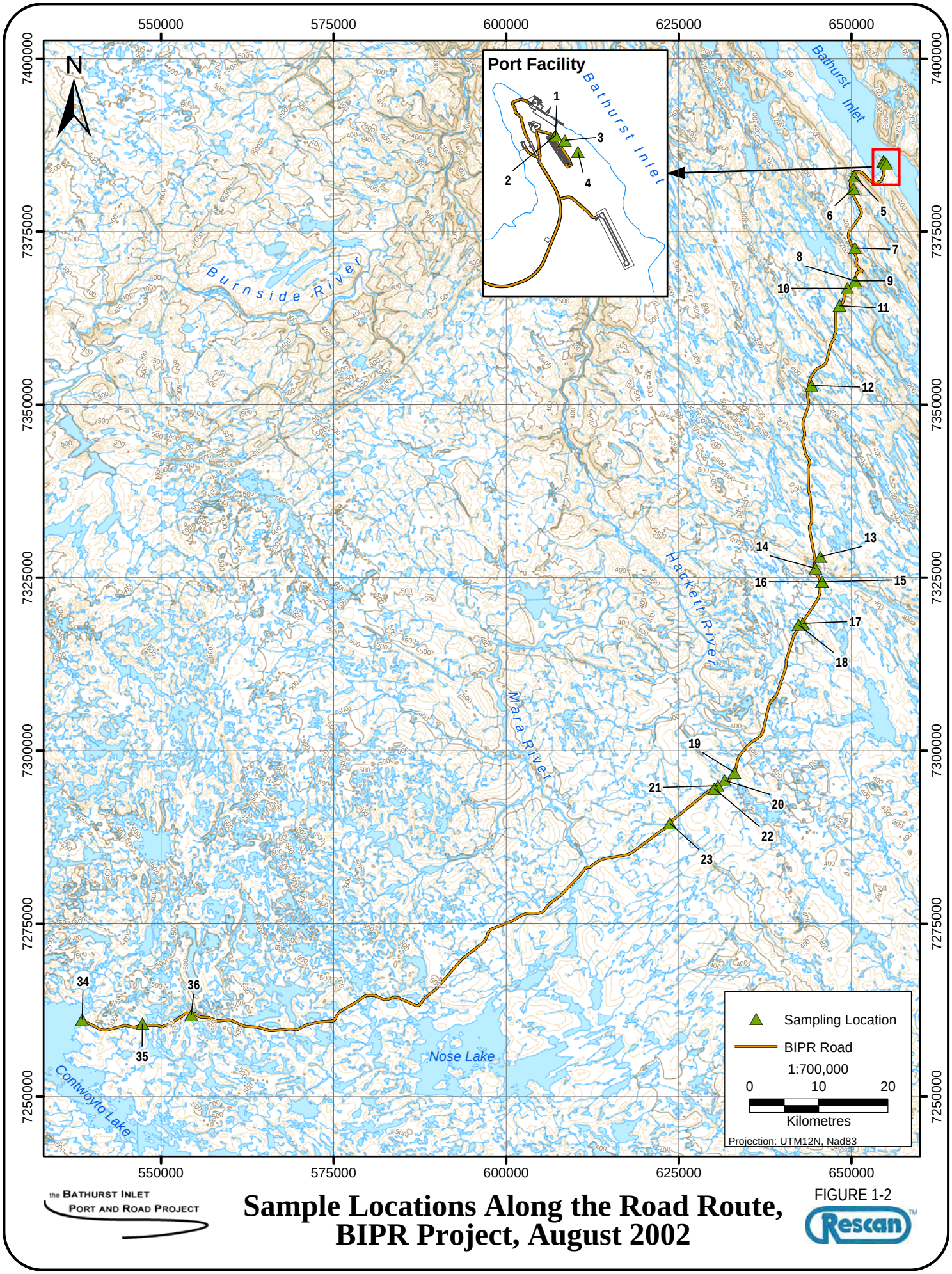
Study Objectives

The objectives of the bedrock mapping component of the Bathurst Port and Road Project baseline study were:

1. Identify areas of mineralization containing sulphides and other minerals of potential environmental concern;

2. Provide a record of lithologies (in the form of bedrock geology maps) that outcrop and occur as subcrop and boulders along the route corridor;

3. Sample any sulphide bearing rocks for ARD concerns;



the BATHURST INLET PORT AND ROAD PROJECT

Sample Locations Along the Road Route, BIPR Project, August 2002

FIGURE 1-2

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4. Sample representative lithologies (at the reconnaissance level) along the route corridor to be assessed for potential ARD concerns; and

5. Identify any possible carving stone locations.

The presence of carving stone along the proposed road route was also identified as a study objective that should be integrated into the bedrock geology reconnaissance study. The Inuit continue to utilize carving stone for traditional carvings throughout many areas of Nunavut and the Northwest Territories. Carving stone is commonly referred to as soapstone and is a white to pale green, soft, compact rock that is easily cut and carved. It may be composed of a variety of minerals, commonly containing fine-grained talc, serpentine, chlorite, mica and altered dolomite. The formation of soapstone materials results from metamorphic alteration of a ferromagnesian silicate-rich rock, to a hydrous silicate of magnesia (Spence, 1922).

2. METHODS

2. Methods

Geological mapping and sampling was undertaken at a reconnaissance level along a 1 km wide corridor running the length of the proposed road route. The mapping was completed using 1:60,000 scale black and white air photos as a base map, and sampling was carried out concurrently with the bedrock mapping. Bedrock samples were selected based upon presence of mineralization as well as a requirement to sample representative lithologies. For convenience, route intervals and sample locations were called "Bathurst km x", where x was the distance west from the marine port.

2.1 Bedrock Geology Mapping

The bedrock geology mapping and ARD screening assessment fieldwork was focused on the identification and location of lithologies. The largest scale base maps available during fieldwork were 1:60,000 air photos. The anticipated 1:20,000 colour air photos were not available until after the completion of the fieldwork component. The 1 km road corridor was traversed in its entirety: areas with bedrock, subcrop, and boulders were walked through and long intervals where bedrock was not exposed were flown over by helicopter. The lithology of each outcrop, subcrop, and boulder field was recorded and an outline of the exposed rock was traced onto mylar sheets overlaying the air photos. Rock units along the road route were categorized based on composition and texture. Rock codes describing the rock units are displayed on the bedrock map: a number indicates the overall composition and a lower case letter indicates dominant texture, fabric or grain size.

Locations of larger outcrops were identifiable on the air photos. Lakes and prominent topographic features were used to aid in placing smaller outcrops not visible on the base photos. Upon returning from the field, 1:20,000 colour stereoscopic air photo pairs were used in conjunction with the field maps and a stereoscope to transfer the mapping details onto mylar overlays at a 1:20,000 scale. These mylar overlays were used to digitize the bedrock mapping and produce the bedrock geology map. The mapping was transferred to the 1:20,000 scale sheets to serve as quality control for outcrop locations, and to reduce the potential for error during digital reproduction of the maps. The final maps are presented at 1:60,000 scale, representative of the detail at which they were mapped. Small sections of the final proposed road route were not field mapped due to route changes that occurred after the field program was completed. During the mapping process, particular attention was directed toward documenting the occurrence of any carving stone along the route corridor.

2.2 Sampling

The objectives of the bedrock sampling program were to sample both representative lithologies found along the road route as well as specific occurrences of mineralization that could potentially generate ARD if excavated. Potential quarry and road cut locations were not available before fieldwork was carried out, thus, specific sampling of such areas was not possible.

Field sampling was completed concurrently with bedrock mapping. Samples were extracted from bedrock outcrops using a standard rock hammer and chisel. Every effort was taken to obtain fresh unweathered material, however, all samples taken from surface outcropping exhibit a certain degree of weathering. Samples weighing one to two kilograms were collected in clean clear plastic sampling bags. To ensure proper identification, a waterproof label indicating the sample number was placed inside each bag and the sample number was also written on the outside of the sample bag using a permanent marker. A geological description of each sample was recorded in a field logbook at the time of collection. The description details included lithologic composition and presence or absence of inclusions, visible sulphides, and presence of oxidation staining on the weathered surface of the outcrop. Duplicate samples were randomly collected at 10% replication for quality control purposes; one homogenous sample was divided into two separate bags and each bag was assigned separate sample numbers. All samples were double bagged and shipped directly to B.C. Research Inc. in Vancouver from the Fieldwork Basecamp at the Lupin minesite.

2.2.1 Potential Quarry Sites and Road Cuts

Locations of potential rock quarries and a road cut along the proposed Bathurst Inlet Port Site were identified after the completion of the bedrock geology reconnaissance field study. The engineering study currently proposes only one road cut near the location of the future port. Potential quarry locations were plotted on the bedrock geology base maps, and where practical, assessed relative to local rock types and the results of ARD screening. This method enabled limited identification of lithologies and ARD potential of the proposed quarry sites. Some quarries could not be reliably assessed in this manner because they were located in areas of complex geology or they were not proximal to mapped and sampled outcrops.

2.3 Acid Formation Potentials

Laboratory analysis of rock samples to determine the balance between acid consuming potential and acid generating potential is known as static testing. The method most widely used is that of acid-base accounting or ABA. The ABA methods used to analyze Bathurst samples are based upon those developed by the U.S. EPA (Sobek *et al.*, 1978). Acid Base Accounting Methods are described in greater detail in the Indian and Northern Affairs Canada (INAC) Acid Rock Drainage Guidelines (INAC, 1993) and more recent Guidelines developed by the British Columbia Ministry of Energy and Mines (Price, 1998). Parameters determined as part of the static testwork included fizz test, paste pH, total sulphur, sulphate sulphur, inorganic carbon and neutralization potential.

All samples were forwarded to BC Research Inc. in Vancouver for analysis. The following sections provide an overview of the analytical procedure for each of these parameters.

2.3.1 Acid Base Accounting Tests

Fizz Test

The fizz test is conducted through exposing a crushed rock subsample to one or two drops of 25% hydrochloric acid solution in order to determine the presence of calcium carbonate

($CaCO_3$). The presence of $CaCO_3$ is indicated by the evolution of bubbles or fizz from the sample. Based on the extent to which bubbles evolve from the material, the sample is assigned a 'Fizz Rating' that is then used to determine the volume and strength of hydrochloric acid to be used in determining the samples capacity to neutralize acid (neutralization potential).

Paste pH

Paste pH provides a measure of the amount of readily available neutralizing material associated with a sample. The analytical procedure involves adding approximately 5 ml of de-ionized water to 10 grams of crushed sample and allowing it to become saturated. The sample is gently stirred and the pH of the resulting paste is measured using a combination pH meter/electrode.

Sulphur Analysis

Sulphides are the sulphur component of minerals which have not yet oxidized and could theoretically oxidize during weathering processes thereby producing sulphuric acid in the presence of water. The analysis procedure involves determining the total amount of sulphur in a sample through burning a subsample in an induction furnace. Sulphide species that are already oxidized (sulphates) are determined through acid treatment. The sulphide sulphur component (%S) is then reported as the difference between the total sulphur and sulphate sulphur.

Neutralization Potential

The capacity of a sample to neutralize an acid is known as the Neutralization Potential or NP. The method for analysis is according to Sobek also known as the EPA-600 method. The analysis involves treating a sample of crushed material with the volume and normality of hydrochloric acid pre-determined by the fizz test and then heating it to ensure a complete reaction. The remaining cooled solution is titrated with an equivalent normality of sodium hydroxide (base) to determine the equivalence point (point of neutral pH). The normalities and volumes of reagents used in the process are then used to calculate the NP of the sample expressed as kilograms of calcium carbonate per tonne of material (kg $CaCO_3$/t).

2.3.2 Calculated Parameters

The sulphide sulphur component is used to estimate what is known as the Maximum Potential Acidity (MPA) of the sample. The MPA is determined through converting percent sulphide (%S) to equivalent kilograms of calcium carbonate per tonne of material (kg $CaCO_3$/tonne). The calculation is facilitated by the assumption that all sulphide sulphurs would become fully oxidized and subsequently form sulphuric acid in the water column of the environment. This assumption is conservative because conditions produced in the laboratory are designed to react all sulphide contained in the sample. In practice, crushed rocks (gravel and fill; -¾" to -4") have reduced bulk surface areas that limit the amount of sulphide readily available for oxidation. The MPA is therefore considered a "worst case" estimate.

The overall balance between the MPA and NP of a material is determined through dividing the Maximum Potential Acidity into the Neutralization Potential. The resulting dimensionless value is known as the Net Potential Ratio (NPR). The NPR provides a valuable indication of the overall *potential* for a sample to produce net acidity. Theoretically, rock with equal masses of

sulphide (MPA) and neutralizing (NP) minerals should generate neutral drainage when exposed to weathering processes. The resulting NPR for this condition is unity and is rarely observed in the environment as neutralizing minerals are not always completely exhausted when counteracting the production of acid. The INAC guidelines therefore set an NPR of >3.0 as the point at which one can safely assume an unlikely potential for a sample to generate net acidity. Table 2.3-1 summarizes the guidelines stipulated by INAC.

Table 2.3-1
Guidelines for Interpretation of ABA Tests (INAC, 1993)

NPR	Acid Generating Potential
NPR >3.0	Unlikely to generate net acidity
1.0 ≤ NPR ≤ 3.0	Uncertain acid generating potential
NPR < 1.0	Likely potential to generate acid

2.3.3 Quality Assurance and Quality Control

During the sample analysis process, BC Research Inc. conducts regular quality assurance and control tests to assess both the reproducibility and accuracy of the test methods employed for acid base accounting. Laboratory duplicates are run periodically to assess analysis reproducibility while standards are also tested to evaluate the accuracy of the testing equipment.

2.4 Distilled Water Extraction and Metals Analysis

Distilled water extraction involves laboratory simulation of the initial rinsing that freshly crushed rock experience in the field due to precipitation drainage. The results of rinse water analysis can then be used to assess drainage water quality that could initially be expected from bedrock excavations. Distilled water extraction testwork was not undertaken in 2001 but should be considered as part of any future screening investigations.

Whole rock metals analysis is often undertaken to help assess the results of distilled water extraction tests. Whole rock metals concentrations are determined using a two stage analytical process. A subsample of crushed rock is first digested using a strong acid solution that liberates metals from the rock matrix into the solution. The metal content of the solution is then determined using spectroscopy techniques. Metals analysis was undertaken as a component of the 2001 test program and results are presented in this report.

3. RESULTS

3. Results

3.1 Bedrock Geology Mapping

Bedrock geology mapping identified occurrences of bedrock as outcrop, subcrop/felsenmeer, or boulders. Outcrop is defined as areas of bedrock that protrudes above the soil, and continues below surface. Subcrop is rock which is not contiguous with the bedrock below surface; it is bedrock that is no longer in its original strata or orientation, as would occur during upheaval and rotation with frost heaving. Felsenmeer (a.k.a. block fields), is a common type of subcrop found along the route; it is a thin, flat sloping accumulation of angular blocks of rock found in place. Boulder fields frequently occur along the route and are comprised of large rounded transported rocks lying on the surface or embedded in soil. Areas that did not contain bedrock were mapped as overburden and were assessed within the surficial geology and terrestrial mapping component of the Baseline Studies. The bedrock geology map is comprised of an outcrop map with identifying lithologies, structural measurements of bedding and jointing orientation, ARD sample locations, proposed quarry sites, and the route corridor boundaries superimposed on the photo mosaics. Bedrock identified during the fieldwork consisted of granites, gneisses, mafic volcanics, schists, carbonaceous sediments, argillite, and diabase dikes. Table 3.1-1 contains a log of the bedrock geology along the proposed road route.

The bedrock geology map for the proposed road route is presented in Appendix A.

3.1.1 Rock Types

Granite

Granites are labelled as rock code 7 on the bedrock geology maps. Granite is the dominant rock type from Bathurst km 112 to 210 and is often gradational with coarse-grained gneissic rocks of granitic composition. The granites are coarse-grained, gray to white or pink in colour with 10 to 50% coarse biotite, 15 to 30% white to pink feldspar, and 20 to 50% quartz. They form the dominant topographic features along this section of the route, such as the ridges along the sides of the lakes near Bathurst km 198. Granites also occur in large boulders fields as well as boulders dispersed widely across areas of overburden.

Gneiss

Gneisses are mapped as unit 4c. At Bathurst km 190.5 to 196 a well-exposed outcrop of gneiss is visible alongside an esker. The gneissic fabric is well defined in a white to light gray medium to fine-grained augen gneiss with biotite, muscovite, and feldspars displaying strong foliation at 124º/82ºN. Polyphase deformation is observed in twice folded biotite and quartz bands, ranging from 3 mm to 5 cm wide. From Bathurst km 174 to 186, gneissic rocks occur as subcrop, felsenmeer and boulders. This gneiss is gradational in texture to granite, becoming coarser grained and lacking a well-defined fabric.

Table 3.1-1
Bathurst Inlet Port and Road Bedrock Geology Route Log, August 2001

Route Leg	From (km)	To (km)	Rocktype	Description	Comments	Samples	Sample Location
B	0.0		1d	Gabbro/basalt. Fine to medium grained dark grey silicified basic intrusive, with uniform texture, no visible sulphides or inclusions.	Outcropping rock forms steep embanquement at portsite location. Atop of the ridge is blocky frostheaved rock covered by till.	ARD 1,2,3 and 4. ARD 2 is duplicate of ARD 1.	samples within 500 meters of each other all at ~km 0.
B	1.0	4.5	o/b	No outcrop	Overburden and till		
B	4.5	18.0	5a	Red platy argilliceous shale. Highly weathered dark pink fine grained carbonaceous rock, with no visable sulphides. Fold in outcrop observed with trend and plunge measured.	This unit readily sloughs into thin slabs, broken plates of this rock is ubiquitous. Rock outcrop forms a large ridge around which the road route is located. Scree is common along the slopes of the ridge.	ARD 5 ARD 6	7.5 km 9.5 km
B	18.0	20.0	9	Diabase, medium to coarse grained magnetic with massive texture.	Forms high ridges along eastern boundary of route corridor, platy argillaceous shale scree along lower slopes of diabase ridge	ARD 7	18.5 km
B	20.0	23.0	o/b	Primarily sand surrounding Amgkok creek	Exposed 5a in cut of stream bank.		
B	23.0	24.5	5b/5a	Fine grained thinly bedded light to med grey-green unit, weathers to dunn colour, highly siliceous with anastimozing qtz carb stringers. Trace amount of sulphide (pyrhotite) observed in one quartz stringer.	Interbeds of 5a unit seen on large ridge, with the 5b until, contacts between the two are flat lying.	ARD 8,9 (9 is duplicate) ARD 10	23.0 km 24.5 km
B	24.5	27.5	o/b	No outcrop	Overburden and till		
B	27.5	28.0	9	Diabase, medium to coarse grained magnetic with massive texture.	Forms narrow ridge within route corridor.	ARD 11	27.5 km
B	28.0	28.5	5b	Fine grained thinly bedded light to med grey-green unit, highly siliceous with anastimozing qtz carb stringers.			
B	28.5	30.0	o/b	No outcrop	Overburden and till		
B	30.0	30.1	9	Diabase, medium to coarse grained magnetic with massive texture.	narrow ridge		
B	30.1	32.0	o/b	No outcrop	Overburden and till		
B	32.0	32.1	9	Diabase, medium to coarse grained magnetic with massive texture.	narrow ridge		
B	32.1	33.8	o/b	No outcrop	Overburden and till		
B	33.8	34.0	9	Diabase, medium to coarse grained magnetic with massive texture.	Forms a narrow ridge.		

(continued)

Table 3.1-1
Bathurst Inlet Port and Road Bedrock Geology Route Log, August 2001 (continued)

Route Leg	From (km)	To (km)	Rocktype	Description	Comments	Samples	Sample Location
B	34.0	38.0	o/b	No outcrop	Overburden and till		
B	38.0	39.5	5a/o.b	Argillliceous red shale, platy sloughing off into thin slabs.	Very sparse outcrop, mostly overburden		
B	39.5	41.0	1a/2a	Basalt, fine grained dark to med grey green basaltic to andesitic flow no visable sulphides and no noted inclusions or veins.	Occurs as outcrop and subcrop with much frost heave and boulders.	ARD 12	40 E
B	41.0	43.5	o/b	No outcrop	Overburden and till		
B	43.5	44.0	1a	Basalt, fine grained dark to med grey green basaltic to andesitic flow no visable sulphides and no noted inclusions or veins.	Subcrop and boulders.		
B	44.0	45.0	o/b	No outcrop	Overburden and till		
B	45.0	47.0	1a	Basalt, fine grained dark to med grey green basaltic to andesitic flow no visable sulphides and no noted inclusions or veins.	Outcrop, subcrop and boulders		
B	47.0	50.5	o/b	No outcrop	Overburden and till		
B	50.5	53.5	2a	Andesitic flow, fine to med grained well weathered, pink to grey rock, flow banding and poorly preserved pillows observed in outcrop, no visable sulphides or other intrusions.	Large area is extensively frost heaved, with some outcrop and boulders.		
B	53.5	55.5	o/b	No outcrop	Overburden and till		
B	55.5	56.5	9	Diabase, fine to medium grained dark grey magnetic	ridge		
B	56.5	64.0	o/b	No outcrop	Overburden and till		
B	64.0	66.5	2/3a	Andesitic to rhyolitic fine grained massive flow, light grey on fresh surface, weathers to pink when not obscured by lichen, no visable sulphides, rock is well weathered.	Large fields of of frost heaved rocks, very little insitu outcrop.	ARD 13	65.75 km
B	66.5	67.0	o/b	No outcrop	Overburden and till		
B	67.0	68.0	5a	Argillliceous red shale, as described above, well weathered.	Sloghs off in slabs.	ARD 14	67.5 km
B	68.0	69.5	o/b	No outcrop	Overburden and till		

(continued)

Table 3.1-1
Bathurst Inlet Port and Road Bedrock Geology Route Log, August 2001 (continued)

Route Leg	From (km)	To (km)	Rocktype	Description	Comments	Samples	Sample Location
B	69.5	71.0	4a	Quartz biotite schist, fine grained moderate to well developed foliation, defined primarily by biotite, medium grey to brown color less than 1% quartz veins, no visable sulphides, and rare small gossanous patchesoutcropping with thickness of less than 1m wide.	Abundant outcrop over this interval, strike/dip of outcrop foliation is ~320/59 N	ARD 15,16 (16 is duplicate of 15)	70.00 km
B	71.0	76.0	o/b	No outcrop	Overburden and till		
B	76.0	99.0	4a	Quartz biotite schist medium to coarse grained grey brown with 20-25% biotite and 2-3% anastamosing 1-2cm bull white quartz stringers and comman 1-2mm remnant garnets. No visable sulphides within either the schist or the quartz stringers.	Outcrop,subcrop and boulders. Route corridor made up of ~ 15% outcrop and subcrop.	ARD 17	76.5 km
B		77.0	9	Diabase, fine to medium grained dark grey magnetic	Occurs as 15m wide intrusion into quartz biotite schist outcrop.	ARD 18	77.0 km
B	99.0	102.0	4a	Quartz biotite schist with narrow bands up to 5m wide, of iron formation and well weathered gossanous rock, haloed by pink garnetiferous band. Unit is cross-cut by bull white and smokey grey quartz veins, trace visable sulphides, pyrhotite and chalcopyrite.	Area has potential for mineralization and higher sulphide content below the weathered surface outcrops.	ARD 19	101 km
B	102.0	104.5	1a/d shear	Basaltic to gabroic composition, dark grey to green. Two shear zones encountered in this area, both 15 to 25 m wide, both with strong fabric striking west-north-west. Material within the sheared zones are comprised of calc-silicate alteration with abundant gossanous o/c. Shear zone is highly fractured and well weathered with trace to 2% sulphides.	Area has potential for mineralization and higher sulphide content below the weathered surface outcrops.	ARD 20 ARD 21 ARD 22	102.5 km 103.75 km 104.25 km
B	104.5	107.0	1a/d	Basaltic to gabroic composition, dark grey to green.	Outcrop of basic composition and medium to coarse grained texture, also granite boulder patches.		
B	107.0	112.0	o/b	No outcrop	Overburden and till		
B	112.0	115.0	7	Granite, pink to lt pink color	Outcrop and frost heaved rock	ARD 23	112.5 km
B	115.0	157.0	o/b with 7 boulders	No outcrop, common granitic boulders, occuring as small patches and larger fields.	10 % cover is granitic boulders the rest is till and ground cover.		

(continued)

Table 3.1-1
Bathurst Inlet Port and Road Bedrock Geology Route Log, August 2001 (completed)

Route Leg	From (km)	To (km)	Rocktype	Description	Comments	Samples	Sample Location
B	157.0	167.5	7	Granite, pink to white color medium to coarse grained intrusive.	Patchy outcrops of granite, with till between. Outcrop covers 10 to 15% of route, remainder is overburden and lakes and esker.		
B	167.5	173.0	o/b	No outcrop	Overburden and till		
B	173.0	174.0	7	Granite, pink to white color medium to coarse grained intrusive.	Outcrop and frost heaved rock and boulders.		
B	174.0	186.0	4c/7	Granite to gneissic rock of granitic composition, gneissic texture discenable in some outcrops defined withinin biotite bandings.	Subcrop, frostheave and boulders, with rare patchy outcrop. Patches of rock are widely spaced and cover 2-5% of the road route.		
B	186.0	190.5	o/b	No outcrop	Overburden and till		
B	190.5	196.0	4c	Gneissic rock, fine to caorse grained white to lt grey rock , of granitic composion, with wk to very well developed gneissic texture.	Route covered by 60 to 70 % outcrop. Esker runs through this area at 194km.	ARD 36	194.5 km
B	196.0	197.5	o/b	No outcrop	Overburden and till		
B	197.5	198.0	7	Granite, pink to white color medium to coarse grained intrusive.	Boulder field, no outcropping rock.		
B	198.0	200.5	o/b	No outcrop	Overburden and till		
B	200.5	202.0	7	Granite, white to pink	Forms prominent ridges between lakes.	ARD 35	201.5 km
B	202.0	208.0	o/b	No outcrop	Overburden and till		
B	208.0	210.0	7	White granite, medim to coarse grained intrusive	Outcrop and subcrop of rock, rock cover is very sparse, covers less than 1%, remainder is till.	ARD 34	210.0 km Contwoyto South bargesite

Notes: **o/b = overburden**

Rocktypes defined in table 2.1-1

Route Leg "B" denotes the route west of the Bathurst Inlet Port Site

Mafic Volcanics

Mafic Volcanics are denoted by number 1, 2 or 3, to indicate composition, as basalt andesite and rhyolite respectively, and letters a, b, c, or d identify the texture as massive flow, tuffs, conglomerates or coarse grained intrusives respectively. At the Bathurst Inlet port site location there is a ridge of fine to medium-grained mafic volcanics that outcrops along the eastern side of the peninsula. This rock is dark gray and silicified with no visible sulphides, veining or inclusions. From Bathurst km 64 to 66.5 there is a large field of frost heaved andesitic to rhyolitic flows, dominantly felsenmeer with very little in place outcrop. These are massive to tuffaceous, basaltic to andesitic in composition, gray in colour weathering to pink, with no visible sulphides and no noted quartz veins or stringers. Flow banding and poorly preserved pillows were seen in outcrop. At Bathurst km 102 to 107 there is fine-grained dark gray to green mafic rocks with massive texture, no foliation, and 1-2% bull white quartz veins and stringers throughout containing no visible sulphides.

Schists

The schistose rocks along the route are mapped as unit 4a and consist of quartz-biotite-schist (QBS). From Bathurst km 69.5 to 102.0 the QBS is fine-grained and medium gray colour with moderate to strong foliation, commonly containing inclusions of almandine garnets, cordierite, andalusite, and small lenses and pods of amphibolite iron formations. The QBS contains 20 to 25% biotite, which is often coarse grained and defines the foliation. Foliation in outcrop at Bathurst km 70 measures 332º/60ºE and 310º/58ºE. The QBS contains 1% to 3% quartz veins and no visible sulphides in either the schist or in the quartz stringers.

Argillite

Argillite is mapped as unit 5a, it stretches from Bathurst km 4.5 to 18.0 and is interbedded with the carbonaceous sediment unit at Bathurst km 23.0 to 24.5. It also outcrops at Bathurst km 38.0 to 39.5 and Bathurst km 67.0 to 68.0. This rock is dark pink to purple in colour, very fine grained, fizzes when exposed to 10% HCl acid solution, contains no visible sulphides and forms flat plates that readily slough off of the outcrop. There are three well defined joint sets measured in this unit at 184º/84ºW; 100º/90º and; 058º/88ºE. Folded bedding was observed in outcrop, with a fold axis trending 078º and plunging 70º degrees to the east.

Carbonaceous Sediments

Carbonaceous sediments are mapped as unit 5b and are comprised of fine-grained, thinly bedded light to medium gray material, which weathers to a dun colour. This rock is very hard and highly siliceous, and contains anastomosing quarts carbonate stringers and veinlets that fizz when exposed to a 10% HCl solution. The stringers are in relief from the host rock, and range from 1 mm to 5 mm wide with trace amounts of pyrrhotite. This unit commonly outcrops interbedded with argillites, with lithological units ranging from 5 to 15 m thick which form ridges at Bathurst km 23 to 24.5.

Diabase Dykes

Diabase dykes are the youngest rocks along the proposed road route and frequently crosscut through the other lithologies. Dykes, identified as rock unit 9 on the maps, were mapped across

the route. They form high steep sided ridges and have medium to very coarse-grained textures of gabbroic to dioritic compositions. Dyke material is dark gray with patchy red hematite staining on freshly broken rock surfaces and is commonly magnetic.

3.1.2 Mineralized Zones

Mineralized zones were observed at Bathurst km 99 to 104 which is the host of two shear zones. This area was mapped and sampled for ARD purposes; however, a detailed evaluation of the mineralization is beyond the scope of this assessment. The potential for mineralized zones to change width and orientation quickly over short distances was observed in surface outcrop.

Amphibolitic Iron Formation is commonly found as very narrow bands and lenses within the quartz biotite schist unit, and is occasionally observed as wider zones of well-banded silicified amphiboles (commonly hornblende, tremolite and grunerite), haloed by bands of pink almandine garnets. The amphibolite bands contain 5 to 10% quartz, as both bull white and smoky gray veins containing trace to 2% visible sulphides (pyrite and pyrrhotite). At Bathurst km 99, multiple 0.2 to 5 m wide bands of iron formation were observed containing quartz veins and rusty staining on the host metasediments and approximately 5% disseminated pyrrhotite. The individual bands are not well defined on the maps at this scale.

Two shear zones were mapped between Bathurst km 102 and 104.5, within the mafic volcanic unit. The shears are comprised of a highly fractured rock with a strong fabric striking 290º. The rock displays calc-silicate alteration with trace to 2% visible sulphides and strong rusty oxidation staining. The first zone at Bathurst km 102 is 30 m wide, highly friable and weathered, making it difficult to obtain a fresh sample. The second shear zone is 15 m wide and contains the same mineralogy and quartz veining as the first with 1-2% sulphides seen in the surface rocks.

3.1.3 Carving Stone

Exploration for carving stone materials along the proposed road route was conducted in conjunction with the bedrock geology mapping. No occurrences of soapstone or other materials suitable for carving stone were identified along the proposed road route.

3.1.4 Overburden

Significant intervals of overburden were observed along the proposed road route. These areas are indicated on the bedrock map as “o/b” and are noted in the road route log (Table 3.1-1).

3.1.5 Sampling

Representative samples of each rock type within the route corridor, as well as rocks displaying evidence of mineralization, were collected for subsequent acid-base accounting (ABA) analysis. Table 3.1-2 presents rock types, field descriptions, and approximate locations of 26 samples obtained along the road route. Duplicate samples are identified in the comments section. In addition to Figure 1-2, each sample location is indicated on the bedrock geology map presented in Appendix A.

Table 3.1-2
Bedrock Characterization Samples, Bathurst Port and Road Project, August 2001

Sample	Location- UTM			Sample Description			Comments
	Location	Easting	Northing	Rock Type	% vis. sx	Rust Stain	
1	B 0.0	654604.02	7385128.95	Mafic Volcanic	no vis sx	no	Silicified gabbro
2	B 0.1	654604.02	7385128.95	Mafic Volcanic	no vis sx	no	Duplicate of Sample 1
3	B 0.2	654798.39	7385024.22	Mafic Volcanic	no vis sx	no	Silicified gabbro
4	B 0.3	655070.02	7384784.84	Mafic Volcanic	no vis sx	no	Silicified gabbro
5	B 7.5	650416.17	7383022.65	Argillite	no vis sx	no	
6	B 9.5	650249.12	7381224.09	Argillite	no vis sx	no	
7	B 18.5	650481.19	7372652.18	Diabase	no vis sx	no	Magnetic
8	B 23.0	650516.67	7367898.23	Metaseds w qtz-carb veinlets	trace (po)	no	Siliceous rock
9	B 23.0	650516.67	7367898.23	Metaseds w qtz-carb veinlets	trace (po)	no	Duplicate of Sample 8
10	B 24.5	649409.92	7366823.27	Metaseds	no vis sx	no	
11	B 27.5	648267.00	7364329.37	Diabase	no vis sx	no	Magnetic
12	B 40.0	644194.96	7352782.27	Mafic Volcanic	no vis sx	no	
13	B 65.7	645492.94	7328044.95	Mafic Volcanic	no vis sx	no	
14	B 67.5	644764.74	7326349.22	Argillite	no vis sx	no	
15	B 70.0	645748.66	7324415.54	Schist	no vis sx	no	
16	B 70.0	645748.66	7324415.54	Schist	no vis sx	no	Duplicate of Sample 15
17	B 76.5	642934.39	7318413.06	Schist	no vis sx	no	
18	B 77.0	642301.22	7318226.50	Diabase	no vis sx	no	Magnetic, red hematite stain
19	B 101.0	633059.76	7296838.85	Schist with amphibolite and Qtz vns	trace (po and cp)	Yes	Abundant pink garnets
20	B 102.5	631622.26	7295705.57	Mafic Volcanic	no vis sx	no	Magnetic
21	B 103.75	630652.14	7294931.55	Calc-silicates	1-2% (py and po)	yes	In a shear zone
22	B 104.3	630121.13	7294520.27	Calc-silicates	Trace - 1% (py and po)	yes	In a shear zone
23	B 112.5	623699.71	7289553.36	Granite	no vis sx	no	
34	B 210.0	538595.60	7261147.19	Granite	no vis sx	no	
35	B 201.5	547302.69	7260583.94	Granite	no vis sx	no	
36	B 194.5	554379.74	7261750.58	Gneiss	no vis sx	no	

Notes: vis sx = visible sulfides
B x = Distance along route west of the Bathurst Inlet Port Site

A total of five samples, including one duplicate, displayed visual evidence of mineralization containing either sulphides, or having rusty oxidation staining on the weathered surface of the outcrop. Sulphides were identified in hand sample as pyrite, pyrrhotite or chalcopyrite, and were in visible quantities ranging from 0.01% to 0.14%. Samples containing visible sulphides displayed rusty staining on the surface outcrop with the exception of Sample 8, where the sulphides were confined in quartz carbonate veinlets. The remaining four mineralized samples occurred within amphibolite banding or structural shear zones.

The remainder of the samples did not contain visual evidence of mineralization, and are considered to be typical representations of bedrock across the route corridor. Seven samples were taken from mafic volcanics, five from unmineralized meta-sedimentary units, three from diabase dike intrusions, three from granites, and three from sedimentary rocks. Both lithological composition and mineralization occurrences in the bedrock can be determined visually, however, there is insufficient sample density to draw conclusions regarding ARD potential based upon visual assessment alone.

3.1.6 Potential Quarry Sites and Road Cuts

Potential quarry sites and road cuts localities were not established prior to fieldwork. These sites were evaluated after the completion of mapping, using the completed bedrock geology maps and the results from the ARD sampling program. Each quarry location as indicated on the engineering maps, was plotted on the bedrock geology map. The rock type of a quarry was identified where it coincided with field-mapped outcrop, subcrop, or boulder fields. Quarries that did not occur on or near field-mapped outcrops were not assigned a rock type classification. Of the 37 proposed quarry locations, 19 are located in close proximity to mapped bedrock. A summary of the quarry bedrock evaluation based upon geological mapping is provided in Table 3.1-3.

Samples from the ARD screening program were also considered in evaluating the quarry sites and road cut locations. The proximity to sample locations was noted; however, it is not possible to establish ARD potential of a site based on samples taken from a different site. The results of the ARD screening program are discussed in the following section.

3.2 Acid Formation Potentials

The potential for acid formation was evaluated for each of the samples obtained from along the proposed road route. Results of ABA analysis conducted by BC Research Inc. are presented in Table 3.2-1.

Paste pH values ranged from a maximum of 9.2 for a sample of Argillite taken from near the port site (Sample 6) to a minimum of 6.5 for a sample obtained at kilometre 104.3 (Sample 22). Remaining samples did not have particularly high sulphide contents but did have a lack of neutralizing minerals.

Figure 3.2-1 graphically illustrates the relationship between sample NP and MPA values for all samples with the exception of Samples 6, 8, 9, 10, and 14. These later samples of

Table 3.1-3
Potential Quarry Sites and Road Cuts

Quarry Site Location	Bedrock Unit	Sample Description			Closest Sample (#)	Proximity of Sample (m)	Comments
		Rock Type	Sulphides	Gossan?			
B 0.0	1d	Mafic Volcanic	no vis sx	no	1	500	Roadcut occurs on mapped outcrop.
	1d	Mafic Volcanic	no vis sx	no	2	500	
	1d	Mafic Volcanic	no vis sx	no	3	500	
	1d	Mafic Volcanic	no vis sx	no	4	500	
B 6.5	5a	Argillite	no vis sx	no	5	1000	Quarry occurs on mapped outcrop.
B 7.8	5a	Argillite	no vis sx	no	6	1000	Quarry occurs on mapped outcrop.
B 12.0	5a	*no sample taken*			-	-	Quarry occurs on mapped outcrop.
B 24.5	5b,5a	Metasedimentary	trace (po)	no	8	500	Quarry occurs on mapped outcrop,
	5b,5a	Metasedimentary	trace (po)	no	9	500	between Samples 8, 9 and 10.
	5b,5a	Metasedimentary	no vis sx	no	10	500	
B 39.5	1a,2a	Mafic Volcanic	no vis sx	no	12	50	Quarry occurs on mapped outcrop.
B 43.0	1a	*no sample taken*			-	-	Quarry occurs on mapped boulders.
B 45.0	1a	*no sample taken*			-	-	Quarry occurs on mapped outcrop.
B 47.5	1a	*no sample taken*			-	-	Quarry occurs on mapped outcrop.
B 53.0	2a	*no sample taken*			-	-	Quarry occurs on mapped boulders.
B 59.5	-	*no sample taken*			-	-	Quarry does not occur on mapped outcrop.
B 65.0	2,3a	Mafic Volcanic	no vis sx	no	13	1500	Quarry is 100m from from mapped outcrop.
B 75.0	4a	Schist	no vis sx	no	16	500	Quarry is 1km from from mapped outcrop.
B 78.7	4a	*no sample taken*			-	-	Quarry occurs on mapped boulders.
B 83.0	4a	*no sample taken*			-	-	Quarry occurs on mapped outcrop.
B 87.0	4a	*no sample taken*			-	-	Quarry occurs on mapped outcrop.
B 101.0	4a	Schist with amphibolite and Qtz vns	trace (po & cp)	Yes	19	0	Quarry occurs on mapped outcrop.
B 107.0	1a,d	*no sample taken*			-	-	Quarry occurs on mapped outcrop.
B 115.0	7	Granite	no vis sx	no	23	2000	Quarry occurs in mapped subcrop and boulders.
B 120.0	7	*no sample taken*			-	-	Quarry occurs on mapped boulders.
B 149.0	7	*no sample taken*			-	-	Quarry occurs in mapped subcrop and boulders.
B 155.0	7	*no sample taken*			-	-	Quarry occurs in mapped subcrop and boulders.
B 158.0	7	*no sample taken*			-	-	Quarry occurs amidst many small outcrops and till.
B 161.0	7	*no sample taken*			-	-	Quarry occurs on mapped outcrop.
B 168.0	7	*no sample taken*			-	-	Quarry occurs on mapped outcrop.
B 174.0	7	*no sample taken*			-	-	Quarry occurs on mapped outcrop.
B 190.0	4c	Gneiss	no vis sx	no	36	4000	Quarry occurs on mapped outcrop.
B 204.0	-	*no sample taken*			-	-	Quarry does not occur on mapped outcrop.

Notes: vis sx = visible sulfides
B x = Distance along route west of the Bathurst Inlet Port Site

Table 3.2-1
ABA Results for Bathurst Bedrock Samples

Sample ID	Paste pH	Inorganic Carbob CO_2 (Wt.%)	Equivalent $CaCO_3$ (kg $CaCO_3$/tonne)	Total Sulphur (Wt.%)	Sulphate Sulphur (Wt.%)	Sulphide Sulphur[1] (Wt.%)	Maximum Potential Acidity[2] (kg $CaCO_3$/tonne)	Neutralization Potential (kg $CaCO_3$/tonne)	Net Neutralization Potential (kg $CaCO_3$/tonne)	Net Potential Ratio[3] (kg $CaCO_3$)	Fizz Rating
1	9	0.28	6.36	0.01	<0.01	0.01	0.30	33.3	33.30	111.00	slight
2	9.1	0.04	0.91	0.01	<0.01	0.01	0.30	23.2	23.20	77.33	none
3	8.9	<0.03	0.00	0.03	<0.01	0.03	0.94	21	20.06	22.40	none
4	8.9	0.14	3.18	0.01	<0.01	0.01	0.30	29.3	29.30	97.67	none
5	9	0.46	10.44	0.01	<0.01	0.01	0.30	11.9	11.90	39.67	none
6	9.2	2.43	55.16	0.01	<0.01	0.01	0.30	59.2	59.20	197.33	moderate
7	8.4	0.25	5.68	0.01	<0.01	0.01	0.30	20.2	20.20	67.33	none
8	8.7	36.04	818.11	0.01	<0.01	0.01	0.30	832.5	832.50	2775.00	strong
9	8.9	37.45	850.12	0.04	<0.01	0.04	1.25	826.2	824.95	660.96	strong
10	8.9	27.31	619.94	0.01	<0.01	0.01	0.30	615.9	615.90	2053.00	strong
11	8	0.07	1.59	0.02	<0.01	0.02	0.63	14.4	13.78	23.04	none
12	7.9	0.04	0.91	0.01	<0.01	0.01	0.30	4.8	4.80	16.00	none
13	7.3	0.04	0.91	0.01	<0.01	0.01	0.30	0.8	0.80	2.67	none
14	8.8	20.52	465.80	0.01	<0.01	0.01	0.30	448.4	448.40	1494.67	moderate
15	8.5	0.7	15.89	0.04	<0.01	0.04	1.25	22.7	21.45	18.16	moderate
16	8.8	0.46	10.44	0.06	<0.01	0.06	1.88	29	27.13	15.47	moderate
17	7	<0.03	0.00	0.05	<0.01	0.05	1.56	6.1	4.54	3.90	none
18	8.1	0.11	2.50	0.14	<0.01	0.14	4.38	19.2	14.83	4.39	none
19	6.8	0.04	0.91	0.01	<0.01	0.01	0.30	11.9	11.90	39.67	none
20	7.6	0.04	0.91	0.01	<0.01	0.01	0.30	12.6	12.60	42.00	none
21	8.1	0.67	15.21	0.07	<0.01	0.07	2.19	15.8	13.61	7.22	none
22	6.5	<0.03	0.00	0.01	<0.01	0.01	0.30	2.5	2.50	8.33	none
23	7.3	<0.03	0.00	0.01	<0.01	0.01	0.30	3.5	3.50	11.67	none
34	7.4	<0.03	0.00	0.04	<0.01	0.04	1.25	11.6	10.35	9.28	none
35	7.1	<0.03	0.00	0.01	<0.01	0.01	0.30	8.9	8.90	29.67	none
36	7.5	<0.03	0.00	0.14	<0.01	0.14	4.38	6.1	1.73	1.39	none
Minimum	6.50	0.04	0.00	0.01	0.00	0.01	0.30	0.80	0.80	1.39	
Maximum	9.20	37.45	850.12	0.14	0.00	0.14	4.38	832.50	832.50	2775.00	
Average	8.14	6.69	110.96	0.03	0.00	0.03	0.94	118.88	118.13	301.12	

Notes:

[1] **Based on difference between total sulphur and sulphate-sulphu**

[2] **Based on sulphide-sulphur**

[3] **Net Potential Ratio = Neutralization Potential (kg $CaCO_3$) / Maximum Potential Acidity (kg $CaCO_3$)**

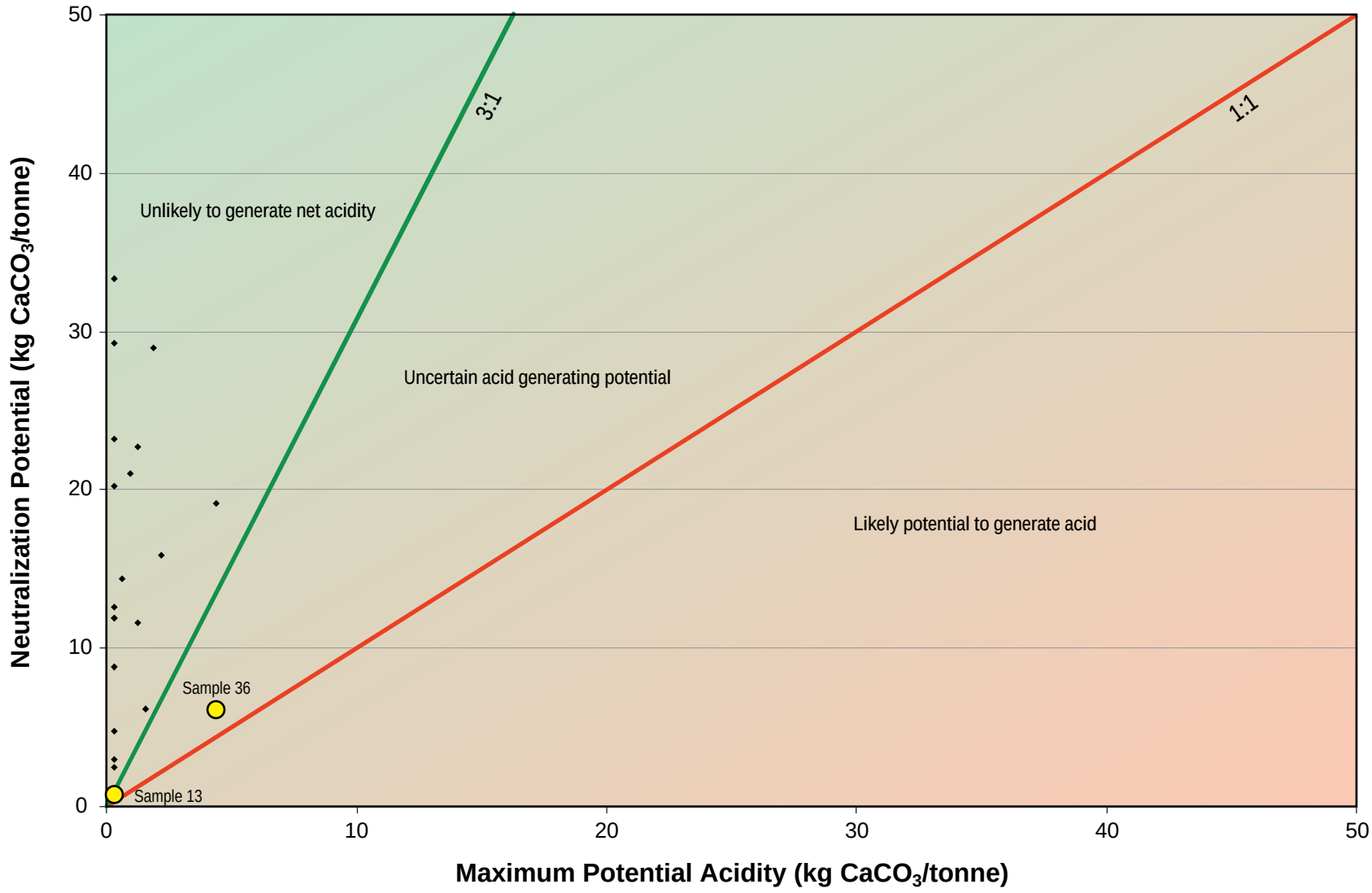

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FIGURE 3.2-1

Neutralization Potential on Maximum Potential Acidity

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metasedimentary rock displayed high carbonate neutralization potentials (Ca-NP) and were not included in the figure. NPR guidelines stipulated by INAC (Table 2.3-1) were also plotted on the figure to aid in data interpretation.

The NP:MPA ratios of two samples (13, 36) were determined to fall into the $1.0 \leq NPR \leq 3.0$ guideline range of uncertain acid generation potential. Table 3.2-2 summarizes each of these samples geological and Net Potential Ratio characteristics.

Table 3.2-2
Rock Types and Proximities to Proposed Quarries of Samples with NPR Values ≤ 3.0

Sample Site	Road Location (~km)	Rock Type	Proximity to Proposed Quarry (km)	Net Potential Ratio (NPR)
13	B 65	Mafic Volcanic	1.5	2.7
36	B 190	Gneiss	4.0	1.4

3.2.1 Quality Assurance and Quality Control

Appendix B presents the results of QA/QC tests conducted by BC Research Inc. during the analysis of Bathurst samples. Review of these data indicated good use of QA/QC techniques by B.C. Research Inc.

3.3 Distilled Water Extraction and Metals Analysis

Distilled water extraction testwork was not undertaken in 2001 but should be considered as part of any future screening investigations. Whole rock metals analysis was completed as a component of the 2001 test program and results are presented in Appendix C. The results of the metals analysis should be reviewed and discussed in combination with any future distilled water extraction testwork.

4. CONCLUSIONS AND RECOMMENDATIONS

4. Conclusions and Recommendations

The reconnaissance survey and subsequent ARD screening of bedrock outcrops along the proposed road route was designed to provide a preliminary understanding of both bedrock geology and any potential for acid generation. Sampling of bedrock for ARD screening was not intended to be a comprehensive study, as specific road engineering plans have yet to be fully developed. The program was focussed to provide a baseline of information thereby forming a foundation for future work.

Mapping as well as previous exploration activity in these regions has shown that mineralized bands of iron formation and mineralized shear zones occur scattered throughout the sedimentary rocks of the Yellowknife Supergroup. Small bands and lenses of iron formations potentially expand below surface and are unpredictable in size and sulphide content. Outcropping of mineralized zones containing sulphides are generally indicated by rusty staining produced from the oxidization of iron minerals.

The ARD screening assessment determined that most of the bedrock samples obtained during the 2001 program have a low potential to generate net acidity. A total of two samples (13 and 36) were determined to have an uncertain potential to generate net acidity when compared to INAC guidelines. The screening assessment has demonstrated that potentially acid generating bedrock may be present within the vicinity of the proposed road route.

As part of project environmental planning, a more detailed ARD screening program is recommended for each of the proposed quarry sites and any potential bedrock road cuts that may be identified during the engineering feasibility study. Detailed ARD screening would provide project planners with an understanding of the potential for metals leaching and/or acid generation from certain rock types. This information can then be used to establish protocols for how best to avoid potentially problematic materials. Such a screening program should include:

- Representative sampling of rock types within prescribed areas (proposed quarries and road cuts);
- Geological classification of samples;
- Acid base accounting of samples; and
- Static leach tests to establish runoff water quality.

The screening program would have 2 main objectives:

1. Establish whether rocks that may potentially leach metals or generate net acidity exist within proposed quarries or road cuts.

2. Determine if potentially problematic rock types can be visually identified in the field without undergoing ABA analysis.

Figure 4-1 illustrates a potential ARD screening process that could be employed during future quarry development and road construction. Depending upon the results of such a screening program, it may be possible for potentially acid generating bedrock to be identified visually by a field geologist during quarry development. Avoidance of potentially problematic bedrock is the preferred management solution as mitigation can be both costly and logistically challenging in any working environment.

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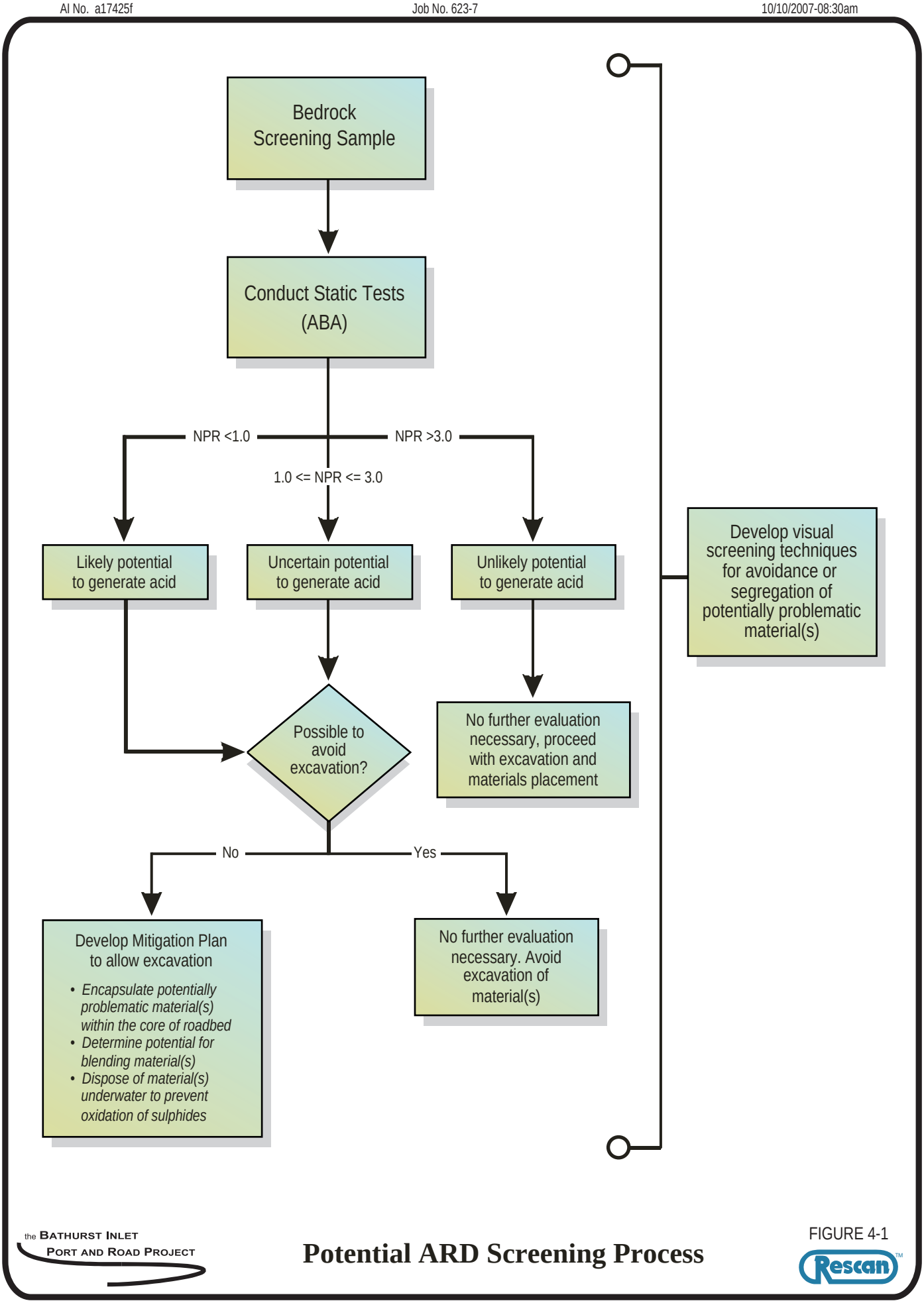

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Potential ARD Screening Process

FIGURE 4-1

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APPENDIX A
BEDROCK GEOLOGY MAP

(available in map pocket)

Km 0 - km 59

Km 59 - km 114

Km 114 - km 171

Km 171 - km 213

Bathurst Inlet

Contwoyto Lake

Eskar (Sand)

Eskar (Sand and Gravel)

Boulders + Saharop

Bathurst Inlet Port and Road Project

Bedrock Geology Mapping

Lithology:

1	Basaltic	a Fine grained, massive
2	Andesitic	b Tuff
3	Rhyolitic	c Conglomerate
		d Coarse grained, intrusive
4	Meta - Sedimenatary	a Quartz biotite schist
		b Biotite muscovite quartz schist
		c Gneiss
5	Sedimantary	a Argilite
		b Carbonaceous
7	Granite	
9	Diabase	

Modifier:

Gn	Garnets
Cord	Cordierite
And	Andalusite
IF	Iron rich banding
Sx	Sulphites
o/b	Overburden

- Kilometre Marker
- Gravel Pit
- Quarry
- Surface Mapping
- Road Alignment
- Bedrock Outcrops

1:60,000

0 1.5 3

Kilometres

the Bathurst Inlet Port and Road Project

Date: November 28, 2007
File Reference: 623-7-39
Projection: UTM 12, Nad83

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APPENDIX B
ACID BASE ACCOUNTING QUALITY ASSURANCE AND QUALITY CONTROL DATA

Appendix B
Acid Base Accounting Quality Assurance and Quality Control Data

QA/QC for Neutralisation Potential Determination

Sample No.	Neutralisation Potential ($kgCaCO_3$/Tonne)	Neutralisation Potential ($kgCaCO_3$/Tonne)
Duplicates		
21	15.8	17.1
NBM-1 Std. (NP=52)	53.3	-

QA/QC for Sulphur/Sulphate Analysis

Sample No.	Sulphur (Wt.%)	Sulphur (Wt.%)
Duplicates (Total Sulphur)		
10	<0.02	<0.02
20	<0.02	<0.02
Acme In-house Std. 5.2%S	5.35	5.30
Acme In-house Std. 0.11%S	0.11	0.11
Duplicates (Sulphate Sulphur)		
4	<0.01	<0.01
16	<0.01	<0.01
35	<0.01	<0.01
NBM-1 Ref. (<0.01% SO4-S)	0.01	-

QA/QC for CO2 Analysis

Sample No.	$\%CO_2$ (Wt.%)	$\%CO_2$ (Wt.%)
Duplicates		
10	27.31	26.85
20	0.04	<0.03
Acme Std. (1.5% CO_2)	1.48	1.50

APPENDIX C
RESULTS OF METALS ANALYSIS, BATHURST SAMPLES

Appendix C
Results of Metals Analysis, Bathurst Samples

Sample	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppm	Ni ppm	Co ppm	Mn ppm	Fe %	As ppm	U ppm	Au ppm	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm	Ca %
1	2.2	218	3	70	< .1	24	25	383	5.28	< 1	< 1	< 2	1	40	< .2	< .5	< .5	260	1.26
2	1.3	231	2	60	< .1	20	23	338	5.02	< 1	< 1	< 2	1	19	< .2	< .5	< .5	241	1.04
3	1.6	253	2	70	0.1	20	24	439	5.19	< 1	< 1	< 2	1	20	< .2	< .5	< .5	264	0.93
4	2.1	155	2	55	< .1	35	31	457	5.95	< 1	< 1	< 2	2	24	< .2	< .5	< .5	252	0.80
5	7.1	1	3	3	< .1	2	1	96	0.58	2	1	< 2	7	3	< .2	< .5	< .5	13	0.26
6	4.5	2	3	8	< .1	6	4	533	1.42	2	2	< 2	12	8	< .2	< .5	< .5	17	1.81
7	2.2	185	18	71	0.1	23	18	291	3.71	2	< 1	< 2	1	25	< .2	< .5	< .5	258	1.10
8	0.7	80	< 2	3	< .1	3	6	1843	1.34	< 1	1	< 2	3	28	< .2	< .5	< .5	6	16.54
9	0.6	110	2	3	< .1	7	7	1940	1.43	< 1	< 1	< 2	3	29	< .2	< .5	< .5	10	17.08
10	0.9	33	6	15	< .1	8	5	2838	1.33	< 1	2	< 2	13	169	< .2	< .5	< .5	7	22.93
11	4.3	209	2	26	< .1	12	14	275	3.56	< 1	< 1	< 2	2	12	< .2	< .5	< .5	175	1.74
12	7.2	14	3	7	< .1	13	4	86	1.70	1	1	< 2	9	3	< .2	< .5	< .5	12	0.13
13	9.5	1	9	1	< .1	2	< 1	24	0.27	< 1	< 1	< 2	2	1	< .2	1.3	< .5	2	0.02
14	4.2	1	4	24	< .1	7	9	1984	4.86	< 1	1	< 2	7	92	< .2	0.8	< .5	8	9.68
15	4.6	41	14	85	0.1	65	16	384	2.81	4	1	< 2	6	20	< .2	< .5	< .5	39	0.71
16	3.9	41	15	102	0.1	85	26	438	3.54	15	1	< 2	5	23	< .2	< .5	< .5	70	0.54
17	4.6	16	3	18	< .1	47	16	275	3.21	1	1	< 2	4	3	< .2	< .5	< .5	74	0.11
18	5.3	53	9	79	0.1	26	26	496	5.34	< 1	< 1	< 2	3	22	< .2	0.6	< .5	110	1.24
19	7.6	8	< 2	18	< .1	11	3	163	3.99	3	1	< 2	2	7	< .2	< .5	< .5	25	1.06
20	5.9	26	6	31	0.1	33	10	245	1.64	< 1	< 1	< 2	1	6	< .2	0.8	< .5	38	0.66
21	10.5	8	19	77	0.1	2	1	176	0.42	1	< 1	< 2	3	3	< .2	1.3	< .5	< 1	0.41
22	4.6	7	5	21	0.1	2	1	100	0.80	1	< 1	< 2	6	3	< .2	< .5	< .5	< 1	0.08
23	10.5	2	2	17	< .1	4	1	115	0.50	1	1	< 2	3	8	< .2	< .5	< .5	5	0.07
34	8.6	17	19	81	0.3	19	11	244	3.16	1	1	< 2	61	6	< .2	< .5	0.5	69	0.57
35	8.4	13	16	68	0.3	17	10	288	2.96	1	2	< 2	40	4	< .2	< .5	0.9	48	0.29
36	5.7	56	3	86	0.3	126	33	276	4.14	3	1	< 2	3	7	< .2	< .5	0.7	195	0.06
Duplicate Analysis																			
10	0.7	32	5	13	< .1	6	4	2711	1.25	< 1	1	< 2	12	162	< .2	< .5	< .5	7	22.23
20	5.9	26	5	30	0.1	32	10	272	1.55	1	< 1	< 2	1	6	< .2	0.7	< .5	36	0.62

(continued)

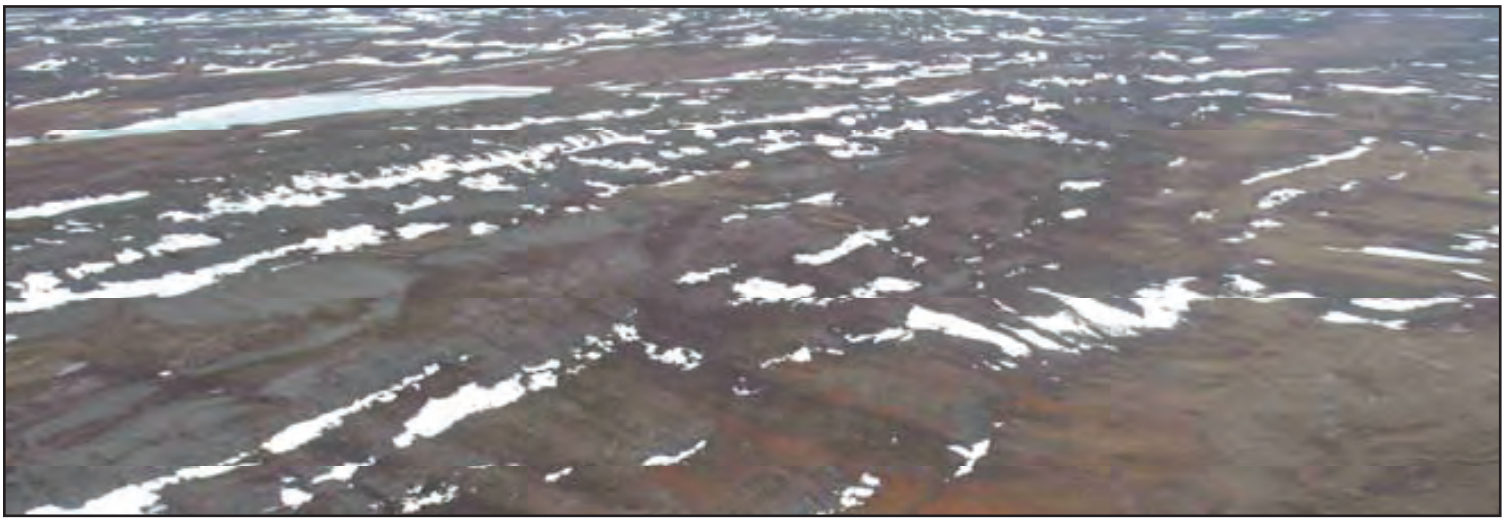
Appendix C
Results of Metals Analysis, Bathurst Samples (completed)

Sample	P %	La ppm	Cr ppm	Mg %	Ba ppm	Ti %	B ppm	Al %	Na %	K %	W ppm	Hg ppm	Sc ppm	Tl ppm	S %	Ga ppm	TOT/S %	CO2 %
1	0.077	10	40	1.23	46	0.252	10	1.79	0.208	0.33	< 1	< 1	4.3	< 1	0.02	9	< .02	0.28
2	0.078	10	23	0.90	48	0.306	19	1.16	0.061	0.37	< 1	< 1	2.3	< 1	< .02	8	< .02	0.04
3	0.077	10	26	0.83	52	0.337	49	1.12	0.076	0.38	< 1	< 1	2.3	< 1	0.02	9	0.03	< .03
4	0.072	10	67	2.55	43	0.230	19	2.16	0.092	0.3	< 1	< 1	7.6	< 1	< .02	12	< .02	0.14
5	0.031	46	101	0.19	19	0.005	7	0.22	0.015	0.14	< 1	< 1	0.8	< 1	< .02	2	< .02	0.46
6	0.066	36	74	0.60	12	0.018	3	0.43	0.021	0.11	< 1	< 1	1.5	< 1	< .02	2	< .02	2.43
7	0.096	10	27	0.67	60	0.183	14	1.27	0.103	0.2	< 1	< 1	1.1	< 1	< .02	8	< .02	0.25
8	0.012	12	16	9.48	14	0.001	1	0.16	0.027	0.03	< 1	< 1	2.2	< 1	0.02	< 1	< .02	36.04
9	0.013	13	18	10.42	14	< .001	2	0.20	0.025	0.02	< 1	< 1	2.6	< 1	0.02	1	0.04	37.45
10	0.039	22	24	0.95	715	0.007	1	0.55	0.007	0.09	< 1	< 1	2.0	< 1	0.02	2	< .02	27.31
11	0.227	18	52	0.68	14	0.199	6	1.38	0.057	0.08	< 1	< 1	0.8	< 1	< .02	14	0.02	0.07
12	0.054	23	110	0.52	25	0.011	1	0.71	0.018	0.11	< 1	< 1	0.6	< 1	< .02	4	< .02	0.04
13	0.002	14	121	0.01	5	0.001	1	0.06	< .001	0.06	< 1	< 1	0.1	< 1	< .02	< 1	< .02	0.04
14	0.069	13	75	5.70	43	0.025	1	0.40	0.017	0.14	< 1	< 1	2.4	< 1	< .02	2	< .02	20.52
15	0.050	17	130	1.34	32	0.022	< 1	1.79	0.018	0.12	< 1	< 1	1.2	< 1	< .02	6	0.04	0.70
16	0.048	17	150	1.66	25	0.025	< 1	2.21	0.012	0.1	< 1	< 1	2.8	< 1	0.02	9	0.06	0.46
17	0.054	15	143	1.61	167	0.124	4	2.29	0.025	1.01	< 1	< 1	4.6	< 1	< .02	8	0.05	< .03
18	0.283	28	66	0.89	23	0.234	6	1.47	0.044	0.11	< 1	< 1	3.1	< 1	0.1	9	0.14	0.11
19	0.258	8	100	0.41	5	0.015	1	1.53	0.023	0.02	< 1	< 1	1.1	< 1	< .02	5	< .02	0.04
20	0.075	11	127	0.94	69	0.079	< 1	1.11	0.077	0.28	< 1	< 1	2.0	< 1	< .02	5	< .02	0.04
21	0.003	12	106	0.44	25	0.002	2	0.38	0.004	0.11	< 1	< 1	0.4	< 1	0.04	2	0.07	0.67
22	0.010	29	58	0.10	17	0.018	2	0.40	0.017	0.15	< 1	< 1	0.5	< 1	< .02	2	< .02	< .03
23	0.011	5	136	0.18	20	0.016	1	0.30	0.062	0.09	< 1	< 1	0.5	< 1	< .02	2	< .02	< .03
34	0.134	114	107	0.84	283	0.270	2	1.57	0.044	1.15	< 1	< 1	4.5	< 1	0.02	10	0.04	< .03
35	0.141	70	104	0.68	233	0.225	2	1.36	0.022	1.14	< 1	< 1	3.2	< 1	< .02	9	< .02	< .03
36	0.020	11	295	1.66	318	0.379	2	3.17	0.055	1.78	< 1	< 1	15.3	1	0.12	12	0.14	< .03
Duplicate Analysis																		
10	0.040	21	24	0.92	780	0.007	1	0.53	0.006	0.08	< 1	< 1	1.9	< 1	0.02	2	< .02	26.85
20	0.076	11	126	0.93	66	0.080	< 1	1.11	0.058	0.27	< 1	< 1	2.0	< 1	< .02	5	< .02	< .03

Appendix D-6

Environmental Geochemistry of Surficial Samples from Proposed Rock Quarries, Granular Pits, Port Area and Airstrip

Author: **Morwijk Enterprises Ltd.**
Date: **October 2007**



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Bathurst Inlet Port and Road (BIPR) Project - Environmental Geochemistry of Surficial Samples from Proposed Rock Quarries, Granular Pits, Port Area, and Airstrip

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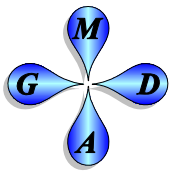

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October 28, 2007

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EXECUTIVE SUMMARY

The Bathurst Inlet Port and Road (BIPR) Project consists of a proposed port, and a road starting at Bathurst Inlet and extending south and west to Contwoyto Lake. Mines and mineral deposits in Nunavut and Northwest Territories will be connected to the port at Bathurst Inlet by this new 211 km all-weather road.

An environmental and geochemical concern along the proposed road corridor, around the port area, and at the nearby rock-quarry and granular sand-gravel sites, is the potential for acidic rock drainage (ARD) and accelerated metal leaching (ML). This ML-ARD carries the potential for creating deleterious drainage that would enter, and could degrade, the surrounding environment. ML-ARD has been a problem for other road projects in Canada, leading to at least one prosecution under the *Fisheries Act*.

ARD testwork showed that up to 50% of the surficial samples collected for this study might generate ARD someday. However, the uncertainties in laboratory analyses, including measurements near inaccurate detection limits, and with other technical issues meant the percentage was not highly reliable. Nevertheless, a large geochemical zone around the southwestern end of the proposed road, from proposed Quarry Q23 to Quarry Q39, showed the greatest ARD potential. Also, a geochemical zone with high neutralizing capacity, around Gravel-Site G5 to Quarry Q7, could be used to offset the ARD potential in other zones if needed.

Even in the absence of ARD and acidic conditions, the potential for leaching of metals and other elements, like selenium, was present at some sites. This leaching, if strong, could degrade local water quality.

Recommendations were offered to improve ML-ARD prediction before and during road construction. These included additional tests, which are currently underway. They also included baseline water analyses before road disturbance and excavation, to ensure any water with pre-existing high concentrations would not be attributed to road construction.

REPORT SUMMARY

The Bathurst Inlet Port and Road (BIPR) Project consists of a proposed port and a road starting at Bathurst Inlet and extending south and west towards Contwoyto Lake. Mines and mineral deposits in Nunavut and Northwest Territories will be connected to the Bathurst Inlet port by this new 211 km all-weather road.

For road construction, gravel and sand are the preferred substrates from granular pits (labelled "G" sites here), but their availability is reportedly limited along the road alignment. Thus, approximately 80% of road fill material may originate from rock quarries (labelled "Q" sites here).

An environmental and geochemical concern along the proposed road corridor, around the port area, and at the nearby G and Q sites, is the potential for acidic rock drainage (ARD) and accelerated metal leaching (ML). This ML-ARD carries the potential for creating deleterious drainage that would enter, and could degrade, the surrounding environment.

This study involved the collection and geochemical analyses of 45 surficial samples from the proposed G and Q sites, the port area, and the airstrip. Deeper material could not be collected, but should be analyzed before disturbance, excavation, and construction.

The surficial samples were analyzed for acid-base accounting (ABA), total solid-phase elements, and mineralogy. Additionally, electrical conductivity of water in any local puddles, ponds, or rivulets was used as a general indicator of surficial geochemical reactivity.

Results of Acid-Base Accounting

All 45 surficial samples had near-neutral to alkaline paste pH values (6.8 to 8.6). Therefore, no samples were net acid generating at the time of analysis.

Most sulphur analyses and species in the 45 surficial samples were close to or below analytical detection, but with relatively high analytical inaccuracy. As a result, the sulphide levels and the resulting Acid Potentials could not be reliably estimated for most samples. However, mineralogy confirmed the presence of trace amounts of potentially acid-generating sulphide minerals. Predictions of ARD potential must recognize the uncertainty near the detection limit, which is simply a human artifact and not a criterion of environmental protection.

The bulk Sobek Neutralization Potential (NP), important for neutralizing acidity, was relatively low in many samples, below 10 kg/t. Unavailable NP, which is the measured portion that is not readily reactive, could not be resolved with current information. However, a range of 0 to 10 kg/t may be appropriate for unavailable NP in this study, meaning most samples contained little to no available and reactive NP. The Sobek NP in many samples was apparently composed of slow-reacting aluminosilicate minerals, but the NP in the remaining samples was probably fast-neutralizing calcite ($CaCO_3$).

Net balances of acid-generating and acid-neutralizing capacities indicated roughly 0% to 50% of the 45 surficial samples were net acid generating and might release ARD, when compared with non-site-specific generic criteria. In turn, 50-100% of the samples were predicted to be net neutralizing indefinitely. However, the uncertainties in sulphur analyses that were close to detection, and in the applicable value of unavailable NP, substantially increased the uncertainty in these percentages.

Results of Total-Element Analyses

Total-element analyses of the 45 surficial solid-phase samples were the first step in predicting the leaching of metals and other elements into water. These analyses showed that most samples were composed of aluminum and silicon, with the high-NP samples containing much less of these two elements due to their high carbonate content. Iron, potassium, magnesium, calcium, and sodium were also significant in many samples.

Trace elements frequently above maximum crustal abundances were bismuth and selenium. Cesium, lithium, and thorium were above crustal abundance only in one or two samples. All others were more typical of crustal abundance, but could still leach at high concentrations if very reactive. Elements like selenium can create water-quality problems if they leach at high rates into water, but long-term kinetic testing for at least a year is needed to determine leaching rates. These tests are currently underway.

Correlations suggested leaching of metals and other elements could be more closely related to simple dissolution of Neutralization Potential, rather than sulphide oxidation, upon disturbance at the Q Sites, G Sites, port, and airstrip. This would mean even the simple exposure of some rock and granular material to rain and snowmelt will create higher concentrations in some nearby waters.

Spatial Patterns in ABA and Total Solid-Phase Elements

Spatially arranged geochemical data of surficial samples, from the proposed port at Bathurst Inlet to the rock-quarry Site Q39 near Contwoyto Lake, showed some significant spatial trends.

A large geochemical zone from Q23 to Q39 had the greatest ARD potential. Also, a geochemical zone with elevated carbonate and neutralizing capacity, around G5 to Q7, could be used to offset the ARD potential in other zones if needed.

Solid-phase element levels do not necessarily reflect potential leaching rates into water. Nevertheless, several solid-phase elements displayed a spatial pattern of highly variable levels, among the highest and lowest, from the proposed port south to roughly Q8; typically low levels from Q11 to Q15; and then generally variable but moderate levels to Q39 near Contwoyto Lake.

Electrical Conductivity of Water from Local Puddles, Ponds, and Rivulets

A weak, positive correlation of Electrical Conductivity with Inorganic Carbon and CaNP suggested the higher measured electrical conductivities at some sites may reflect elevated alkalinity and hardness in water. Some trace metals may have dissolved into these waters also, but laboratory analyses are needed to confirm this.

At all sites (Q rock-quarry sites, G granular sites, the port area, and the airstrip), laboratory water analyses should be used to define baseline water quality before any disturbance, excavation, and construction. This would ensure any water with currently high concentrations would not be attributed to road construction in the future.

Recommendations

1) Due to the uncertainties in ABA analytical data and the lack of deeper samples, a thorough assessment of ARD potential of the various sites cannot be made at this time. However, surficial ARD potential was highest from Sites Q23 to Q39 at Contwoyto Lake, with some high potential sporadically east and north of Site Q23 (towards Bathurst Inlet). Therefore, before disturbance and excavation, deeper rock and granular materials should be sampled and analyzed for a more complete assessment of ARD potential. This is important, because a recent road-related prosecution under the *Fisheries Act* showed that surficial pre-construction information may not be sufficient to identify ML-ARD potential properly.

2) The high-neutralizing carbonate content of rock and sand-gravel around Sites G5 to Q7 may be used to decrease ARD potential in other areas. This would require transportation to more distance sites, so economics will determine if this is more appropriate than other means of reducing ARD potential like imported lime.

3) Even without acidic conditions and with near-neutral pH, the potential for leaching of metals and other elements, like selenium, is present at some G and Q sites. However, this potential cannot be quantitatively defined with existing information, because it requires long-term leaching tests. These tests are currently underway.

4) Electrical conductivity of local waters, and the spatial distribution of solid-phase carbonate minerals, suggested leaching may be related to the dissolution of neutralizing minerals. This can cause an increase in alkalinity and hardness, and perhaps in some trace metals also. Thus, the simple exposure of some rock and granular material to rain and snowmelt could create higher concentrations in some nearby waters.

5) Baseline water analyses should be conducted before disturbance and excavation. This would ensure any water with currently high concentrations would not be attributed to road construction.

1. INTRODUCTION

The Bathurst Inlet Port and Road (BIPR) Project consists of a proposed port and a road starting at Bathurst Inlet. This port will connect to mines and mineral deposits in Nunavut and Northwest Territories by the new 211 km all-weather road to Contwoyto Lake, and the existing "Tibbitt to Contwoyto" winter road.

For road construction, gravel and sand are the preferred substrates from granular pits (labelled "G" sites here), but their availability is reportedly limited along the road alignment. Thus, approximately 80% of road fill material may originate from rock quarries (labelled "Q" sites here).

An environmental and geochemical concern along the road corridor, around the port area, and at the nearby G and Q sites, is the potential for acidic rock drainage (ARD) and accelerated metal leaching (ML). This ML-ARD carries the potential for creating deleterious drainage that would enter, and could degrade, the surrounding environment.

In 2001, Rescan Environmental Services Ltd. conducted a reconnaissance-level bedrock geology survey along the road alignment itself (Rescan, 2007), which included a preliminary assessment for environmental geochemistry and ML-ARD (see Chapter 2 of this report). In contrast, this report looks specifically at the proposed G and Q sites, which were frequently at some distance from the road alignment, as well as the proposed port and airstrip.

2. PREVIOUS WORK

Previous work along the road alignment was conducted by Rescan Environmental Services (Rescan, 2007). The following paragraphs were taken from that report.

Rescan Environmental Services Ltd. (Rescan) was retained by the Bathurst Port and Road Project Technical Committee to undertake baseline environmental studies along the proposed road route during the 2001 field season. One component of the 2001 program was to conduct a reconnaissance level bedrock geology survey and sampling campaign along the proposed route. The program included the collection of bedrock samples for environmental analysis to evaluate potential acid formation concerns and provide a foundation for future work in this study area.

Geological mapping and sampling was undertaken at a reconnaissance level along a 1 km wide corridor spanning the length of the proposed road route. Bedrock was selected for sampling based upon presence of mineralization as well as a requirement to randomly sample representative lithologies. Bedrock geology was developed into an outcrop map with identifying lithologies, structural measurements, sample locations, proposed quarry sites and the route corridor boundaries superimposed onto air photo mosaics. Bedrock identified during the fieldwork consisted of granites, gneisses, mafic volcanics and intrusives, schists, carbonaceous sediments, argillite, pegmatite and diabase dikes. These lithologies are consistent with published geological mapping for this region.

Potentially mineralized amphibolitic iron formation is commonly found as very narrow bands and lenses within the quartz biotite schist unit, and is occasionally observed as wider zones of well-banded silicified amphiboles, haloed by bands of pink almandine garnets. Two shear zones were mapped between Bathurst km 102 and 104.5. The shears are comprised of a highly fractured rock with a strong fabric, which displays calc-silicate alteration, visible sulphides and strong rusty oxidation staining. The first zone is at Bathurst km 102 and is 30 m wide, highly friable and weathered; the second shear zone is at Bathurst km 104 and is 15 m wide. The potential for mineralized zones to change width and orientation quickly over short distances was observed in surface outcrop.

No occurrences of soapstone or other materials suitable for carving stone were identified across the 1 km corridor. Significant intervals of overburden void of outcropping bedrock were observed along the proposed road route.

A total of 26 bedrock samples were obtained representing both overall lithologies as well as any rocks displaying evidence of mineralization. Five samples, including one duplicate, displayed visual evidence of mineralization containing either sulphides, or having rusty oxidation staining. The remaining samples are considered to be typical representations of bedrock along the route corridor. Seven samples were taken from igneous intrusives, five from unmineralized meta-sedimentary units, three from diabase dike intrusions, three from granites and one from sedimentary rock. Environmental analysis of bedrock samples included acid base accounting in order to determine if any samples had a potential to generate acid rock drainage (ARD) concerns. Such predictive acid base accounting of samples from proposed rock excavations (i.e. bedrock quarries) has become a best management practice endorsed by regulatory agencies such as the Water Board of the

Northwest Territories and the British Columbia Ministry of Transportation.

Results of the ARD screening assessment determined that 24 of the 26 bedrock samples did not indicate a potential to generate acid. Two of the remaining samples were determined to have an uncertain potential to generate acid as compared to acid base accounting guidelines established by Indian and Northern Affairs Canada (INAC).

Potential quarry sites and road cut localities were established after completion of the field program by Rescan (2007). Rescan's screening of the proposed quarry sites indicated that 4 of the 16 sites were in the vicinity of bedrock sampling locations. Based on the bedrock mapping and ARD screening program it was determined that bedrock in these areas may include lithologies with a potential to generate ARD concerns if excavated. Bedrock samples from the proposed road cut near the port site did not indicate any potential ARD concerns.

It is anticipated that the eventual construction of the Bathurst Port and Road Project will include the implementation of a comprehensive environmental management plan. The plan should incorporate detailed ARD screening of potential bedrock quarries and road cuts thereby allowing project planners to avoid and mitigate (if necessary) potentially negative environmental effects.

3. FIELD INSPECTION AND SAMPLING

3.1 Primary Objective and General Approach

From June 19 to June 23 of 2007, the two authors of this report accompanied Mr. Dick Turner, an independent consultant representing SNC-Lavalin, to the Bathurst Inlet area. Our primary objective was to visually examine and to sample the surficial, exposed materials at:

- proposed rock quarries ("Q" sites),
- proposed granular borrow pits with sand and gravel ("G" sites), and
- the rock at the proposed port site at Bathurst Inlet and the nearby granular cover over the proposed airstrip.

Mr. Dick Turner had prior knowledge of the Q and G sites, and ensured the correct locations were inspected and sampled for environmental geochemistry. Mr. Turner also explained the existing GPS coordinates for the 38 proposed Q and G sites were "reconnaissance" level coordinates. Thus, the locations could be moved. In fact Mr. Turner did move some, hundreds of meters to kilometers, during our field work.

Due to large distances between some sites, Mr. Turner also created new sites, resulting in additional samples. Furthermore, some sites initially labelled "G" for granular were mislabelled and were thus changed to "Q" rock quarries by Mr. Turner. For all sites, Mr. Turner recorded new GPS coordinates, which are included in this report. GPS coordinates for the port site and airstrip were from maps and design drawings provided by Rescan (personal communication).

A list of sites and samples can be found in Table 3-1 and Appendix A. Selected photographs are provided in Appendix B, with more than 200 other photographs archived.

3.2 Sampling of Proposed Rock Quarries ("Q") and Proposed Granular Sites ("G")

At each site, a composite was collected of surficial, exposed rock chips (Q Sites) or granular material (G Sites). Each composite was generally representative of the surficial material within a radius of about 100-300 m of the new GPS coordinate. The visual description of the material, and any visual iron staining, was noted (Appendices A and B).

In some quarries, the abundant vegetation or soil cover did not allow confirmation that the few exposed rocks (called "subcrop" in previous work and thus here also) were actually representative of the deeper rock. In all cases, future drilling should confirm the nature of the deeper material, and deeper samples should be analyzed for comparison to the current analyses of surficial material. This is because surficial observations may not be sufficient to reliably predict any future environmental effects (Morin and Hutt, 2007).

Table 3-1. Proposed Rock Quarries ("Q"), Granular Sites ("G"), and Port-Area Locations (see also Appendices A and B)

Old Designation	New Designation[1]	Dominant Rock Type	EC[2]
	Airstrip #1 (southeastern half)	sand and gravel	NA
	Airstrip #2 (northwestern half)	sand and gravel	NA
	Port #1	sandstone	NA
	Port #2	gabbro	NA
Q1	Q1	not clear	70-120[3]
Q2	Q2	sandstone	20-30
Q3	Q3	sandstone	20-30
Q4	Q4	sandstone	20
G5	G5	sand and gravel	NA
G6	G6	sand and gravel	NA
Q7	Q7	quartzite	60-170
G8 (mislabelled)	Q8	gabbro	20-30
Q9	Q9	quartzite	10-20
Q10	Q10	quartzite	30-160
Q11	Q11	quartzite	10-20
Q12	Q12	quartzite	10-20
Q13	Q13	quartzite	10-20
Q14	Q14	snow covered; ridges showed no rock outcrops	
Q15	Q15	quartzite	10-20
G16	G16	sand and gravel	NA
Q17	Q17	schist	10-20
Q18	Q18	volcanics	NA
G19	G19	sand and gravel	NA
Q20	Q20	volcanics	20-50
Q21	Q21	volcanics	10-40
Q22	Q22	volcanics	10-30
Q23	Q23	granite	10-20

Old Designation	New Designation[1]	Dominant Rock Type	EC[2]
Q24	Q24	granite	10-20
Q25	Q25	granite and gabbro	10-20
G26 (mislabelled)	Q26	granite and gabbro	10
G27	G27	sand and gravel	NA
Q28	Q28	granite	10-30
Q29	Q29	granite	90-120
Q30	Q30	schist	10-20
Q31	Q31	quartzite and granite	10-30
G32	G32	sand and gravel	10-20
Q33	Q33	quartzite and granite	30-110
Q34	Q34A	mixed	100-240
	Q34B	mixed	100
	Q34C	schist	10-30
Q35	Q35	granite and granodiorite	10-20
	Q35A	granite and diorite	10-70
G36	G36	sand and gravel	NA
Q37	Q37	granite and granodiorite	10-30
Q38	Q38	diorite	20-50
	Q39	diorite	20-50
38 SITES	45 SAMPLES		

[1] Sites with the same old and new designations are not necessarily at the same location; many were moved by Mr. Dick Turner; see Appendix A.

[2] Electrical conductivity in µS/cm measured in any puddles, ponds, or rivulets generally within 100-300 m of the new location; NA = no local surface water found.

[3] The elevated conductivity at Q1 was likely due to salt spray from Bathurst Inlet, but baseline water chemistry should be analyzed for confirmation.

Where puddles, ponds, or rivulets were seen (rarely at the granular sites due to relatively high permeability), electrical conductivity in µS/cm was used as a general indication of the reactivity of the surficial material. The higher the conductivity, the higher the assumed reactivity. While conductivities around 10-50 µS/cm were common, values up to 240 µS/cm were found (Table 3-1).

In all cases, background water chemistry should be documented before disturbance and construction with chemical analyses including metals. In this way, any pre-existing elevated levels will not be considered an environmental effect after excavation begins in the future. Also, surficial observations may not be sufficient to reliably predict any future environmental effects (Morin and Hutt, 2007).

3.3 Sampling at the Proposed Port Site and Adjacent Airstrip

Near the proposed port site, the airstrip will be built on granular fill. Two composite samples were collected of the granular fill, representing the southeastern (Airstrip #1) and northwestern (Airstrip #2) halves of the airstrip (Table 3-1 and Appendix B).

At the proposed port site along the shoreline, two surficial samples of rock were collected on the north end. One sample (Port #1) was poorly cemented, or highly weathered, coarse-grained sandstone with gravel, to the east (towards the shoreline) of the prominent gabbro ridge. The second surficial sample (Port #2) was dark grey fine-grained gabbro to basalt, which formed the prominent ridge and rock to the west (away from the shoreline). These same rock types were seen along a 600 m length to the south of these sampling sites.

Based on a few additional outcrops of the same rock, the conglomerate was apparently "plastered" onto relatively fresh surfaces of gabbro. Bedding in the conglomerate was generally lateral, indicating little tectonic disturbance or metamorphism since deposition, and thus likely of relatively recent age. There was little evidence of cross-bedding in the conglomerate. Based on these limited outcrops, the gabbro was apparently quickly eroded by a large, fast-moving river that immediately deposited sand, gravel, and cobbles in a river channel.

In all cases, future drilling should confirm the nature of the deeper material, and deeper samples should be analyzed for comparison to the current analyses of surficial material. This is because surficial observations may not be sufficient to reliably predict any future environmental effects (Morin and Hutt, 2007).

3.4 Laboratory Analyses

The 45 surficial samples of Table 3-1 were submitted to ALS Chemex Labs in North Vancouver for:

1) Chemex Package ABA-PKG05A plus C-IR07, which is standard-Sobek (U.S. EPA 600 compliant) expanded acid-base accounting (ABA; Sobek et al., 1978). This provides measured and/or calculated values of:
   - paste pH in a mixture of pulverized rock and water,

- total sulphur,
- measured sulphide,
- leachable sulphate (both HCl and carbonate leach techniques),
- calculated sulphide by subtracting sulphate from total sulphur,
- barium-bound sulphate calculated from barium analyses,
- calculation of acid potentials based on sulphide levels plus any unaccounted-for sulphur (Sulphide Acid Potential, SAP),
- standard-Sobek neutralization potential (NP) by acid bath and base titration,
- inorganic carbonate for mathematical conversion to Carbonate NP (Inorg CaNP),
- total carbon for mathematical conversion to Carbonate-equivalent NP (Total CaNP),
- CaNP calculated from calcium (Ca CaNP),
- CaNP calculated from Ca + Mg (Ca+Mg CaNP),
- various Net Neutralization Potential (NNP) balances of acid neutralizing capacities minus various acid generating capacities, and
- various Net Potential Ratio (NPR) balances of acid neutralizing capacities divided by various acid generating capacities.

2) total-element contents by:

- Chemex Package ME-MS61m: 49-element analysis after strong four-acid digestion, and
- Chemex Package ME-XRF-06: XRF (x-ray-fluorescence) whole rock for 14 elements and parameters.

ABA and total-element results are compiled in Appendix A and are discussed in Chapter 4.

4. RESULTS OF GEOCHEMICAL ANALYSES

4.1 ARD Potential

As explained in Section 3.4, the 45 surficial samples of rock or granular material (Appendices A and B) were submitted for expanded standard-Sobek (U.S. EPA 600) acid-base accounting (ABA). Expanded ABA includes more than a dozen measured and calculated parameters. These can be combined into four headings: paste pH (Section 4.1.1), sulphur species (Section 4.1.2), neutralization potentials (Section 4.1.3), and net balances of acid-generating and acid-neutralizing capacities (Section 4.1.4).

4.1.1 Paste pH

Paste pH was measured in a mixture of deionized water and pulverized sample after relatively short equilibration times. Any sample with an acidic paste pH below 6.0 was thus already generating net acidity at the time of analysis. Any sample with a near-neutral paste pH may or may not produce net acidity in the future.

All 45 surficial samples had near-neutral to alkaline paste pH values (6.8 to 8.6, Figure 4-1 and Appendix A). Therefore, no samples were net acid generating at the time of analysis.

4.1.2 Sulphur Species

Possible sulphur species that could be found in the samples included: sulphide including acid-generating iron-bearing sulphide minerals (Section 4.3), leachable sulphate, non-leachable sulphate, organic sulphur, and elemental sulphur. The sum of these species theoretically equals total sulphur, although analytical inaccuracy rarely yields an exact mass balance.

Total sulphur in the 45 samples of Table 3-1 ranged from <0.01%S (numerically set at 0.005%S for graphics and calculations) to 0.12%S (Figures 4-1 and 4-2). The Q rock-quarry sites typically had the highest total-sulphur levels. However, one G granular site (G33) also had a relatively elevated sulphur level of 0.06%S.

The linear “bands” of datapoints seen in Figures 4-1 and 4-2 represent rounding of the analytical results. For example, the lowest, discrete values were 0.005%S (same as <0.01%S), 0.01%S, 0.02%S, and 0.03%S, creating vertical or horizontal bands of datapoints.

Most of the samples were close to the detection limit where analytical inaccuracy is typically high, so the actual sulphur contents of many samples are not well known. This is discussed in more detail below and in Section 4.3.

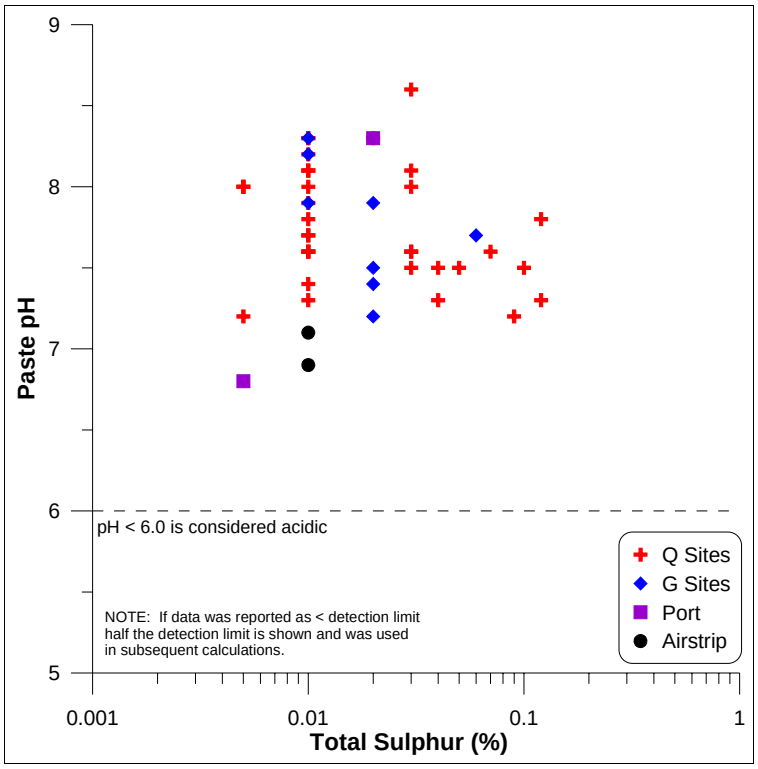

Figure 4-1. Paste pH vs. Total Sulphur in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

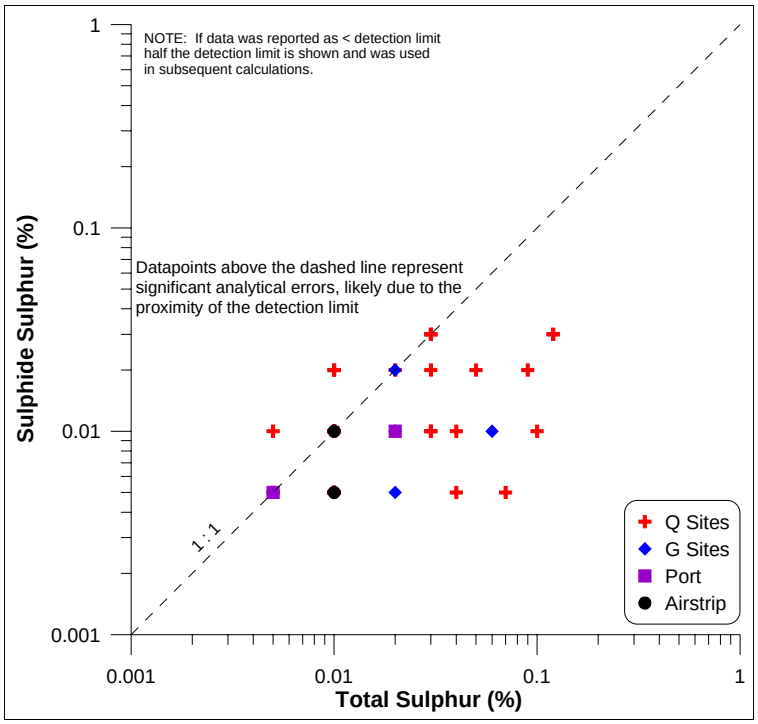

Figure 4-2. Sulphide vs. Total Sulphur in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

Sulphide is the sulphur species that is typically linked to acid generation and ARD. Sulphide in the 45 samples ranged from <0.01%S (numerically set at 0.005%S) to 0.03%S (Figure 4-2 and Appendix A). For the few samples sufficiently above detection (total sulphur above ~0.04%S), sulphide was not the dominant form of total sulphur, whereas at lower values the detection limit precluded a reliable comparison.

Other sulphur species, like HCl-leachable sulphate (Figure 4-3) and calculated barium-bound sulphur (Figure 4-4), may be significant in at least some samples. However, datapoints above the dashed lines in these figures already represent significant errors in analyses close to the detection limit or related calculations.

A mass-balance equation for sulphur species is:

$$\%S(del_{actual}) = \%S(Total) - \%S(Sulphide) - \%S(HCl\text{-}leachable\ sulphate) - \%S(BaSO_4)$$

Large negative values of $\%S(del_{actual})$ indicate the sum of sulphur species exceeds the measured total sulphur, sometimes due to analytical inaccuracy and detection limits. Large positive values indicate either (1) total sulphur was overestimated or (2) one or more sulphur species were underestimated. In this case, positive values (missing sulphur) can be considered acid-generating sulphide for safer calculations.

For the 45 samples, the mass imbalance was typically large and negative (below the lower dashed line in Figure 4-5), with the sum of species typically exceeding 25% of total sulphur. Five samples also had greater than 25% more total sulphur than sulphur species (above the upper dashed line in Figure 4-5). Therefore, only 7 of the 45 samples had good mass balances of sulphur species and thus passed the QA/QC check. Again, this large failure rate was due mostly to values close to or below the analytical detection limits.

In summary, most sulphur analyses and species in the 45 surficial samples were close to or below analytical detection, with relatively high analytical inaccuracy. As a result, the sulphide levels and the resulting Acid Potentials could not be reliably estimated for most samples, although mineralogy confirmed the presence of trace amounts of potentially acid-generating sulphide minerals (Section 4.3). Predictions of ARD potential must recognize the uncertainty near the detection limit, which is simply a human artifact and not a criterion of environmental protection.

4.1.3 Neutralization Potentials

There are various types of neutralizing capacities in rock samples, all expressed in units of kg $CaCO_3$ equivalent/tonne (kg/t). These include:

(1) short-term U.S. EPA-compliant Sobek "bulk neutralization potential" (NP) based on an hours-long acid bath to determine how much acid was neutralized in the short term,

(2) carbonate-equivalent neutralization potential (CaNP) calculated from measured solid-phase levels of inorganic carbonate (Inorg CaNP) or total carbon (Total CaNP), and

(3) calculated CaNP assuming all calcium occurs as calcite (Ca CaNP) or all calcium + magnesium occurs as dolomite (Ca+Mg CaNP).

Each can reveal important aspects of a sample's capacity to neutralize the acidity generated by sulphide oxidation, and all values in this study are compiled in Appendix A.

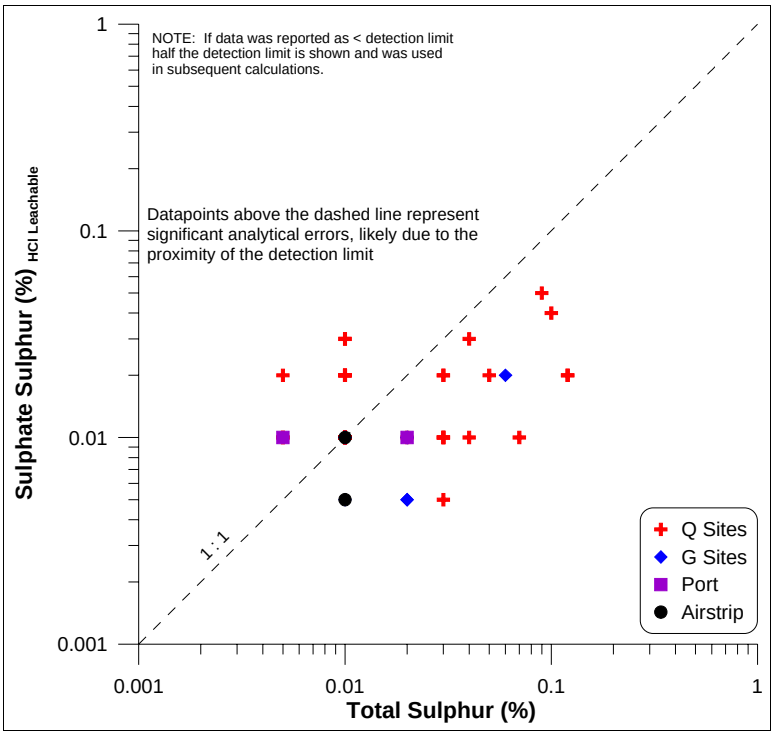

Figure 4-3. HCl-Leachable Sulphate vs. Total Sulphur in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

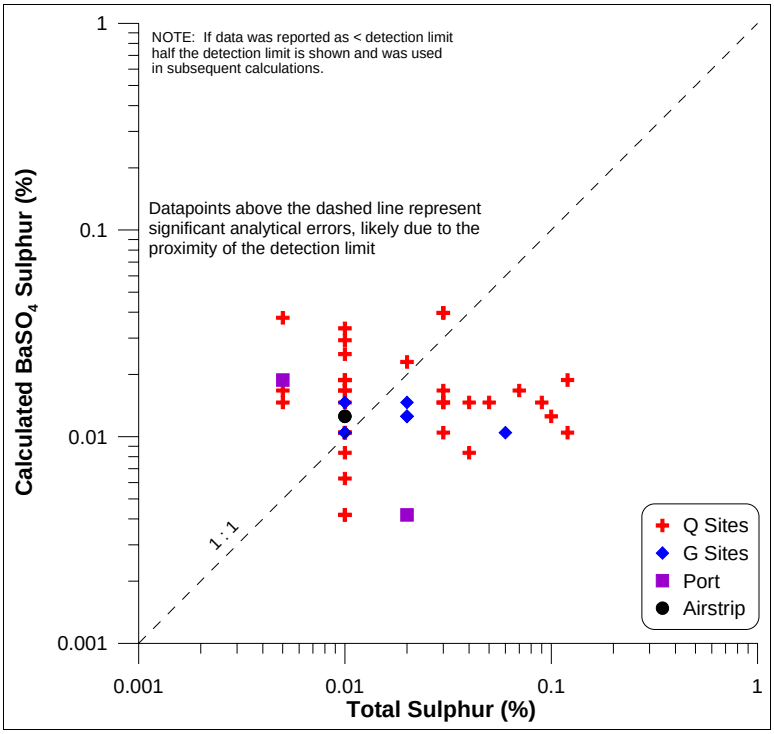

Figure 4-4. Calculated Barium-Bound Sulphur vs. Total Sulphur in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

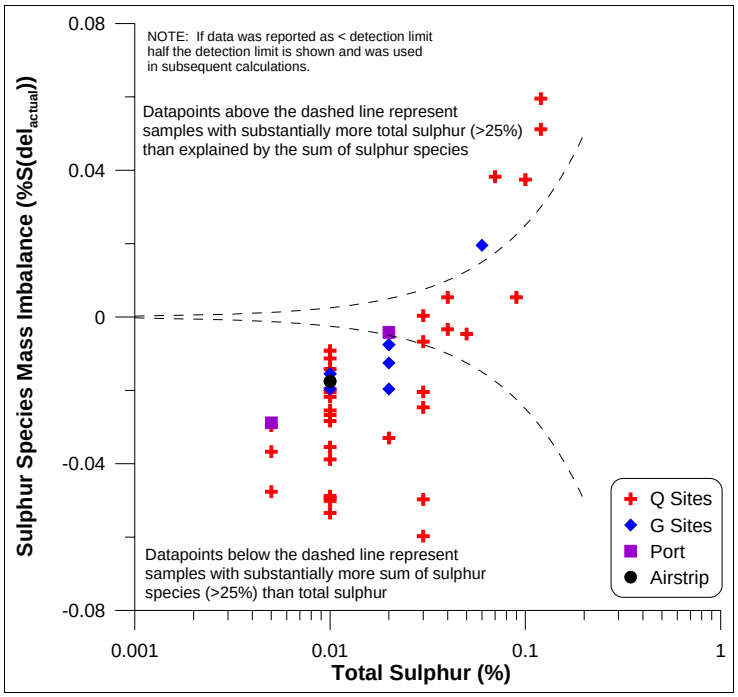

Figure 4-5. Calculated Mass Imbalance of Sulphur vs. Total Sulphur in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

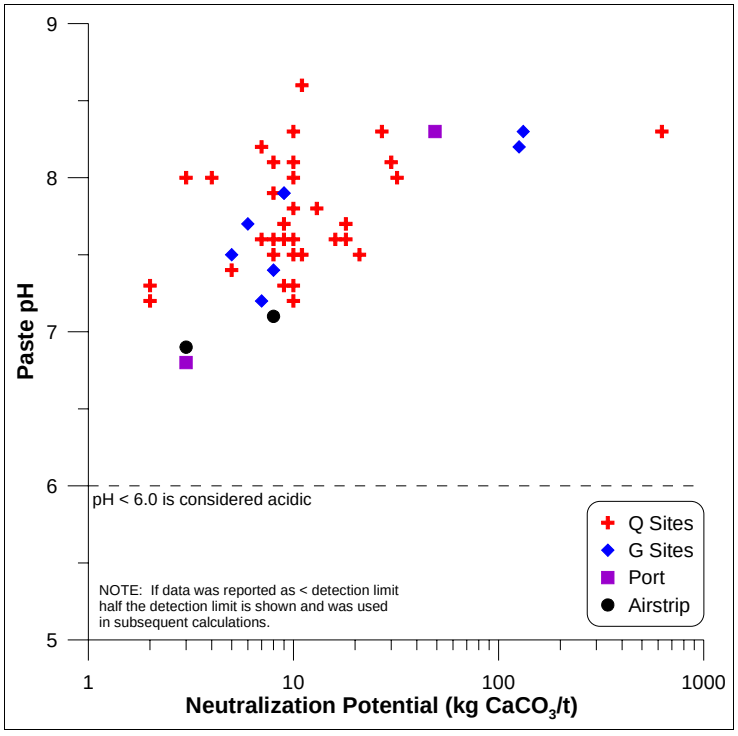

Figure 4-6. Paste pH vs. Sobek Neutralization Potential in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

Short-term Sobek bulk NP (Sobek et al., 1978) in the 45 samples ranged from 2 to 625 kg $CaCO_3$ equivalent/tonne (Figure 4-6). Most samples had an NP of 10 kg/t or lower, which is minimal neutralizing capacity. The highest NP of 625 kg/t was obtained from surficial rock at proposed rock-quarry Site Q7 (Appendix A), with nearby G5 and G6 being the only other samples with NP above 100 kg/t. Such spatial trends in ABA parameters are discussed further in Section 4.4.

An important issue with NP is the amount that is typically "unavailable" for neutralization, although it may still be detected in the laboratory analysis. The delineation of site-specific unavailable NP, which is typically around 5-15 kg/t (Morin and Hutt, 1997 and 2001), can require long-term kinetic testing. However, a rough estimate can sometimes be obtained from a scatterplot like Figure 4-6, showing paste pH falling towards acidic values below a certain NP value. However, no acidic paste pH values were measured in the 45 samples, but paste pH approached 7 and below at NP levels below 10 kg/t. Therefore, for the 45 samples, two cases will be considered. First, unavailable NP is zero, so absolutely all measured NP is available. Second, unavailable NP is 10 kg/t. As shown in Section 4.1.4, this range of unavailable NP has major effects on ARD predictions for many samples.

A scatterplot of bulk Sobek NP with the calculated inorganic-carbon-based NP ("Inorganic CaNP") showed that many samples did not contain detectable inorganic carbon (the horizontal band in Figure 4-7). This meant their NP was not derived from fast-neutralizing carbonate minerals, but likely from slower-reacting aluminosilicate minerals (see also Section 4.3).

For those samples with detectable inorganic carbon, the correlation with the 1:1 line in Figure 4-7 indicated the Sobek NP in those samples was probably related to fast-neutralizing carbonate minerals. A further correlation of these carbonate-bearing samples with calcium-based NP (Ca CaNP, Figure 4-8) suggested the carbonate was mostly fast-reacting calcite ($CaCO_3$), rather than dolomite or other forms of carbonate minerals. This was confirmed for high-NP Sample Q7 by mineralogical x-ray diffraction (Section 4.3).

In summary, the bulk Sobek Neutralization Potential (NP) in many surficial samples was relatively low, below 10 kg/t. Unavailable NP, which is the portion detected in the laboratory but not readily reactive, could not be resolved with current information. However, a range of 0 to 10 kg/t may be appropriate for unavailable NP in this study, meaning most samples contained little to no available and reactive NP. The Sobek NP in many samples was apparently composed of slow-reacting aluminosilicate minerals, but the NP in the remaining samples was probably fast-neutralizing calcite ($CaCO_3$).

4.1.4 Net Balances of Acid-Generating and Acid-Neutralizing Capacities

The acid-generating capacities of the 45 samples were calculated from measured sulphide (Section 4.1.2), to obtain Sulphide Acid Potentials (SAP, Appendix A). As explained in Section 4.1.2, sulphide and total sulphur were often close to or below detection and thus not accurate.

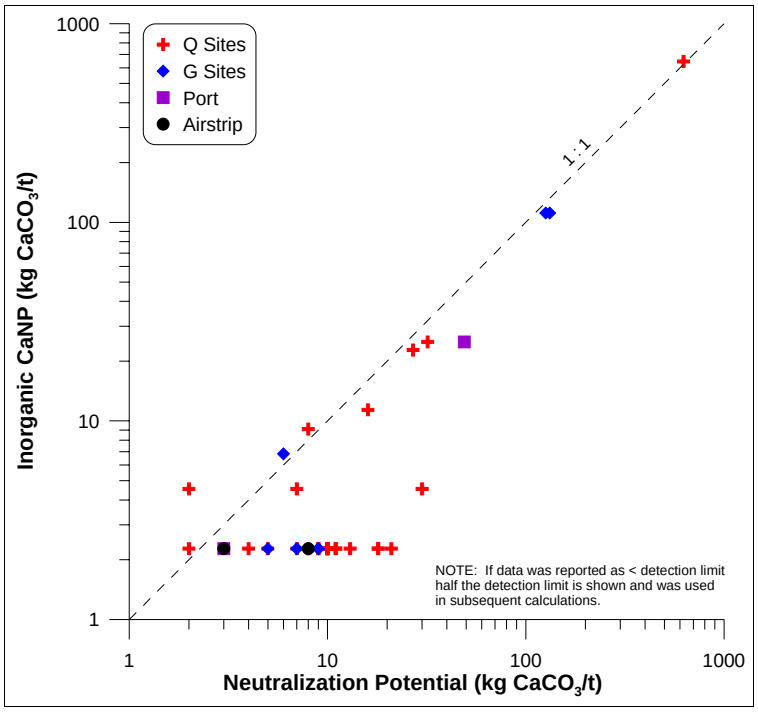

Figure 4-7. Inorganic-Carbon-Based Neutralization Potential vs. Sobek Neutralization Potential in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

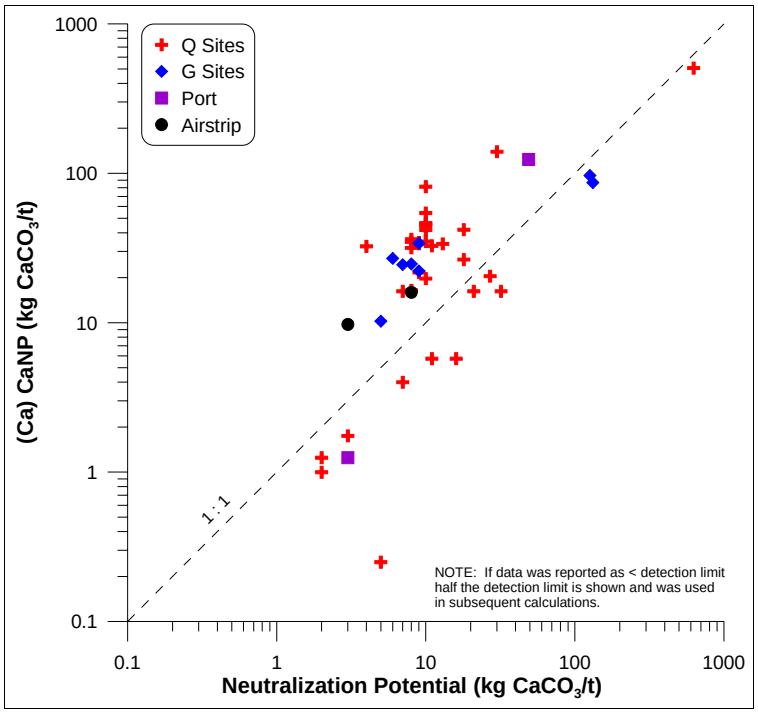

Figure 4-8. Calcium-Based Neutralization Potential vs. Sobek Neutralization Potential in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

Neutralization Potentials were discussed in Section 4.1.3. Not all measured NP was necessarily available and reactive, so 0 or 10 kg/t was subtracted from measured values. Net balances of these two potentials were calculated to predict whether a sample would be net acid generating, perhaps after a long near-neutral "lag time", or net acid neutralizing indefinitely. Net balances can be calculated using division (Sulphide-Based Net Potential Ratio, SNPR = NP / SAP) or subtraction (Sulphide-Based Net Neutralization Potential, SNNP = NP - SAP). SNPR is used here.

"Unadjusted" and "Adjusted" SNPR values were obtained by first subtracting 0 or 10 kg/t of unavailable NP, respectively, from measured NP (Section 4.1.3):

SNPR (unadjusted) = [NP - 0] / [%S(sulphide) * 31.25]

Adjusted SNPR = [NP - 10] / [%S(sulphide) * 31.25]

Generic non-site-specific ABA screening criteria are: SNPR < 1 is net acid generating, perhaps after some lag time, $1 \leq SNPR \leq 2$ is uncertain until further testing, and SNPR>2 is net acid neutralizing. For this report, any Unadjusted or Adjusted SNPR less than 2.0 was considered net acid generating, perhaps after some lag time. The implications of using an alternative criterion of 1.0 are discussed below.

Unadjusted SNPR (with all measured NP available and an unavailable NP of zero as the "best case") indicated all samples (100%) were net neutralizing (SNPR > 2.0) and none were net acid generating (Figure 4-9). This included a default value of 200.0 (see the vertical band at SNPR = 200 in Figure 4-9), which represented samples whose sulphide was less than detection. Still, the substantial uncertainty in sulphur analyses (Section 4.1.2) means this observation of 100% net-neutralizing samples has substantial uncertainty.

In stark contrast, Adjusted SNPR (with an unavailable NP of 10 kg/t) indicated many samples (24 samples, or 53%) were net acid generating (Adj SNPR < 2.0, Figure 4-10). This was primarily due to many samples having a measured NP less than 10 kg/t (Figure 4-6), which was reduced to zero by the unavailable NP value. A criterion of 2.0 vs. 1.0 would affect the status of only one sample, which is not significant, so a criterion of 2.0 is retained here. Nevertheless, the substantial uncertainty in sulphur analyses (Section 4.1.2) means the observation of 47% net-neutralizing samples has substantial uncertainty.

In summary, net balances of acid-generating and acid-neutralizing capacities indicate roughly 0% to 50% of the 45 surficial samples were net acid generating and might release ARD, when compared with non-site-specific generic criteria. In turn, 50-100% of the samples were predicted to be net neutralizing indefinitely. However, the uncertainties in sulphur analyses that were close to detection, and in the applicable value of unavailable NP, substantially increased the uncertainty in the percentages of surficial samples that could generate ARD.

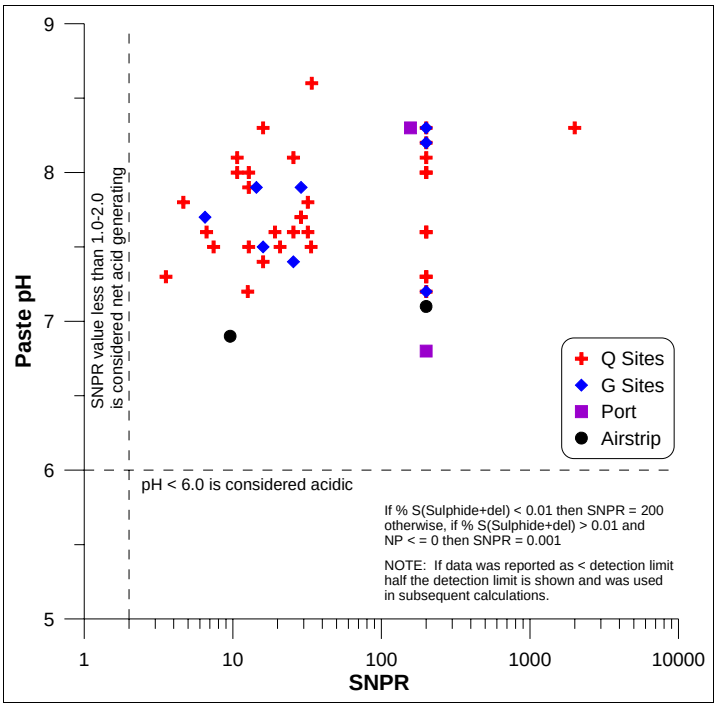

Figure 4-9. Paste pH vs. Unadjusted Sulphide Net Potential Ratio (SNPR) in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

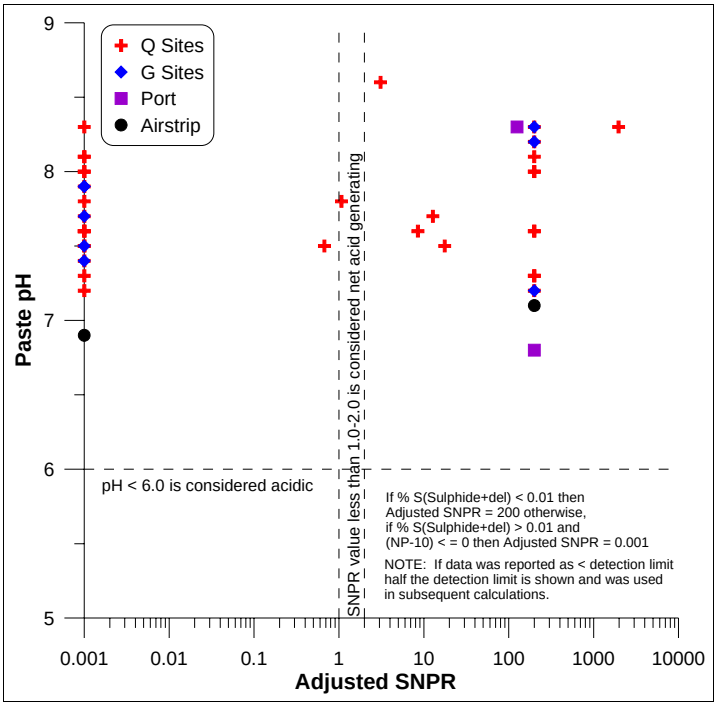

Figure 4-10. Paste pH vs. Adjusted Sulphide Net Potential Ratio (Adj SNPR) in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

4.2 Total-Element Analyses and Metal Leaching Potential

Independent of any capacity to release acidic or near-neutral drainage (Section 4.1), various metals and other elements can leach from rock and sand-gravel at the proposed Q rock-quarry sites, G granular sites, port area, and airstrip. However, the prediction of such leaching requires long-term tests (which are currently underway), and does not necessarily reflect solid-phase levels. For example, an element may have a high solid-phase level simply because it did not leach quickly. Nevertheless, solid-phase levels are a first step in assessing the potential for metal leaching.

Total-element levels in the 45 samples (Table 3-1) were measured by ICP analysis after strong four-acid digestion and by x-ray-fluorescence whole-rock analysis (Section 3.4). The results are compiled in Appendix A. These are not directly comparable to previous road-alignment analyses (Rescan, 2007, and Section 4.4), because the road samples were only partially dissolved in a weaker acid combination.

Overall, the dominant elements in many samples were silicon and aluminum (expressed as SiO_2 and Al_2O_3 in Appendix A). However, these were reduced in high-carbonate Sample Q7, and replaced by calcium and LOI (loss On Ignition) due to its predominant calcite content. Iron, potassium, magnesium, calcium, and sodium were also significant in many samples, probably occurring as various aluminosilicate minerals (Section 4.3).

To identify the metals and other elements occurring at relatively high levels in the rock, each level was compared with average maximum crustal abundances. Any level at least three times greater than average maximum crustal abundance was highlighted with a box in Appendix A.

This showed that elements commonly above crustal abundance were bismuth and selenium. Of these two, bismuth is not currently considered a water-quality issue, but selenium can be if leached at sufficient concentrations. Elevated levels were rarely found for cesium (Sample Q30), lithium (Sample Q30), and thorium (Q37 and Q39). Of these, only thorium is currently recognized as a potential water-quality issue.

Solid-phase correlations of elements can sometimes reveal mineralogical associations. For example, elements correlating with sulphide presumably occur within the sulphide minerals. Correlations with Neutralization Potential (NP) indicate those elements may be concentrated in carbonate or aluminosilicate minerals.

No elements correlated well with sulphide, probably because sulphide was so low, near detection, and relatively inaccurate (Section 4.1.2).

Elements that showed some correlation with NP included calcium (due to the presence of calcite in some samples), cobalt, copper, indium, iron, magnesium, manganese, nickel, niobium, scandium, tantalum, tin, titanium, vanadium, and yttrium (e.g., Figures 4-11 to 4-14). This suggested that the leaching of metals and other elements from these 45 samples could be related to dissolution of Neutralization Potential, rather than sulphide oxidation, upon disturbance. NP can be dissolved by rainwater and snowmelt.

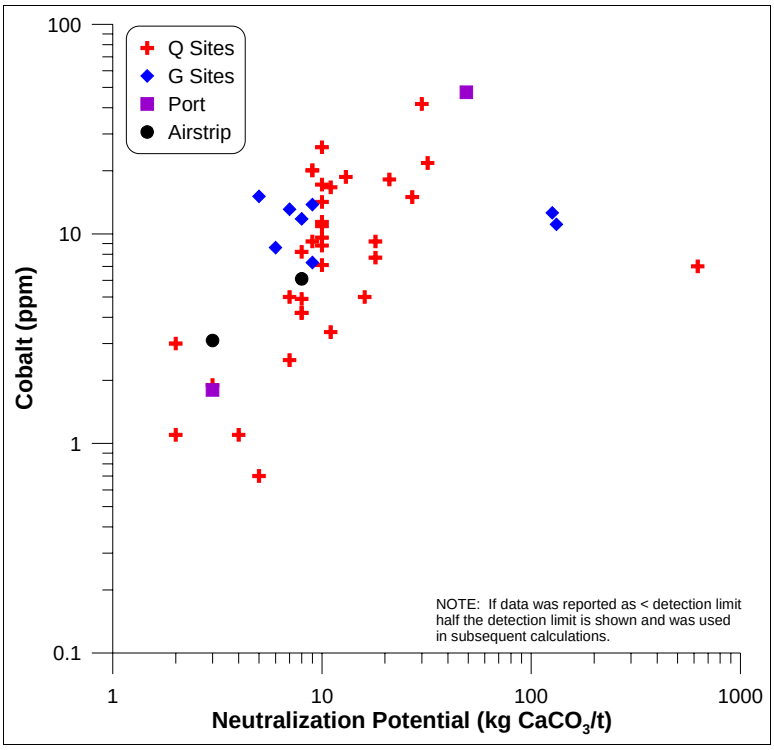

Figure 4-11. Solid-Phase Cobalt vs. Sobek Neutralization Potential in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

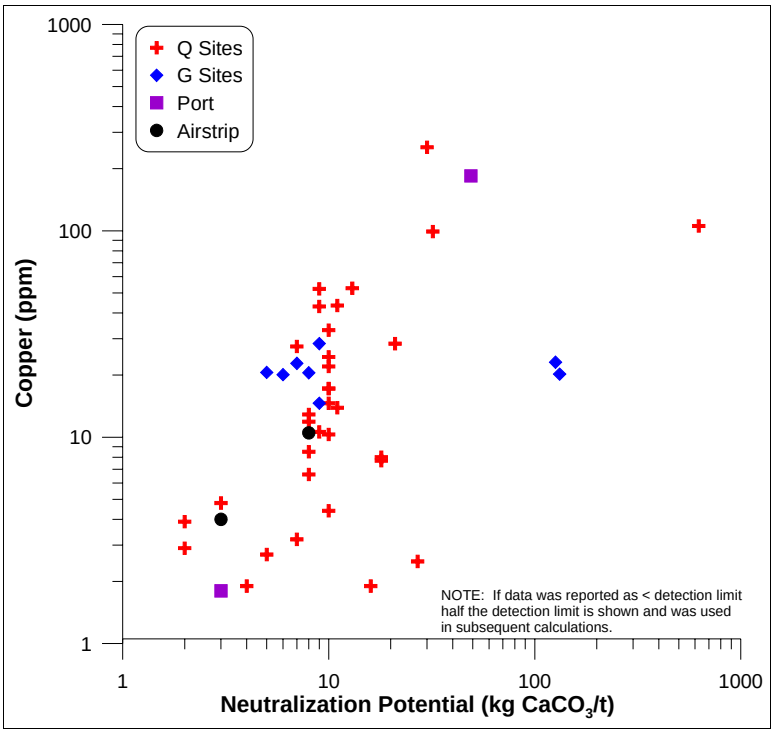

Figure 4-12. Solid-Phase Copper vs. Sobek Neutralization Potential in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

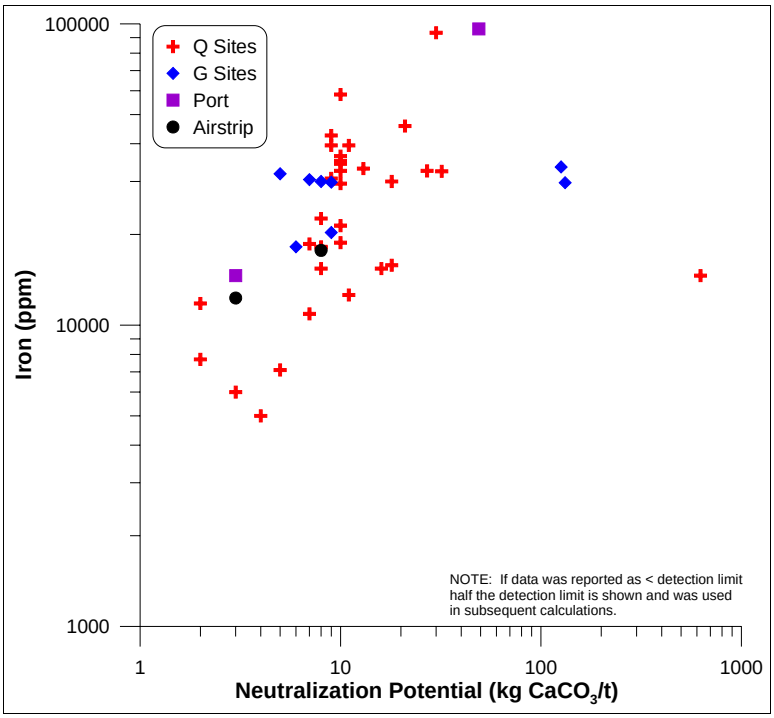

Figure 4-13. Solid-Phase Iron vs. Sobek Neutralization Potential in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

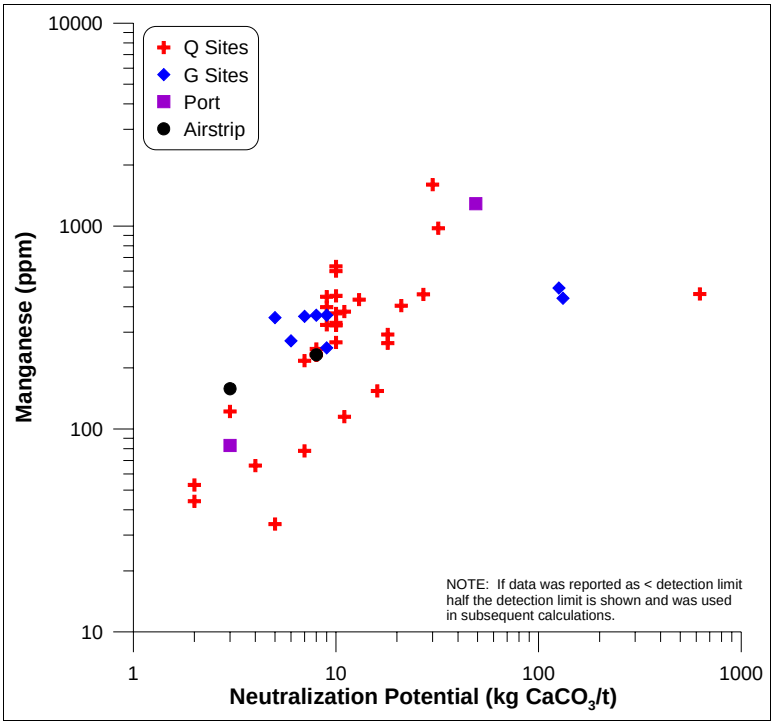

Figure 4-14. Solid-Phase Manganese vs. Sobek Neutralization Potential in the 45 Samples from Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

In summary, total-element analyses of the 45 surficial solid-phase samples were the first step in predicting the leaching of metals and other elements into water. These analyses showed that most samples were composed of aluminum and silicon, with the high-NP samples containing much less due to their high carbonate content. Iron, potassium, magnesium, calcium, and sodium were also significant in many samples. Trace elements frequently above maximum crustal abundance were bismuth and selenium, while cesium, lithium, and thorium were above crustal abundance only in one or two samples. All others were more typical of crustal abundance, but could still leach at high concentrations if very reactive. Correlations suggested leaching of metals and other elements could be more closely related to simple dissolution of Neutralization Potential, rather than sulphide oxidation, upon disturbance at the Q Sites, G Sites, port, and airstrip.

4.3 Mineralogy of Selected Samples

As a general indication of mineralogy, two of the 45 surficial samples from Table 3-1 were examined petrographically (PET) and analyzed by Rietveld x-ray diffraction (XRD, Table 4-1 and Appendix C). The samples were Q7, with the highest measured NP (Section 4.1.3) and composed mostly of carbonate, and Q34A, with a relatively low NP and inorganic carbonate below the detection limit of approximately 0.5% as $CaCO_3$.

Consistent with the sulphide values close to detection at 0.01%S (Section 4.1.2), samples contained trace amounts of one or both potentially acid-generating sulphides minerals of chalcopyrite and pyrrhotite based on petrography (Table 4-1). The implicit detection limit of XRD around 0.1 wt-% did not detect these sulphide minerals.

The carbonate in Sample Q7, as dominant calcite and lesser dolomite, added up to about 65 wt-% and 82 vol-%. This was close to the NP and Inorganic CaNP around 640 kg/t (64 wt-%). The minor carbonate in Sample Q34A was also calcite. This dominance of calcite over dolomite was consistent with ABA results (Section 4.1.3).

The non-carbonate minerals, which comprised most of Sample Q34A, were predominantly quartz, with variable amounts of other, aluminosilicate minerals (Table 4-1). These aluminosilicate minerals can provide some slow-reacting neutralization, and thus account for the minor but detectable amount of NP in Sample 34 A and other samples with little carbonate (Section 4.1.3).

4.4 Spatial Distributions of ABA Parameters and Total Solid-Phase Elements

The preceding sections provided an overall interpretation of the 45 samples for ABA (Section 4.1) and total elements (Section 4.2). That highlighted issues, important parameters, and elements of potential concern. This section looks spatially at selected parameters and elements, looking for particular geochemical zones among the proposed Q rock-quarry Sites, the G granular Sites, the port area, and the airstrip. This section also compares the analyses for these sites to those directly on the road alignment ("Road Sites" from Rescan, 2007) within 5 km. However, the partial-digestion procedure used by Rescan (2007) precludes a reliable comparison for several elements.

Table 4-1. Summary of Mineralogical Examinations on Two Q Samples (values in wt-% and vol-%, see also Appendix C)

Mineral	Ideal Formula	Sample Q7 (in %)[1]		Sample Q34A (in %)[1]	
		XRD	PET	XRD	PET
Quartz	SiO_2	12.9	15	44.5	25
Plagioclase	$NaAlSi_3O_8$ - $CaAl_2Si_2O_8$	4.1		35.7	55
K-feldspar	$KAlSi_3O_8$	4.3			
Muscovite/ sericite	$KAl_2AlSi_3O_{10}(OH)_2$	8.0	2	4.3	2
Biotite		0.8	trace	12.2	17
Clinochlore	$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$	4.7		2.8	
Unspecified carbonates			82		trace
- Dolomite	$CaMg(CO_3)_2$	19.4			
- Calcite	$CaCO_3$	45.9		0.4	
Actinolite ?	$Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$			0.1	
Sillimanite	Al_2SiO_5				1
Rutile	TiO_2		trace		
Chalcopyrite	$CuFeS_2$		trace		trace
Pyrrhotite	FeS				trace
Iron oxides	Fe_2O_3				trace
TOTAL		100.0		100.0	

[1] XRD = x-ray-diffraction result in weight-%, Appendix C1; PET = petrographic results in volume-%, Appendix C2

For example, Section 4.1.1 explained that paste pH was typically above 7.0 with only a few close to or below 7.0 (Figure 4-1). Spatially, the lowest values were found near Bathurst Inlet, at the proposed port and airstrip (circles as datapoints in Figure 4-15). In comparison, Rescan (2007) found the lowest paste pH values on the road alignment close to Q22, which included Road Sites 19 to 22 (diamonds as datapoints in Figure 4-15).

Also, higher total-sulphur levels in this study were generally found in the vicinity of Q17-Q22 and G33-Q39 (Figure 4-16). Similarly, Rescan (2007) reported higher acid-generating sulphide at the road in the vicinity of these same Q and G Sites (Figure 4-17), but the sulphide levels at the road exceeded those of the Q and G Sites. Nevertheless, this suggests significant lengths of the road and the rock or gravel on either side can contain detectable sulphide.

Neutralization Potential showed similar correlations among the Road Sites and the Q and G Sites (Figure 4-18), with the highest values found around G5 to Q7. This was also seen with Inorganic CaNP (Figure 4-19), which represents the amount of inorganic carbonate (Section 4.1.3). These trends suggest a geological zone with elevated carbonate and neutralizing capacity around G5 to Q7 that could be used to offset ARD potential in other zones if necessary.

For the net balances of acid-generating and acid-neutralizing capacities (Section 4.1.4), both Unadjusted SNPR and Adjusted SNPR showed a large zone from Q23 to Q39 with the greatest ARD potential (Figures 4-20 and 4-21). Nevertheless, some ARD potential exists sporadically from the proposed port to Q23.

As explained above, the Road samples were digested in a weaker acid solution, so total elements from the Road Sites can be lower for many elements than for the current 45 samples. This was seen for aluminum (Figure 4-22), which is one of the dominant elements in the rock and sand-gravel (Sections 4.2 and 4.3). For the 45 samples from this study only, solid-phase aluminum was generally consistent among all locations, particularly above Q17 where carbonate was rarer.

Other elements like arsenic, calcium, cobalt, copper, and iron generally showed more overlapping ranges among the 45 samples and the Road samples (Figures 4-23 to 4-27), meaning the partial digestion for the road samples did not substantially affect these results. Other elements like cadmium had higher detection limits at the Road Sites (see horizontal line of diamonds in Figure 4-28), so comparisons could not be made.

Some elements showed spatial geochemical zoning like the ABA parameters. For example, solid-phase copper (Figure 4-26) and zinc (Figure 4-29) were highly variable, among the highest and lowest values, around the port and up to Q8. They became consistently low from Q11 to Q15, and then were generally moderate but variable to Q39. Because solid-phase levels are not direct predictors of leaching rates into water, it is not clear if these solid-phase trends will reflect aqueous concentrations after disturbance.

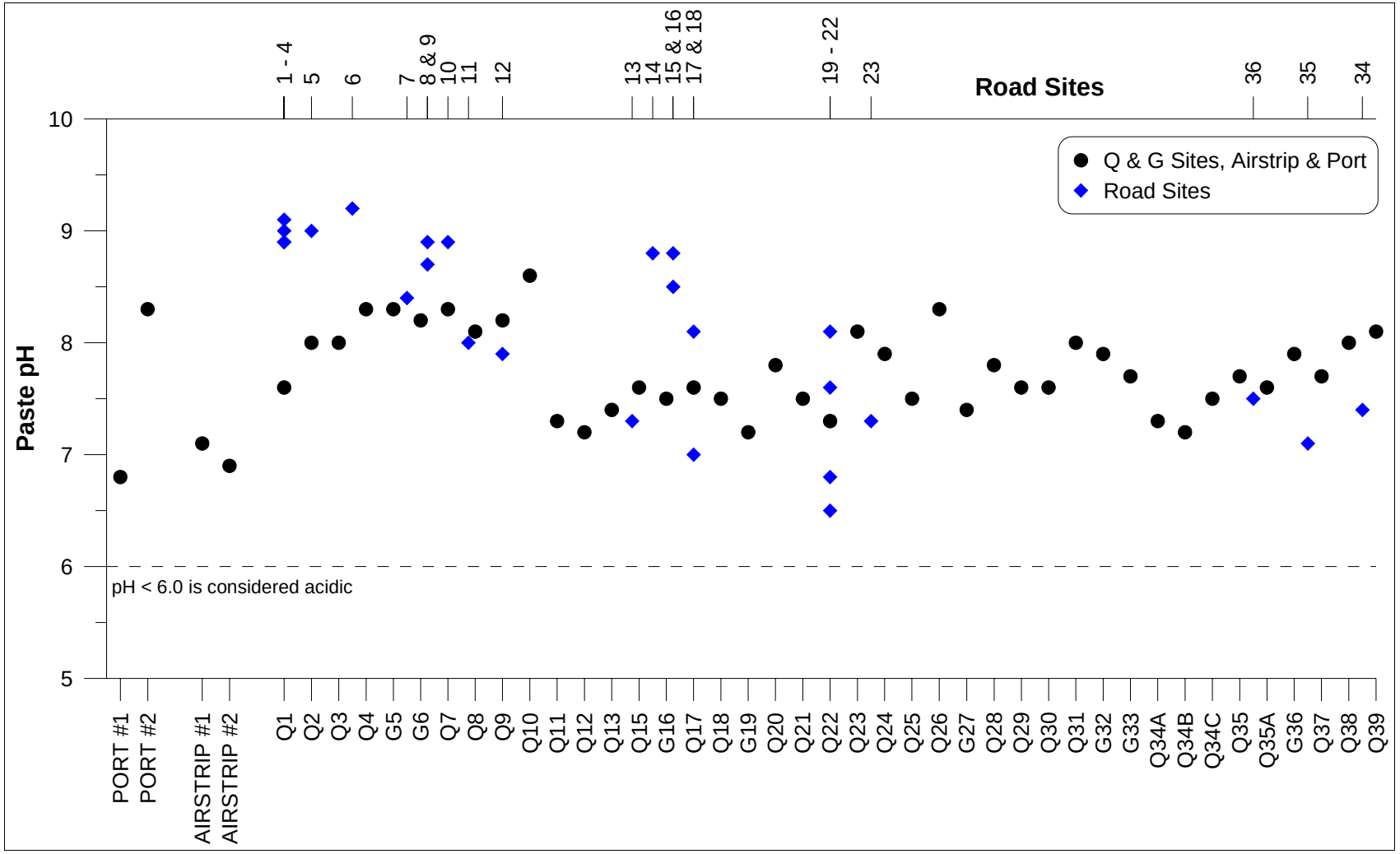

Figure 4-15. Spatial Distribution of Paste pH among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

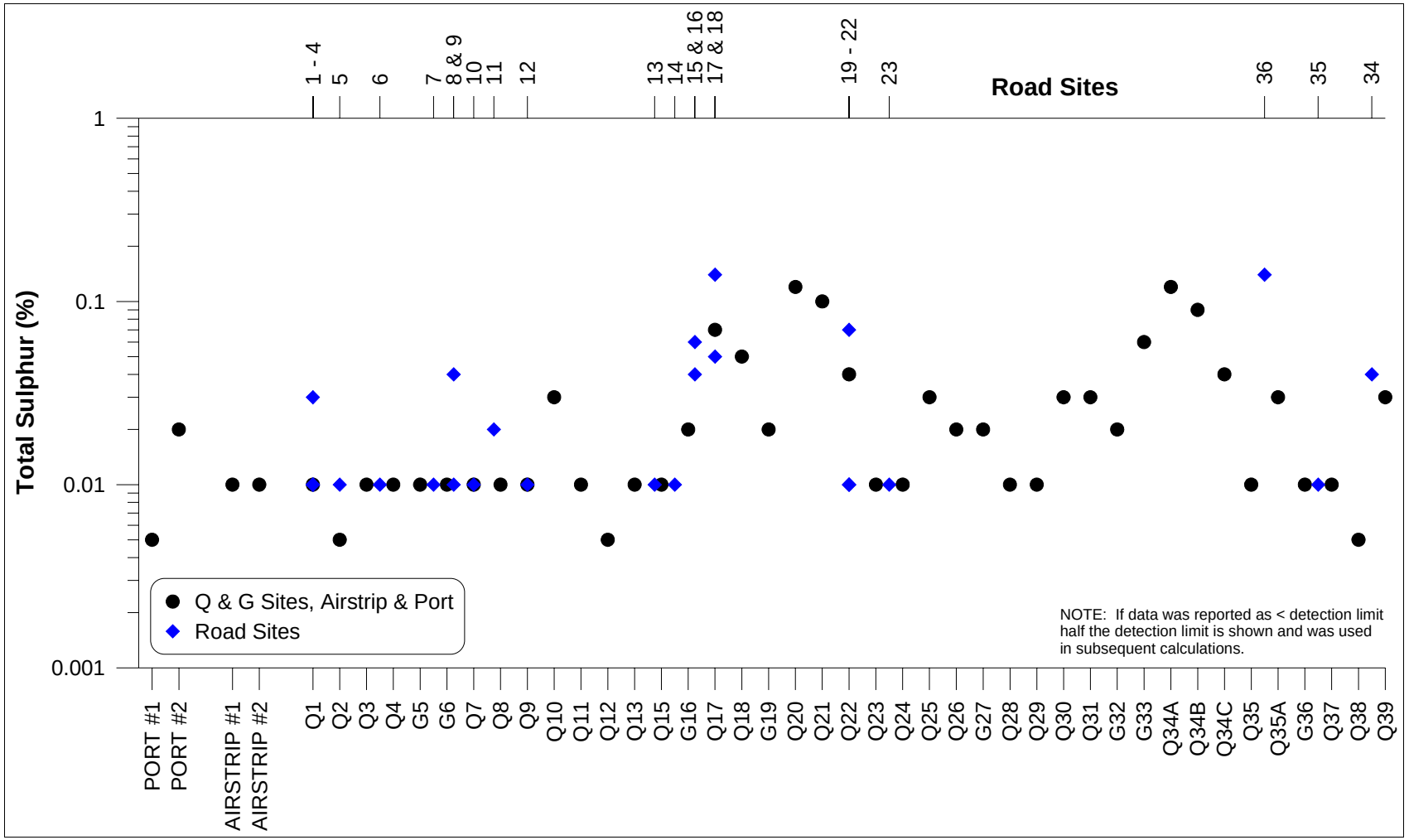

Figure 4-16. Spatial Distribution of Total Sulphur among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

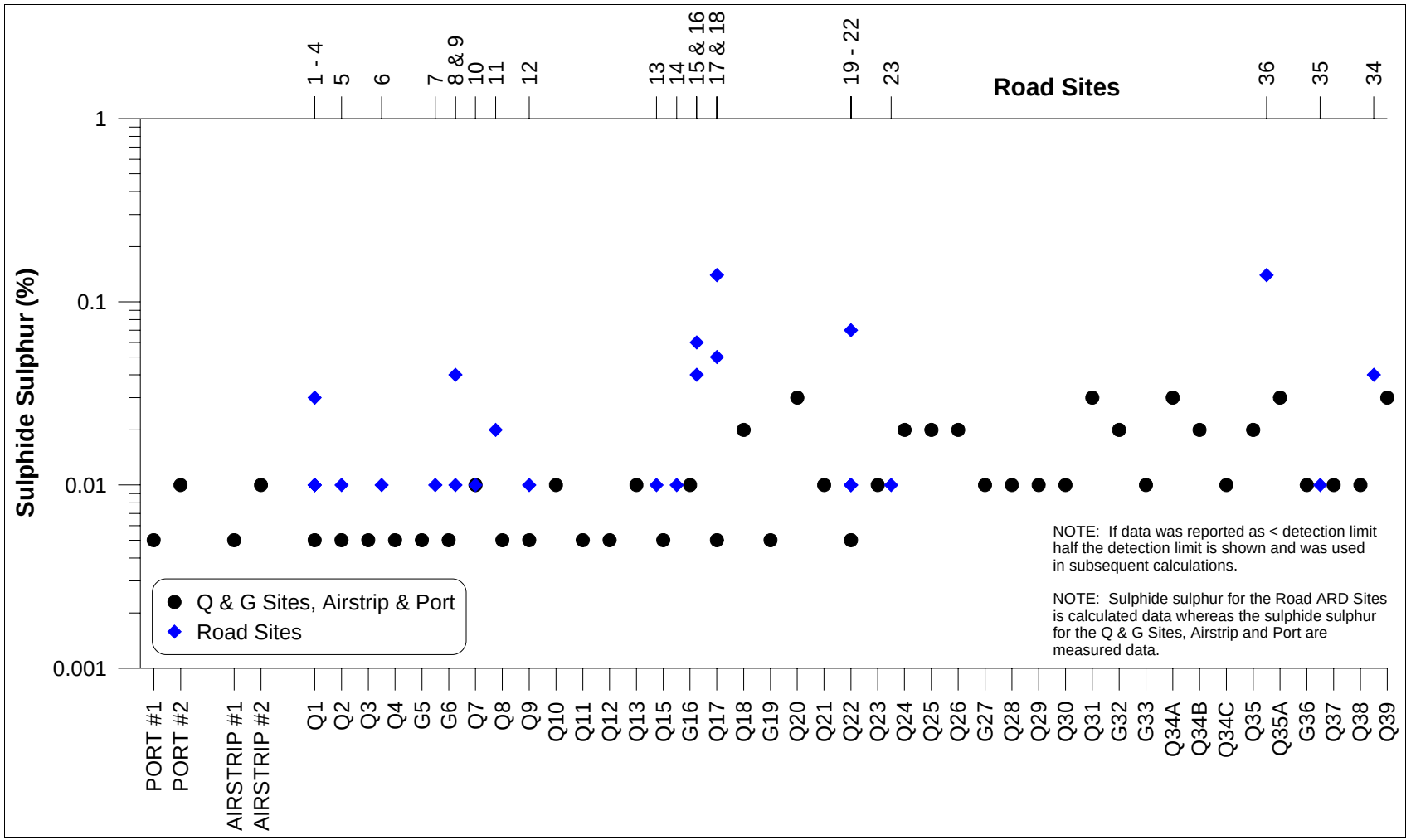

Figure 4-17. Spatial Distribution of Sulphide among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

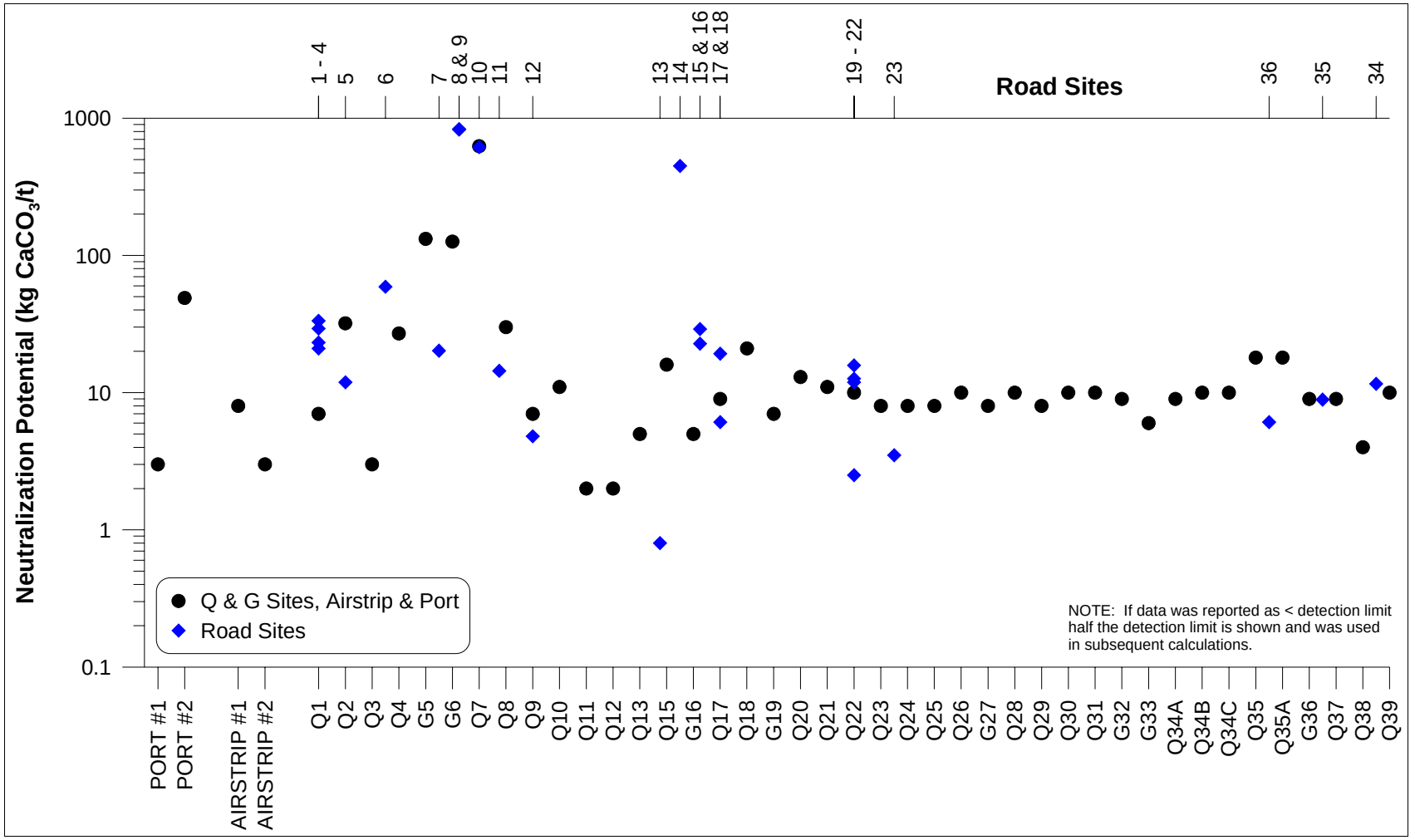

Figure 4-18. Spatial Distribution of Sobek Neutralization Potential among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

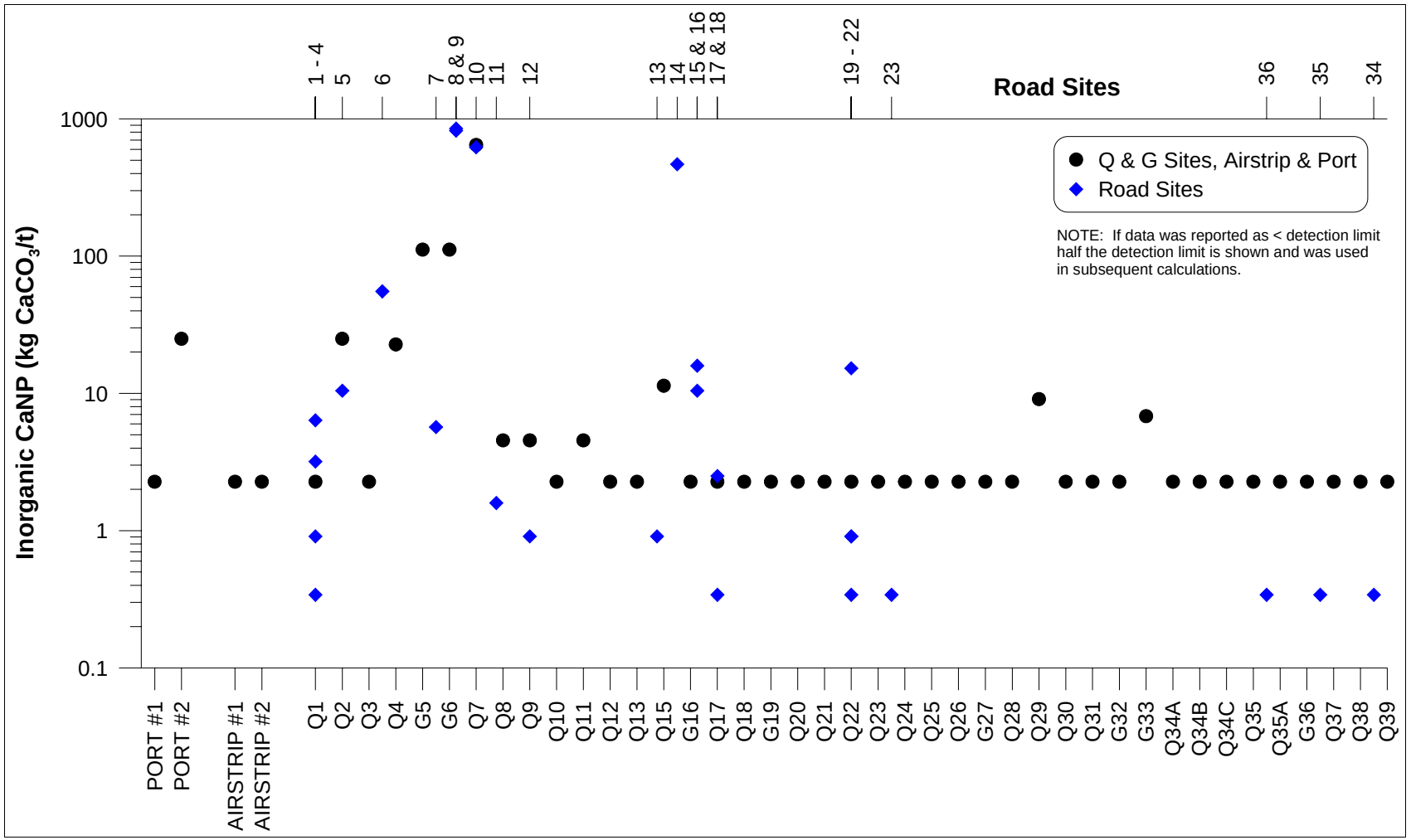

Figure 4-19. Spatial Distribution of Inorganic-Carbon-Based NP among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

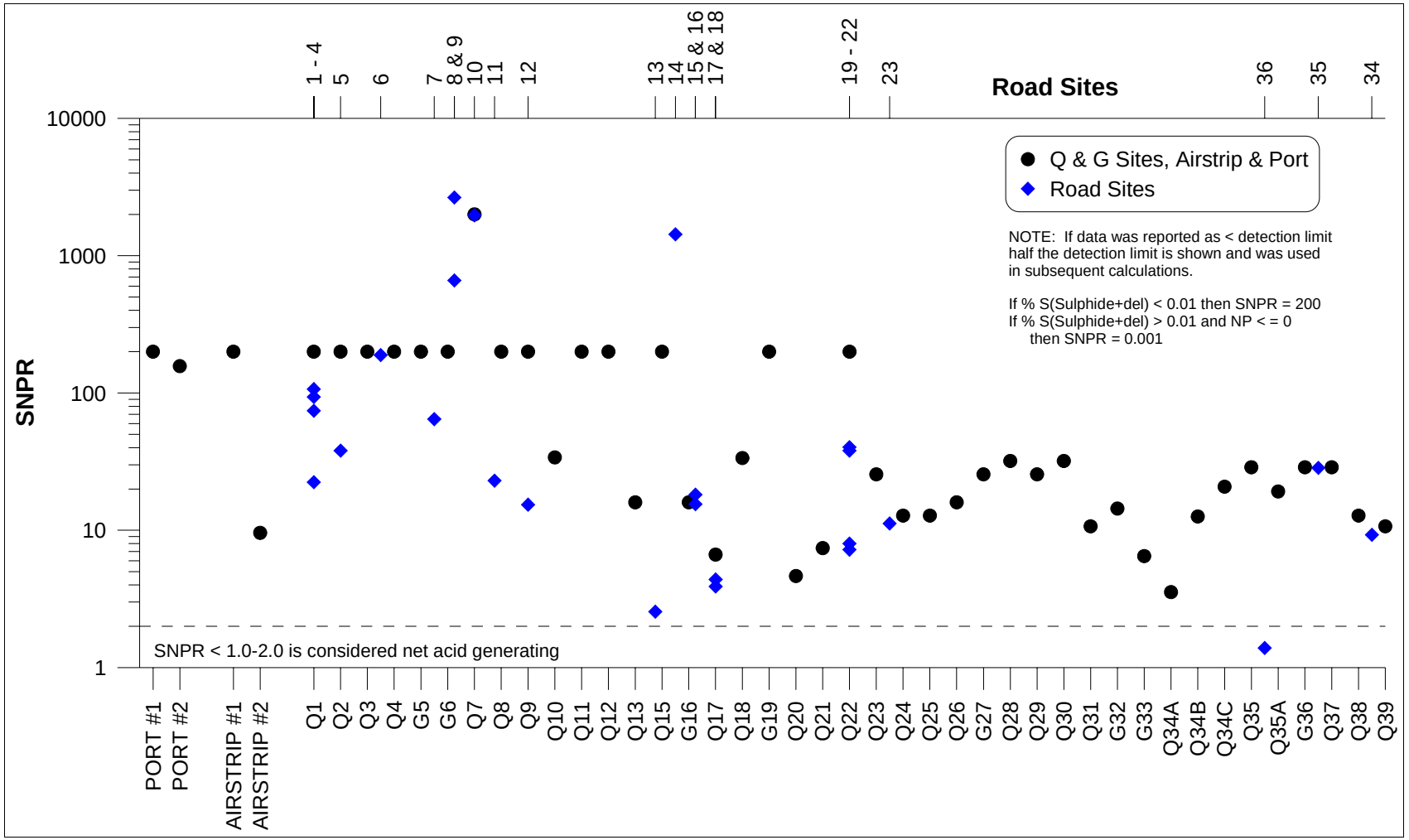

Figure 4-20. Spatial Distribution of Unadjusted Sulphide Net Potential Ratio among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

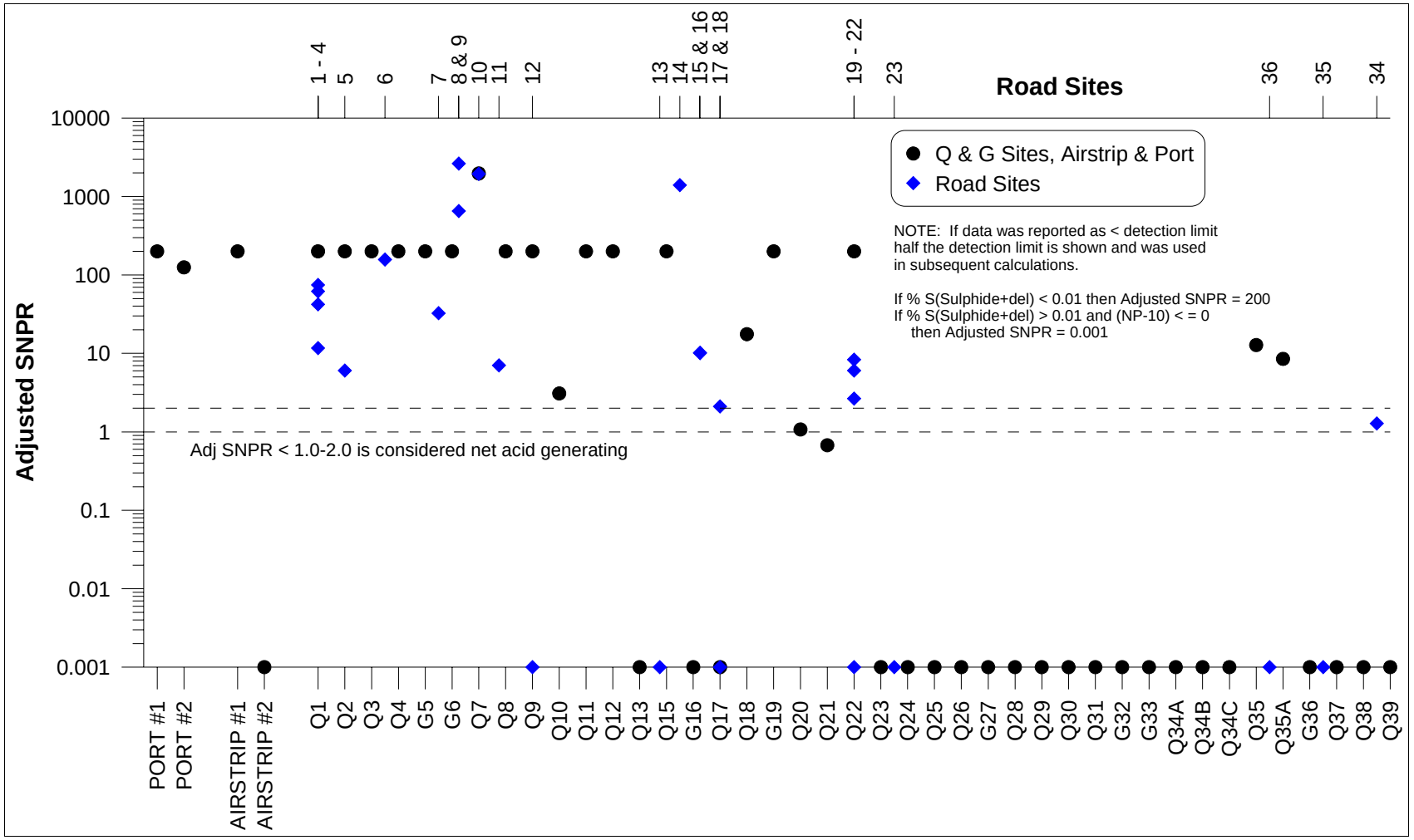

Figure 4-21. Spatial Distribution of Adjusted Sulphide Net Potential Ratio among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

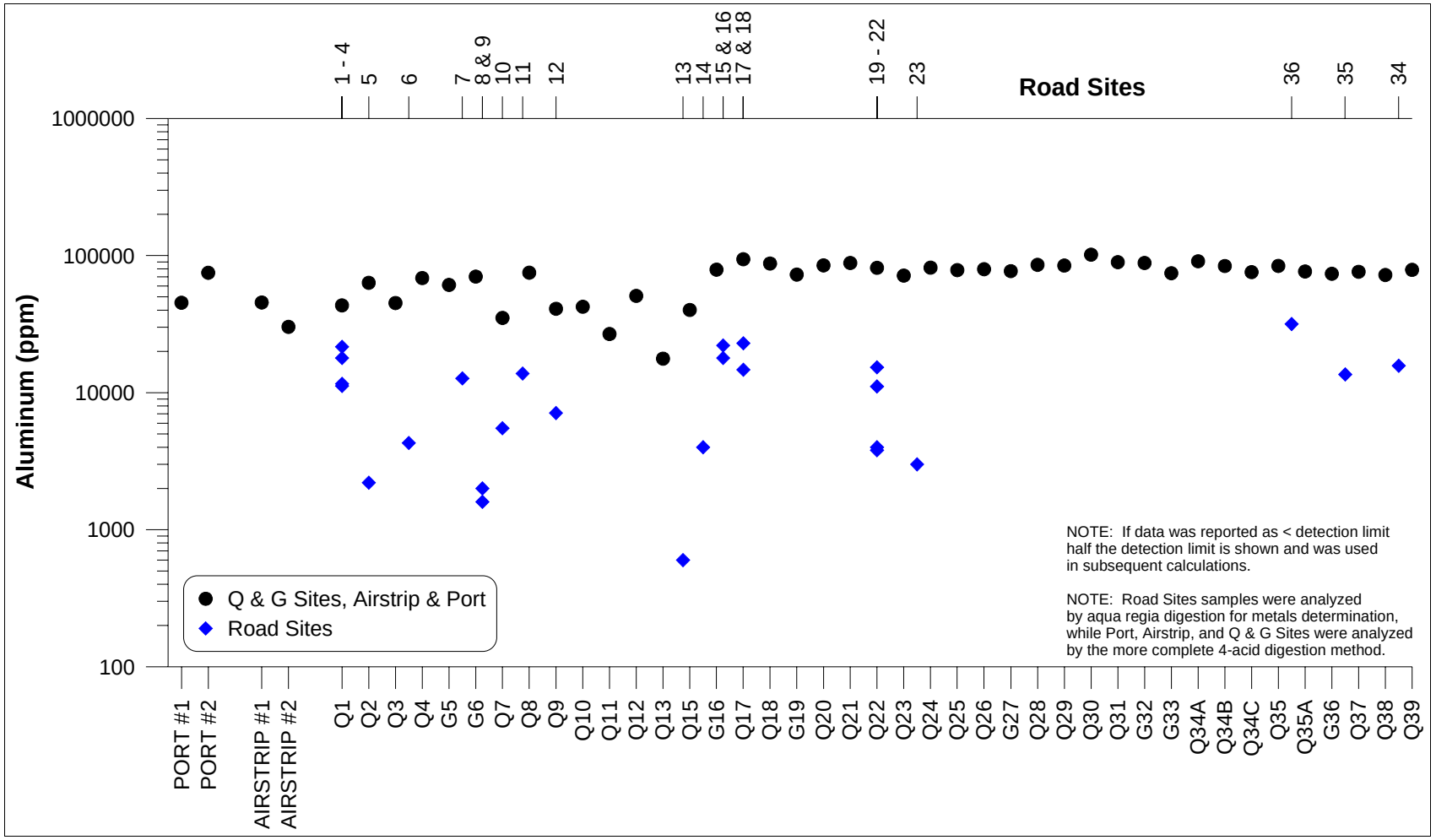

Figure 4-22. Spatial Distribution of Solid-Phase Aluminum among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

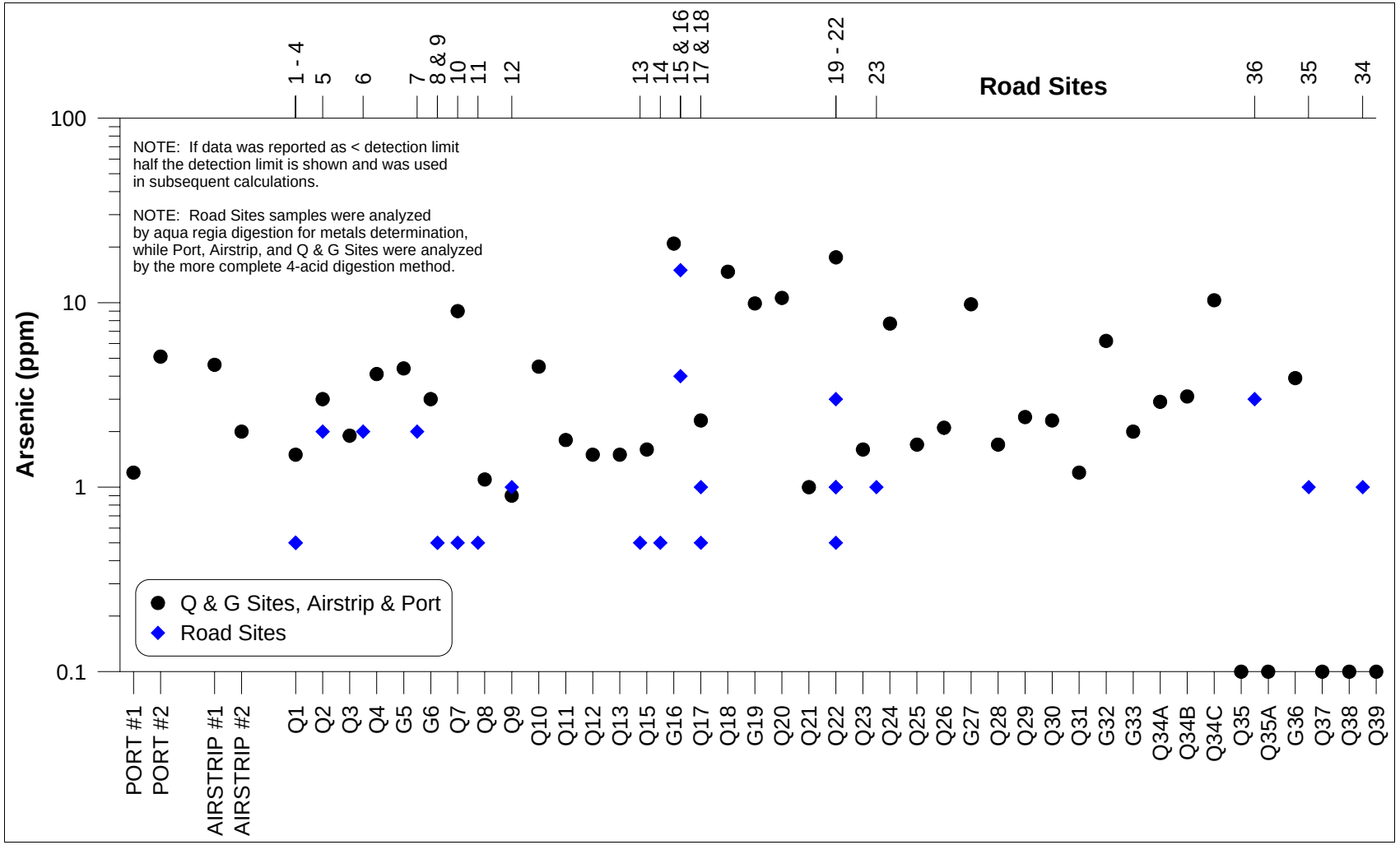

Figure 4-23. Spatial Distribution of Solid-Phase Arsenic among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

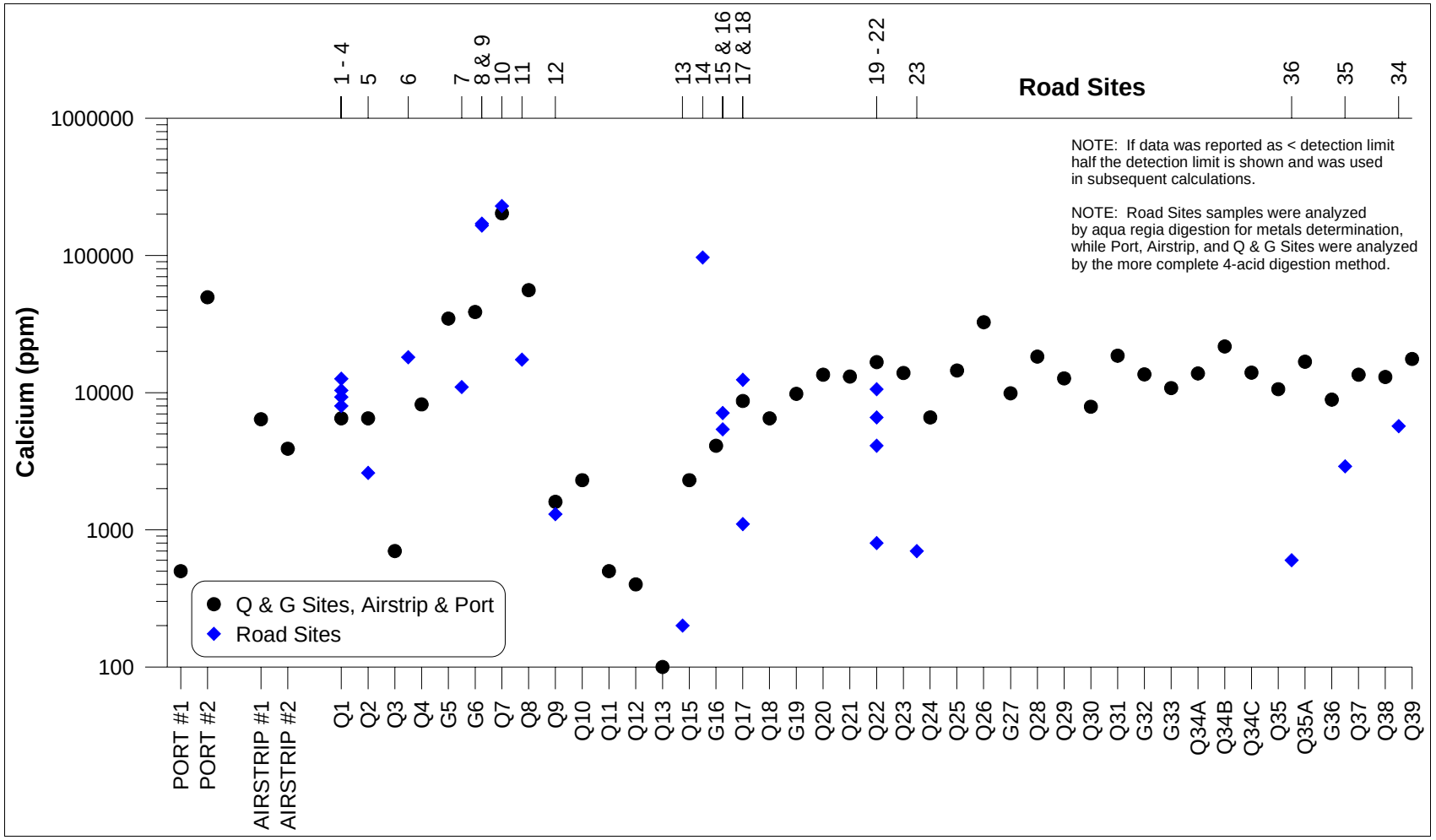

Figure 4-24. Spatial Distribution of Solid-Phase Calcium among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

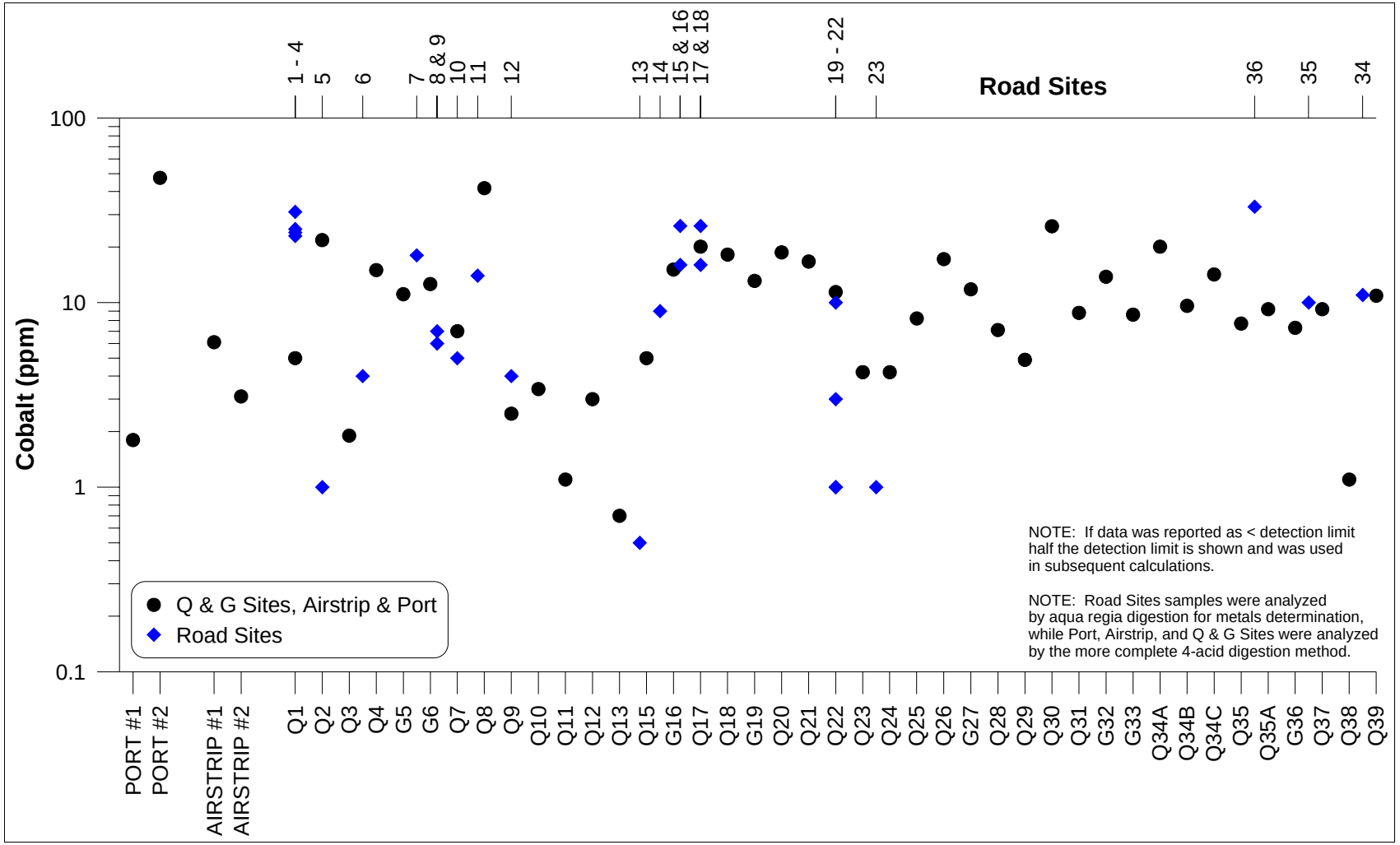

Figure 4-25. Spatial Distribution of Solid-Phase Cobalt among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

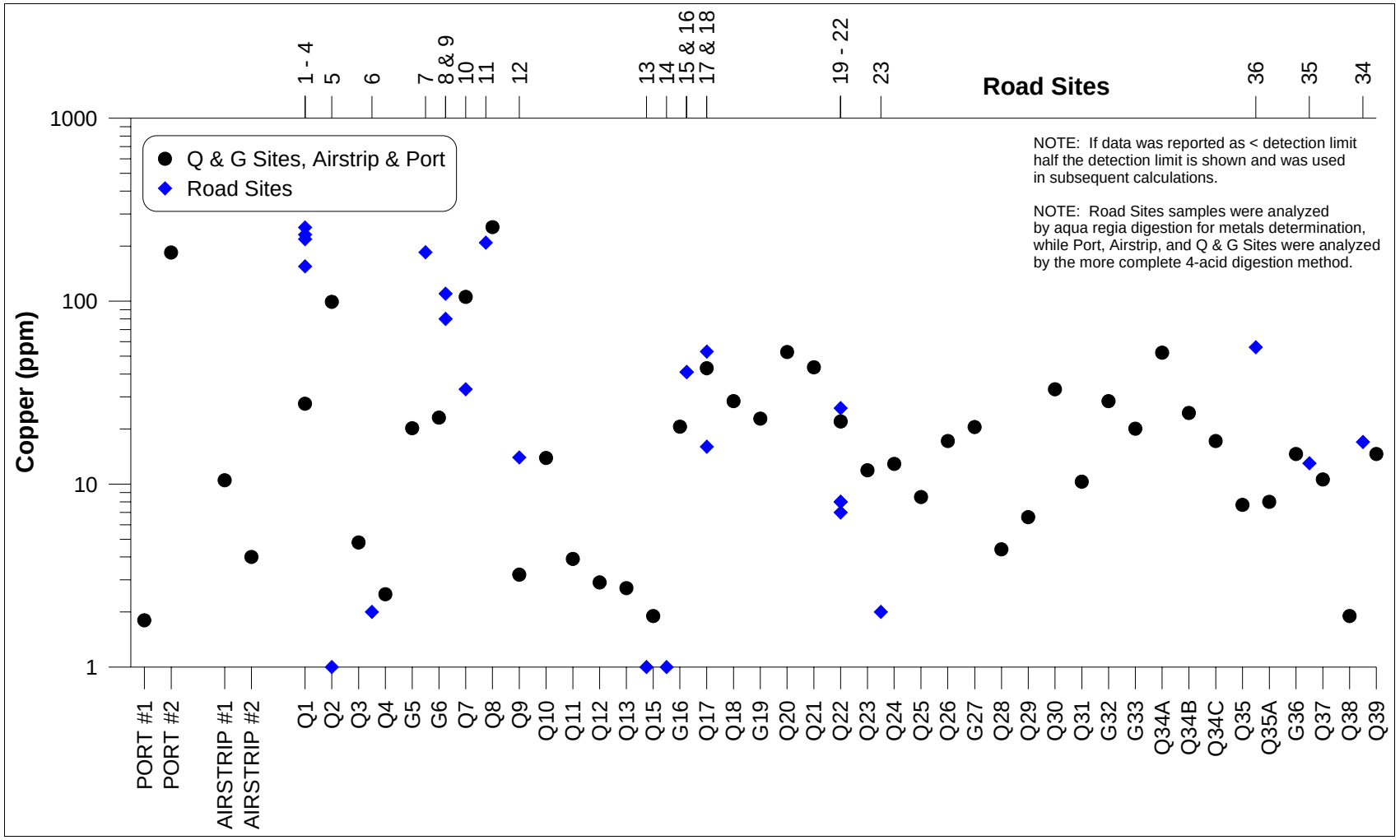

Figure 4-26. Spatial Distribution of Solid-Phase Copper among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

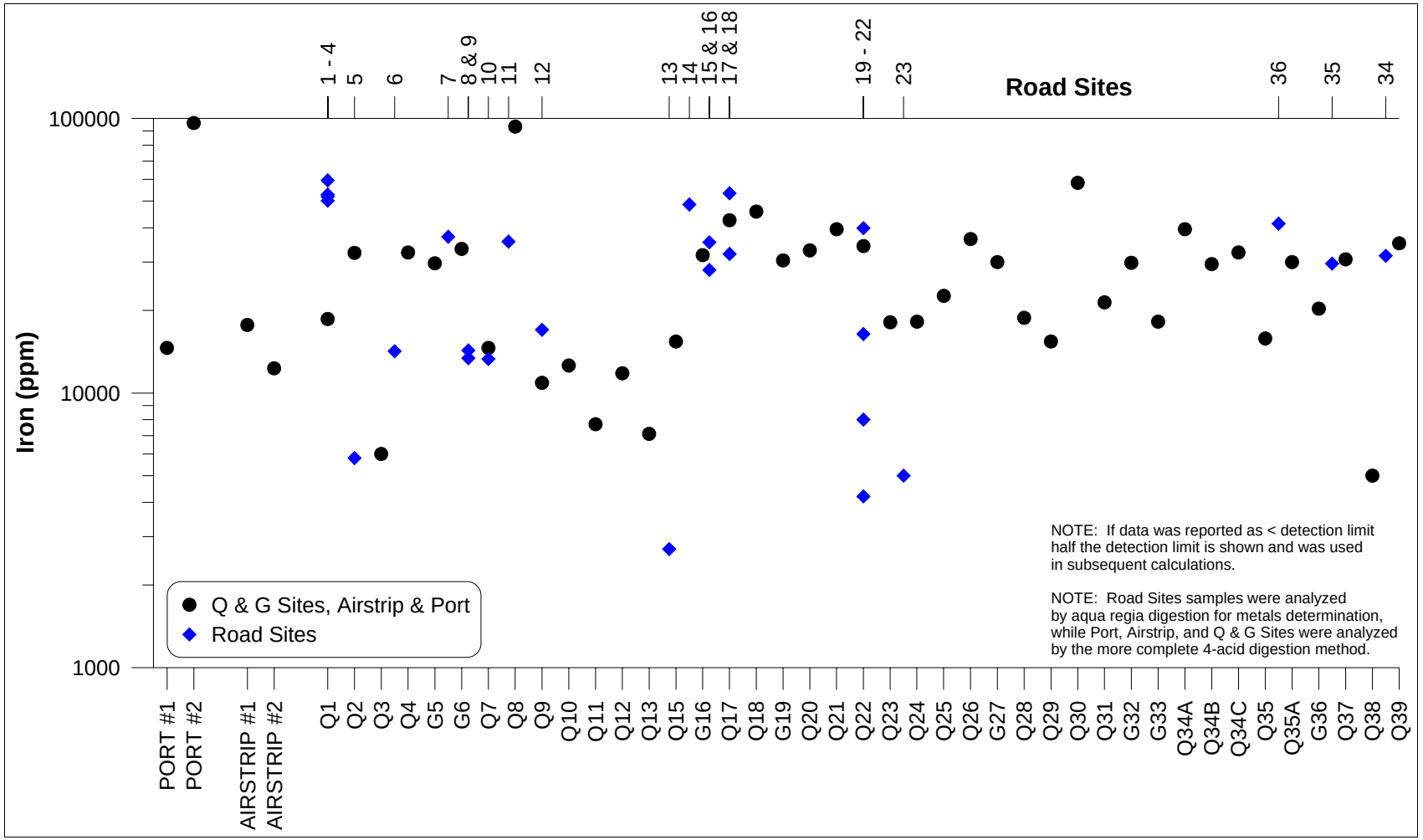

Figure 4-27. Spatial Distribution of Solid-Phase Iron among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

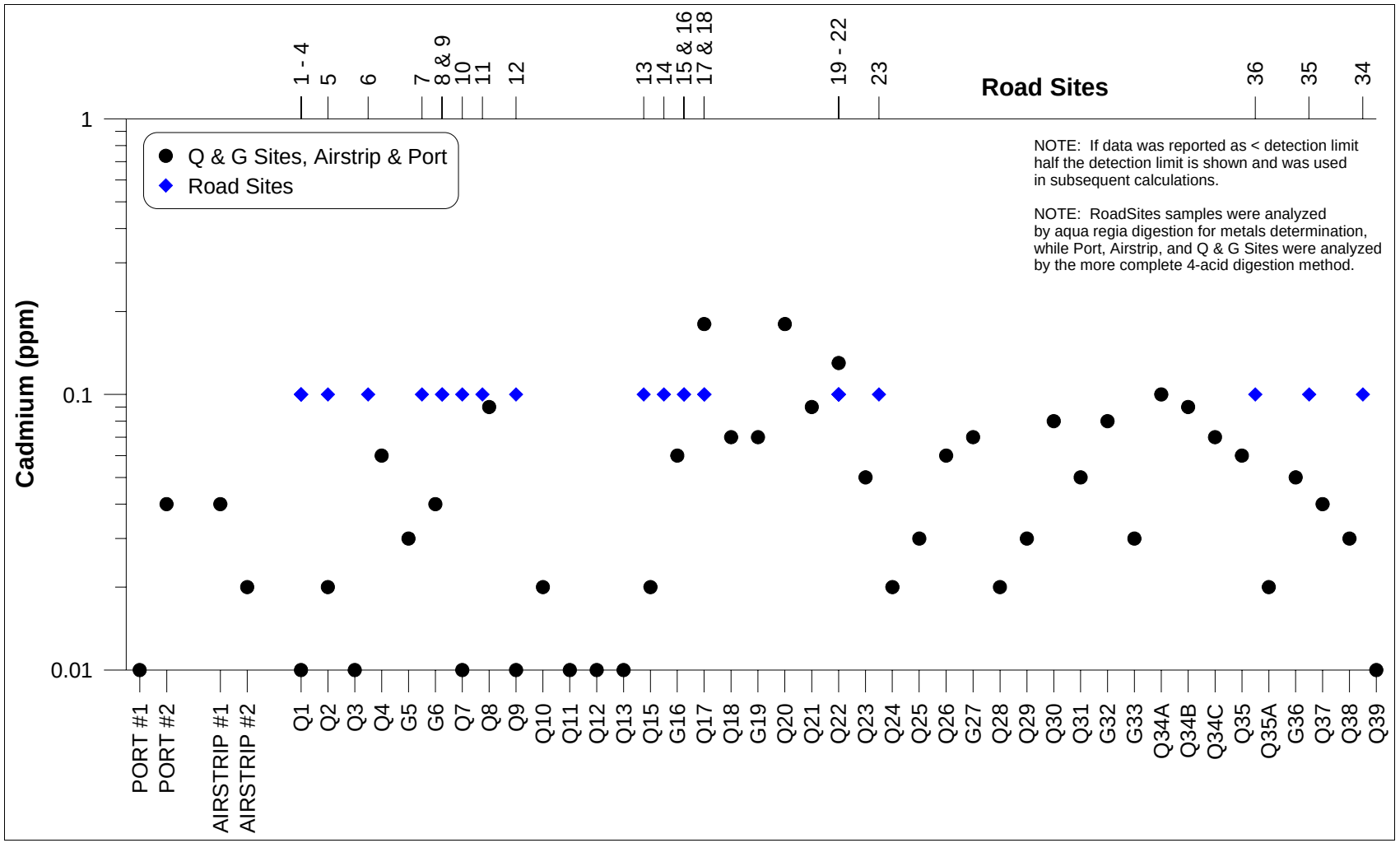

Figure 4-28. Spatial Distribution of Solid-Phase Cadmium among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

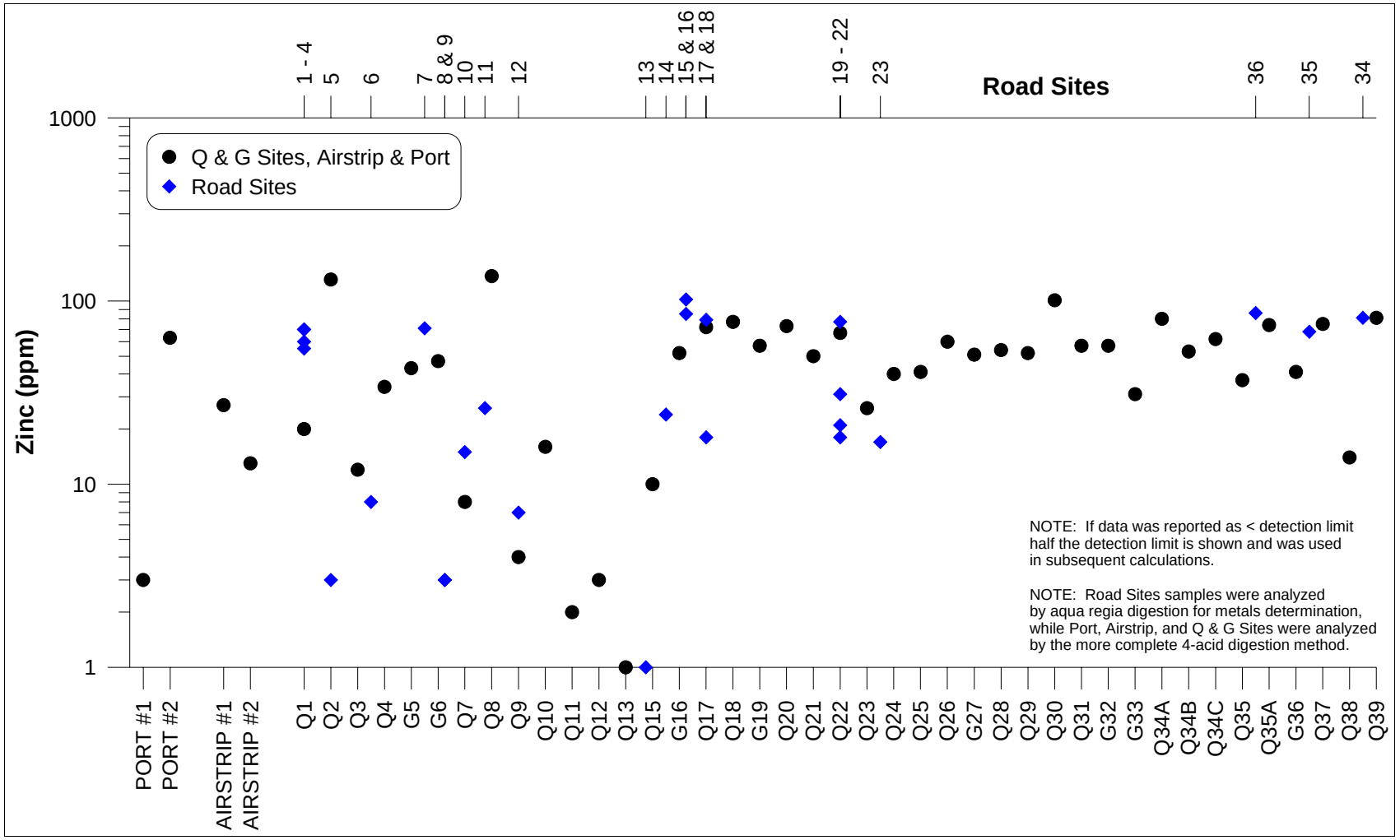

Figure 4-29. Spatial Distribution of Solid-Phase Zinc among the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip, Compared to the Road Sites from Rescan (2007).

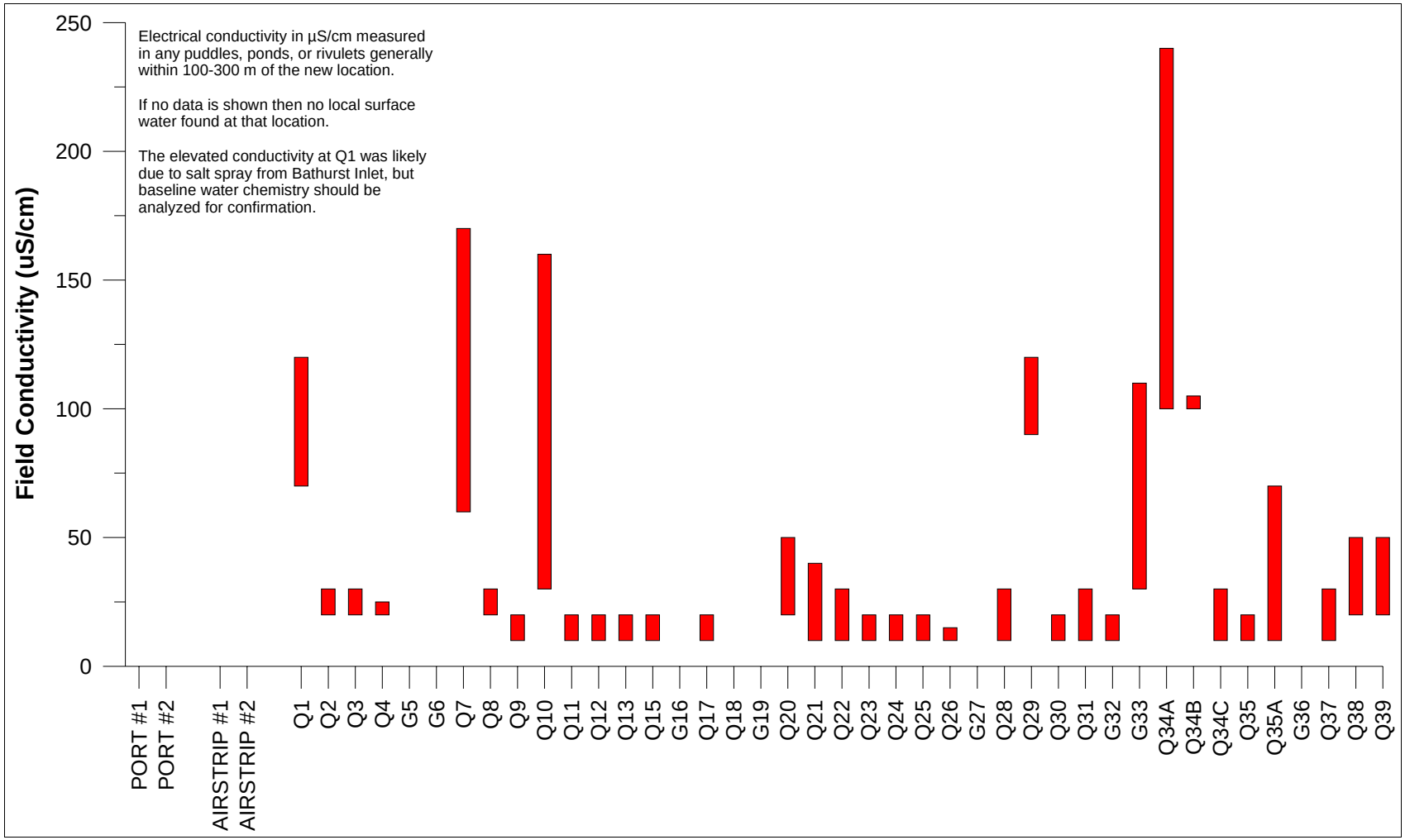

Figure 4-30. Spatial Distribution of Electrical Conductivity of Any Local Puddles, Ponds, or Rivulets at the Proposed Q Rock Quarries, G Granular Pits, the Port, and Airstrip.

In summary, spatially arranged geochemical data of surficial samples, from the proposed port at Bathurst Inlet to the rock-quarry Site Q39 near Contwoyto Lake, showed some significant spatial trends. A large geochemical zone from Q23 to Q39 had the greatest ARD potential. A geochemical zone with elevated carbonate and neutralizing capacity around G5 to Q7 could be used to offset the ARD potential in other zones if needed. Solid-phase element levels do not necessarily reflect potential leaching rates into water. Nevertheless, several elements displayed a spatial pattern of highly variable levels, among the highest and lowest, from the proposed port up to roughly Q8; typically low levels from Q11 to Q15; and then generally variable but moderate levels to Q39.

4.5 On-Site Measurements of Electrical Conductivity in Water

Where puddles, ponds, or rivulets were seen (rarely at the G granular sites due to relatively high permeability), electrical conductivity in µS/cm was used as a general indication of the reactivity of the surficial material. The higher the conductivity, the higher the assumed reactivity. While conductivities around 10-50 µS/cm were common, values up to 240 µS/cm were found (Table 3-1 and Figure 4-30).

A search for correlations of electrical conductivity (Figure 4-30) with ABA parameters and total elements (e.g., Figures 4-15 to 4-29) only yielded a weak, positive correlation with Inorganic CaNP (Figure 4-19). Thus, the higher electrical conductivities may reflect elevated alkalinity and hardness in water, but these waters should be analyzed at a laboratory to confirm this.

At all sites (Q rock-quarry sites, G granular sites, the port area, and the airstrip), laboratory water analyses should be used to define baseline water quality before any disturbance, excavation, and construction. This would ensure any water with currently high concentrations would not be attributed to road construction.

5. CONCLUSION

This study involved the collection and geochemical analyses of 45 surficial samples from the proposed granular (sand and gravel) G sites and rock-quarry Q sites, the port area, and the airstrip. Deeper material could not be collected, but should be analyzed before disturbance, excavation, and construction.

The surficial samples were analyzed for acid-base accounting (ABA), total solid-phase elements, and mineralogy. Additionally, electrical conductivity of water in any local puddles, ponds, or rivulets was used as a general indicator of surficial geochemical reactivity.

Results of Acid-Base Accounting

Acid-base accounting (ABA) showed no samples were generating net acidity at the time of analysis. Also, most sulphur analyses were close to the analytical detection limit, and thus included high "error bars". Sobek Neutralization Potential was low in many samples, below the typical level considered available for neutralization.

Net balances of acid-generating and acid-neutralizing capacities indicated roughly 0% to 50% of the 45 surficial samples were net acid generating and might release ARD, when compared with non-site-specific generic criteria. In turn, 50-100% of the samples were predicted to be net neutralizing indefinitely. However, the uncertainties in sulphur analyses that were close to detection, and in the applicable value of unavailable NP, substantially increased the uncertainty in these percentages.

Results of Total-Element Analyses

Total-element analyses of the 45 surficial solid-phase samples showed that most samples were composed of aluminum and silicon, with the high-NP samples containing much less of these elements due to their high carbonate content. Iron, potassium, magnesium, calcium, and sodium were also significant in many samples.

Trace elements frequently above maximum crustal abundances were bismuth and selenium, while cesium, lithium, and thorium were above crustal abundance only in one or two samples. All others were more typical of crustal abundance, but could still leach at high concentrations if very reactive. Elements like selenium can create water-quality problems if they leach at high rates into water, but long-term kinetic testing for at least a year is needed to determine leaching rates. These tests are currently underway.

Correlations suggested leaching of metals and other elements could be more closely related to simple dissolution of Neutralization Potential, rather than sulphide oxidation, upon disturbance at the Q Sites, G Sites, port, and airstrip. This would mean even the simple exposure of some rock and granular material to rain and snowmelt will create higher concentrations in some nearby waters.

Spatial Patterns in ABA and Total Solid-Phase Elements

Spatially arranged geochemical data of surficial samples revealed that a large geochemical zone from Q23 to Q39 had the greatest ARD potential. Also, a geochemical zone with elevated carbonate and neutralizing capacity, around G5 to Q7, could be used to offset ARD potential in other zones if needed.

Several solid-phase elements displayed a spatial pattern of highly variable levels, among the highest and lowest, from the proposed port south to roughly Q8; typically low levels from Q11 to Q15; and then generally variable but moderate levels to Q39 near Contwoyto Lake.

Electrical Conductivity of Water from Local Puddles, Ponds, and Rivulets

A weak, positive correlation of Electrical Conductivity with Inorganic Carbon and CaNP suggested the higher measured electrical conductivities at some sites may reflect elevated alkalinity and hardness in water. Some trace metals may have dissolved into these waters also, but laboratory analyses are needed to confirm this.

At all sites (Q rock-quarry sites, G granular sites, the port area, and the airstrip), laboratory water analyses should be used to define baseline water quality before any disturbance, excavation, and construction. This would ensure any water with currently high concentrations would not be attributed to road construction in the future.

Recommendations

Based on the findings in this study, the following recommendations are offered.

1) Due to the uncertainties in the ABA analytical data and the lack of deeper samples, a thorough assessment of ARD potential of the various sites cannot be made at this time. However, surficial ARD potential was highest from Sites Q23 to Q39, with some high potential sporadically east and north of Site Q23 (towards Bathurst Inlet). Therefore, before disturbance and excavation, deeper rock and granular materials should be sampled and analyzed for a more complete assessment of ARD potential. This is important, because a recent road-related prosecution under the *Fisheries Act* showed that surficial pre-construction information may not be sufficient to identify ML-ARD potential properly.

2) The high-neutralizing carbonate content of rock and sand-gravel around Sites G5 to Q7 may be used to decrease ARD potential in other areas. This would require transportation to more distance sites, so economics will determine if this is more appropriate than other means of reducing ARD potential like imported lime.

3) Even without acidic conditions and with near-neutral pH, the potential for leaching of metals and other elements, like selenium, is present at some G and Q sites. However, this potential cannot be quantitatively defined with existing information, because it requires long-term

leaching tests. These tests are currently underway.

4) Electrical conductivity of local waters, and the spatial distribution of solid-phase carbonate minerals, suggested leaching may be related to the dissolution of neutralizing minerals. This can cause an increase in alkalinity and hardness, and perhaps in some trace metals also. Thus, the simple exposure of some rock and granular material to rain and snowmelt could create higher concentrations in some nearby waters.

5) Baseline water analyses should be conducted before disturbance and excavation. This would ensure any water with currently high concentrations would not be attributed to road construction.

6. REFERENCES

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Morin, K.A., and N.M. Hutt. 1997. *Environmental Geochemistry of Minesite Drainage: Practical Theory and Case Studies*. MDAG Publishing (www.mdag.com), Vancouver, British Columbia. ISBN: 0-9682039-0-6.

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APPENDIX A. Compilation of Proposed Sites, Samples, and Analytical Results for Environmental Geochemistry and ML-ARD

Project: **BIPR**
Client: BIPR
Data: **Sample Information**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Date Sampled	Sample Type	Road (km)	Coordinates from Dick Turner								
				Elevation	WGS 84 Northing		WGS 84 Westing		Time	Zone	NAD 83 Easting	NAD 83 Northing
PORT #1	23-Jun-07											
PORT #2	23-Jun-07											
AIRSTRIP #1	23-Jun-07											
AIRSTRIP #2	23-Jun-07											
Q1	22-Jun-07	Quarry	0.5	131 +/-17	66	32.205	107	30.653	8:44 AM	13W	0388463	7381984
Q2	22-Jun-07	Quarry	7.8	365	66	31.491	107	36.947	9:29 AM	13W	0383755	7380852
Q3	22-Jun-07	Quarry	7.8	365	66	31.491	107	36.947	9:29 AM			
Q4	22-Jun-07	Quarry	12.1	5536	66	29.497	107	36.049	10:16 AM	13W	0384262	7377117
G5	22-Jun-07	Gravel-sand	18	630	66	26.677	107	39.132	10:47 AM	13W	0381757	7371980
G6	22-Jun-07	Gravel-sand	19.1	690	66	26.142	107	38.145		13W	0382445	7370954
Q7	22-Jun-07	Quarry	26.1	850	66	22.987	107	38.32	11:12 AM	13W	0382068	7365104
Q8	22-Jun-07	Quarry	29.5	940	66	21.783	107	41.042	1:50 PM	13W	0379945	7362951
Q9	22-Jun-07	Quarry	41.7	1124	66	16.224	107	47.090	2:20 PM	13W	0374982	7352824
Q10	22-Jun-07	Quarry	44.5	1374	66	14.739	107	47.843	2:24 PM	13W	0374289	7350113
Q11	22-Jun-07	Quarry	46.7	1410	66	13.532	107	49.306	2:05 PM	13W	0373095	7347910
Q12	22-Jun-07	Quarry	48.9	1476	66	12.127	107	48.214	3:40 PM	13W	0373798	7345264
Q13	22-Jun-07	Quarry	54.7	1550	66	09.432	107	49.337	4:13 PM	13W	0372728	7340313
Q15	22-Jun-07	Quarry	66.5	1410	66	02.402	107	48.71		13W	0372615	7327230
G16	22-Jun-07	Gravel-sand	69.2	1330	66	01.589	107	47.782	5:109 pm	13W	0373250	7325686
Q17	22-Jun-07	Quarry	77	1240	65	57.67	107	49.928	5:27 PM	13W	0371297	7318489
Q18	21-Jun-07	Quarry	81	1383	65	56.413	107	53.872		13W	0368206	7316290
G19	21-Jun-07	Gravel-sand	83	1320	65	55.040	107	54.196	4:52 PM	13W	0367843	7313749
Q20	21-Jun-07	Quarry	85	1283	65	54.217	107	55.436	4:15 PM	13W	0366814	7312267
Q21	21-Jun-07	Quarry	89.4	1360	65	51.878	107	56.480	3:50 PM	13W	0365835	7307967
Q22	21-Jun-07	Quarry	103	1310	65	45.746	108	05.168	3:21 PM	12W	0633442	7296526
Q23	21-Jun-07	Quarry	108.8	1485	65	43.942	108	12.359	2:50 PM	12W	0628105	7292926
Q24	21-Jun-07	Quarry	117.6	1495 +/-24	65	41.039	108	20.556	2:14 PM	12W	0622072	7287264
Q25	21-Jun-07	Quarry	122.5	1581	65	39.578	108	26.484	1:40 PM	12W	0617647	7284365
Q26	21-Jun-07	Quarry	129.1		65	39.209	108	36.408	1:05 PM	12W	0610015	7283379

Project: **BIPR**
Client: BIPR
Data: **Sample Information**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Date Sampled	Sample Type	Road (km)	Coordinates from Dick Turner								
				Elevation	WGS 84 Northing		WGS 84 Westing		Time	Zone	NAD 83 Easting	NAD 83 Northing
G27	21-Jun-07	Gravel-sand	137.7	1391	65	35.263	108	42.480	12:40 PM	12W	0605683	7275885
Q28	21-Jun-07	Quarry	151.5	1450	65	32.049	108	57.363	12:06 PM	12W	0594444	7269520
Q29	21-Jun-07	Quarry	157.4	1629	65	30.128	109	02.735		12W	0590417	7265822
Q30	21-Jun-07	Quarry	160.6	1581	65	29.307	109	06.004		12W	0587945	7264218
Q31	19-Jun-07	Quarry	164		65	29.354	109	10.801		12W	0584242	7264197
G32	19-Jun-07	Gravel-sand	167.6	1584	65	29.748	109	14.448				
G33	19-Jun-07	Gravel-sand	171.3	1519	65	29.280	109	19.234	4:45 PM	12W	0577741	7263882
Q34A	23-Jun-07	Quarry		1577	65	27.180	109	24.866	4:15 PM	12W	0573495	7259868
Q34B	19-Jun-07	Quarry		1563	65	27.709	109	24.674	3:30 PM	12W	0573621	7260846
Q34C	23-Jun-07	Quarry			65	27.277	109	28.716		12W	0570515	7259971
Q35	19-Jun-07	Quarry	193	1658	65	27.913	109	45.389	2:41 PM	12W	0557615	7260873
Q35A	23-Jun-07	Quarry		1614	65	27.709	109	41.207	3:30 PM	12W	0560852	7260559
G36	19-Jun-07	Gravel-sand	197.2		65	28.593	109	49.964	2:00 PM	12W	0554059	7262067
Q37	23-Jun-07	Quarry	203.7	1610	65	27.340	109	58.444	5:12 PM			
Q38	23-Jun-07	Quarry	207.2	1414	65	27.016	110	02.116	4:27 PM			
Q39	23-Jun-07	Quarry		1611	65	27.832	110	07.854		12W	0540271	7260432

Project: **BIPR**
Client: BIPR
Data: **Sample Information**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Description
PORT #1	In-situ (looks to be) poorly cemented (or highly weathered) coarse-grained sandstone of varying rock type with some gravel in it.
PORT #2	Fine-grained dark grey gabbro to basalt.
AIRSTRIP #1	Composite of 5 samples starting from the southeast end working towards the northwest end. There was sand and gravel for ~200 m with a little more fines at ~100 m. A heavy vegetation cover started after 200 m subsamples contained sand, gravel and some organics. At ~400 m the ground was frozen about 4" under the vegetation (mostly soil with a few specs of sand). At ~500 m the vegetation cover became thin with fine-to-medium sand with brown rganic matter.
AIRSTRIP #2	Composite of 5 samples starting from the southeast end working towards the northwest end. First sample at ~540 m was brown fine-to-medium sand with some gravel (nothing over 1") and organic matter. Sparse vegetation and boulders on surface. At 640 m there was clean medium brown sand with rare gravel under sparse vegetation. At 740-840 m there was fine-to medium brown sand with a few specs of coarse sand and no gravel under sparse vegetation. At 940 m there was lots of rganic brown silty fine-to-medium sand under moderate vegetation with more rounded rocks on the surface. At 1040 m there is well graded light brown silt with a few pieces (rare) of gravel to1" with moderate vegetation.
Q1	Broken rock outcrop. Haeavy vegeation which did not allow us to see the in-situ rock. Most of the rock is rounded and probably carried in. Rock types included sandstone (reddish), quartzite, metamorphorzosed granite, gneiss, and diorite. Conductivity is area puddles ranged from 70-120 uS/cm.
Q2	In-situ fractured rock predominantly reddish silicified sandstone (argillite) with areas of silicified siltstone and claystone volcanics (ash, porphyrtic tuff), could be argillite. Conductivity in area puddles ranged from 20-30 uS/cm.
Q3	In-situ fractured rock predominantly silicified reddish sandstone (argillite) Conductivity in area puddles rnged from 20-30 uS/cm.
Q4	In-situ fractured rock predominantly silicified reddish sandstone (argillite) Similar to Q3. Conductivity in area puddles rnged from 10-20 uS/cm.
G5	Sand and gravel of varying rock type. Some thin vegetation cover on top. No water to test.
G6	Sand and gravel of varying rock type. Small amount of shale. Thin vegetation cover on top. No water to test.
Q7	In-situ bedrock outcrop predominantly metasediments mostly quartzite. Iron staining us common, unusal weathering patters. Conductivity in area ponds ranged from 60-170 uS/cm. Sample choosen for HC testing.
Q8	This site was supposed to be a gravel pit but was a rock quarry. Broken rock/boulder outcrop predominantly pink quartzite with some material that looks like rhyolite, some grey quartzite, and rare iron stained, soft weathered rock. Heavy vegetation cover with only boulders showing through. Conductivity is area puddles ranged from 10-20 uS/cm.
Q9	Broken rock/boulder outcrop predominantly pink quartzite with some material that looks like rhyolite, some grey quartzite, and rare iron stained, soft weathered rock. Rock is a bit rounded. Heavy vegetation cover with only boulders showing through. Conductivity is area puddles ranged from 10-20 uS/cm.
Q10	Broken rock outcrop predominantly pink quartzite, mostly gravel sozed with some larger boulders. Rock is rounded, may be carried in. Moderate vegetation cover. Silt with gravel not much sand. Conductivity in area puddles ranged from 30-160 uS/cm.
Q11	In-situ pink quartzite bedrock. Location is ~900 m west original coordinates. Conductivity of area puddles ranged from 10-20 uS/cm.
Q12	In-stu broken rock outcrop predominantly pink to brownish-tan quartzite with minor rhyolite(?). Some rock is more granular and some is more silicic. A 1 m quartz dyke runs through formation. Conductivity in area puddles ranged from 10-20 uS/cm.
Q13	In-situ broken rock outcrop predominantly pink to pale purplish-pink quartzite. Conductivity in area puddles ranged from 10-20 uS/cm.
Q15	In-situ broken rock outcrop predominantly pinky-purplish-brownish quartzite (rhyolite?). Some chocolate brown mud/claystone (~10%). Conductivity in area puddles ranged from 10-20 uS/cm.
G16	Sand and gravel of varying rock types with moderate vegetation cover. No water to test.
Q17	Broken rock outcrop predominantly grey coloured biotite schist with visible quartz and biotite with a moderate vegetation cover. Conductivity in area puddles ranged from 10-20 uS/cm.
Q18	Broken rock outcrop with some intact rock. Substantial vegetation cover. Volcanics (andesite?), some with small to medium biotite minerals. No available water.
G19	Gravel, sand, and silt with quite a range in grain size of the gravel and sand. Deposit grades from silty-sand to sand to gravel from area to area. The gravel contains a variety of rock types. This is a very large deposit (Mr. Turner estimated ~1 km long). The sample taken was a composite fromn 4 locations. No water. GPS coordinates were changed from original as authorized by Mr. Turner.
Q20	Broken rock outcrop, perdominantly volcanics. There is a lot, of looks to be, carried-in-rock which was more rounded than has been seen at quarries Q21-Q28. Rare diorite and coarse grained granite. Hard to tell what was carried in and what was in-situ.
Q21	Broken rock outcrop consisting od volcanics, some fine-grained porphyritics with a bit of schistosity. Iron staining and weathering quite noticeable. The rock, especially the weathered rock, is softer than previously seen granites. Conductivity in area puddles ranged from 10-40 uS/cm, 40 uS/cm was found in one drainage pathway.
Q22	Broken rock quarry. Rock type changed from the more southerly quarries. Rock is predominantly volcanic, fine-grained grey rock with some porphyritic content. Some rock highly weathered and iron stained. The weathered rock crumbles. There was no obvious pyrite.
Q23	Broken rock outcrop 300 to 400 m from reference point. Mostly metamorphozed/silicified granite type rock with minimal mafics and minor volcanics and quartzite. More iron staining than quarries to the west. Dick estimates the borrow area at 20 ha. Conductivity of area puddles ranged from 10-20 uS/cm.
Q24	Broken rock outcrop. There was a mixture of rock types mostly granite with lesser andesite (?). Rare sedimentary rocks (i.e. slate, siltstone) were seen. Conductivity in area puddles ranged from 10-20 uS/cm.
Q25	Broken rock outcrop, a large area ~100 m in diameter. There is a mix of rock types: granite, granodiorite, gabbro, quartzite, fine-grained grey rock (andesite?). The rock is mostly granite and gabbro. The granite ranged from pink with little matrics to pink/orange with more mafics with a range of grain sizes. Conductivity 10-20 uS/cm.
Q26	Intact rock outcrop, this is not a gravel source in this area. G26 was changed to Q26 with new coordinates. The rock (bedrock) is intermingled granite (medium to coarse grained) with very little mafic minerals and fine grained gabbro. The granite could have been shot into, or rafted into the gabbro. Sample contains both granite and gabbro. Conductivity in area puddles consistly 10 uS/cm.

Project: **BIPR**
Client: BIPR
Data: **Sample Information**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Description
G27	Good sand and gravel. Grades from silty sand to medium sand to coarse sand to gravel from area to area. The sample is composited of grabs from 4 areas. The main Deposit is a couple 100 metres long, ranged from 1(to 40 m wide, and 1-3 m thick. No available water.
Q28	Broken rock outcrop consisting of mostly granite and granodiorite, medium to finer grained. There was some diorite and rare occurrences of iron-stained andesite. The conductivity of area puddles ranged from 10-30 uS/cm.
Q29	Landed between two broken rock outcrops. Mostly medium-grained granite, some finer-grained granite and some pegmatite. Some very fine-grained mafic material and some rare fine-grained iron coloured rock, maybe flint. Conductivity of area puddles was ~30 uS/cm except puddles between the two outcrops which had conductivity ranging from 90-120 uS/cm. The higher conductivity water couldbe groundwater springs. No surface expression of rock between the two broken rock outcrops.
Q30	Broken rock outcrop, quite a large elevated area ~100 in diameter. Mostly shist (biotite, muscovite). Quite a lot of iron staining. Visible pyrite in one rock. Small amount of granite. Conductivity in area puddles ranged fro 10-20 uS/cm.
Q31	Large elevated bedrock outcrop flanked by broken rock. Gradational from quartzite to granite with some diorite. Quartzite is pink to white. Granite is medium-grained to occassionally large-granined, same with the quartzite. Conductivity in area puddles ranged from 10-30 uS/cm.
G32	Silt, sand, and gravel. Grading changes in the material from area to area. Material made up of a variety of rock types mostly granite and quartz based. Sample was a composite of material from 4 separate areas. Conductivity in area puddles ranged from 10-20 uS/cm.
G33	Broken rock outcrop several hundred metres in diameter. Quartzite, granite (medium-to-coarse grained with some fine grained). Occassional ultramafic (?). Conductivity in area puddles was ~30 uS/cm on top of outcrop and ~10 uS/cm down the slope of the hill.
Q34A	Broken rock outcrop, not as much surficial broken rock as Q34B, more sand/gravel/vegetation cover. More visible iron staining on the rock. Mixture of rock types, more gneiss and metasediments with metamorphosed granite and granodiorite. Conductivity in are puddles ranged from 100 to 210 uS/cm. On second visit conductivity in are puddles ranged from 150 to 240 uS/cm and it looks like the smaller rock in the area, which may have been carried in or in-situ weathered rock, may be the problem not the boulders not the boulders.
Q34B	Broken rock outcrop 400 m closer to the road alignment, this is a very large area. Did not look at the quarry site. There is a wide range of rock types, coarse to fine-granied granite, granodiorite, diorite, and schist. Some rocks with a lot of K-feldspar and/or mica. Some gneiss alteration, and some meta-sediments. A few occurences of highly weathered rock, iron stained. Dick suggested this site could be an alternative site. Conductivity in area puddles is ~100 uS/cm.
Q34C	Broken rock outcrop a very large area with distinct outcrop areas. Rock was predominantly fine-to-medium biotite schist, some areas had more iron staining on the rock. Conductivity in area puddles is ~10-30 uS/cm.
Q35	Boulder broken rock outcrops with lichen cover. Lots of k-feldspar, granite, granodiorite, some diorite did not see much gneiss. Fine-grained then Q38. Conductivity of area puddles ranged from 10-20 uS/cm. The samples collected was of a variety of rock types.
Q35A	Broken rock outcrop (alternative site) has predominantly granite and diorite. The diorite contains quite a bit of iron colour within the rock mostly in/around the quartz. There was noteable iron staining and weathering on the rock in this location. COnductivity in area puddles ranged from 10-70 uS/cm.
G36	Mostly silt with some sand and gravel. Composite sample collected of mixed rock types. Size of deposit is 100's of metres long and ~10 m high. Standing water in the centre, but could not get a sample. The solid sample collected was mostly silt with some sand and gravel collected/composited from two separate locations. Rare gravel heavily iron stained and encrusted.
Q37	Rock ranges from granite to granodiorite with rare diorite. Some areas have more granite while others tend towards granodiorite. Medium grained minerals (finer than Q38), phaneritic. Noticeable biotite and mica in the rock. Rare carried in sedimentary rocks. Total broken outcrop size is 100's of metres in diameter. Can see quite a bit of intact bedrock showing. Conductivity in puddles in the area ranged from 10-30 uS/cm. Sample Q3 is mostly granodiorite.
Q38	Most of the quarry is covered with overburden ranging from silt-to-gravel. There were a few broken outcrop areas, mostly diorite with some granodiorite. Rare sedimentary pyritic rock does not look to be in-situ. Total broken rock outcrop area is ~10 x 10 m. Rare garnet in the diorite. Conductivity in the puddles around the area ranged from 20-50 uS/cm. Sample Q38 is mostly diorite and granodiorite.
Q39	Broken rock outcrop (Alternative site) containing predominantly fine-to-medium grained diorite. There was occasional soft biotie schist and rare pink quartzite, fine grained grey volcanics both probably carried in. Conductivity in area puddles ranged from 20-50 uS/cm.

Project: **BIPR**
Client: BIPR
Data: **ABA Data**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.
pH of DI water used for paste pH read 6.1.

Sample Id.	Weight Received (kg)	Paste pH Unity	S (Total) (% Leco)	S (Sulphide) (% Leco)	S (Sulphide) (% Calc)	Carbonate Leach S (Sulphate) (%)	HCl Leachable S (Sulphate) (%)	$S(BaSO_4)$ (%)	$S(del_{actual})$ (%)	S(del) (%)	TAP (kg $CaCO_3$/t)	SAP (kg $CaCO_3$/t)	NP (kg $CaCO_3$/t)	Available NP (kg $CaCO_3$/t)
Method	WEI-21	OA-ELE07	S-IR08	S-IR07	S-CAL06	S-GRA06	S-GRA06a	Calculated	Calculated	Calculated	Calculated	Calculated	OA-VOL08	Calculated
MDL		0.1	0.01	0.01	0.01	0.01	0.01						1	
PORT #1	0.471	6.8	*0.005*	*0.005*	-0.005	*0.005*	0.01	0.019	-0.029	0.000	0.2	0.2	3	-7
PORT #2	0.092	8.3	0.02	0.01	0.01	0.01	0.01	0.004	-0.004	0.000	0.6	0.3	49	39
AIRSTRIP #1	0.646	7.1	0.01	*0.005*	0	*0.005*	0.01	0.013	-0.018	0.000	0.3	0.2	8	-2
AIRSTRIP #2	0.406	6.9	0.01	0.01	0.005	*0.005*	*0.005*	0.013	-0.018	0.000	0.3	0.3	3	-7
Q1	0.217	7.6	0.01	*0.005*	-0.02	*0.005*	0.03	0.010	-0.035	0.000	0.3	0.2	7	-3
Q2	0.824	8	*0.005*	*0.005*	-0.005	0.01	0.01	0.038	-0.048	0.000	0.2	0.2	32	22
Q3	0.764	8	0.01	*0.005*	0	*0.005*	0.01	0.017	-0.022	0.000	0.3	0.2	3	-7
Q4	0.231	8.3	0.01	*0.005*	-0.01	0.01	0.02	0.010	-0.025	0.000	0.3	0.2	27	17
G5	0.667	8.3	0.01	*0.005*	0	0.02	0.01	0.010	-0.015	0.000	0.3	0.2	132	122
G6	0.541	8.2	0.01	*0.005*	0	0.01	0.01	0.010	-0.015	0.000	0.3	0.2	126	116
Q7	2.33	8.3	0.01	0.01	0	*0.005*	0.01	0.004	-0.014	0.000	0.3	0.3	625	615
Q8	0.427	8.1	0.01	*0.005*	0	0.01	0.01	0.006	-0.011	0.000	0.3	0.2	30	20
Q9	0.249	8.2	0.01	*0.005*	0	*0.005*	0.01	0.015	-0.020	0.000	0.3	0.2	7	-3
Q10	0.364	8.6	0.03	0.01	0.025	0.02	*0.005*	0.015	0.000	0.000	0.9	0.3	11	1
Q11	0.273	7.3	0.01	*0.005*	-0.02	0.01	0.03	0.025	-0.050	0.000	0.3	0.2	2	-8
Q12	0.248	7.2	*0.005*	*0.005*	-0.015	0.01	0.02	0.017	-0.037	0.000	0.2	0.2	2	-8
Q13	0.31	7.4	0.01	0.01	0	0.01	0.01	0.010	-0.020	0.000	0.3	0.3	5	-5
Q15	0.218	7.6	0.01	*0.005*	0	0.01	0.01	0.004	-0.009	0.000	0.3	0.2	16	6
G16	0.72	7.5	0.02	0.01	0.015	*0.005*	*0.005*	0.013	-0.008	0.000	0.6	0.3	5	-5
Q17	0.289	7.6	0.07	*0.005*	0.06	0.01	0.01	0.017	0.038	0.038	2.2	1.4	9	-1
Q18	0.368	7.5	0.05	0.02	0.03	0.02	0.02	0.015	-0.005	0.000	1.6	0.6	21	11
G19	0.51	7.2	0.02	*0.005*	0.01	*0.005*	0.01	0.013	-0.008	0.000	0.6	0.2	7	-3
Q20	0.514	7.8	0.12	0.03	0.1	0.02	0.02	0.010	0.060	0.060	3.8	2.8	13	3
Q21	0.261	7.5	0.1	0.01	0.06	0.03	0.04	0.013	0.037	0.037	3.1	1.5	11	1
Q22	0.242	7.3	0.04	*0.005*	0.01	0.02	0.03	0.008	-0.003	0.000	1.3	0.2	10	0
Q23	0.441	8.1	0.01	0.01	-0.01	*0.005*	0.02	0.008	-0.028	0.000	0.3	0.3	8	-2
Q24	0.359	7.9	0.01	0.02	-0.01	*0.005*	0.02	0.019	-0.049	0.000	0.3	0.6	8	-2
Q25	0.374	7.5	0.03	0.02	0.01	*0.005*	0.02	0.010	-0.020	0.000	0.9	0.6	8	-2
Q26	0.851	8.3	0.02	0.02	0.01	*0.005*	0.01	0.023	-0.033	0.000	0.6	0.6	10	0
G27	0.523	7.4	0.02	0.01	0.01	*0.005*	0.01	0.013	-0.013	0.000	0.6	0.3	8	-2
Q28	0.174	7.8	0.01	0.01	-0.01	*0.005*	0.02	0.019	-0.039	0.000	0.3	0.3	10	0
Q29	0.385	7.6	0.01	0.01	0	*0.005*	0.01	0.017	-0.027	0.000	0.3	0.3	8	-2
Q30	0.458	7.6	0.03	0.01	0.02	0.01	0.01	0.017	-0.007	0.000	0.9	0.3	10	0
Q31	0.284	8	0.03	0.03	0.02	*0.005*	0.01	0.015	-0.025	0.000	0.9	0.9	10	0
G32	0.487	7.9	0.02	0.02	0.015	*0.005*	*0.005*	0.015	-0.020	0.000	0.6	0.6	9	-1
G33	0.637	7.7	0.06	0.01	0.04	*0.005*	0.02	0.010	0.020	0.020	1.9	0.9	6	-4
Q34A	2.73	7.3	0.12	0.03	0.1	0.01	0.02	0.019	0.051	0.051	3.8	2.5	9	-1
Q34B	0.572	7.2	0.09	0.02	0.04	0.05	0.05	0.015	0.005	0.005	2.8	0.8	10	0
Q34C	0.358	7.5	0.04	0.01	0.03	0.01	0.01	0.015	0.005	0.005	1.3	0.5	10	0
Q35	0.411	7.7	0.01	0.02	0	*0.005*	0.01	0.029	-0.049	0.000	0.3	0.6	18	8
Q35A	0.366	7.6	0.03	0.03	0.02	0.01	0.01	0.040	-0.050	0.000	0.9	0.9	18	8
G36	0.299	7.9	0.01	0.01	0.005	*0.005*	*0.005*	0.015	-0.020	0.000	0.3	0.3	9	-1
Q37	0.117	7.7	0.01	0.01	-0.01	0.01	0.02	0.033	-0.053	0.000	0.3	0.3	9	-1
Q38	0.12	8	*0.005*	0.01	-0.005	*0.005*	0.01	0.015	-0.030	0.000	0.2	0.3	4	-6
Q39	0.48	8.1	0.03	0.03	0.01	*0.005*	0.02	0.040	-0.060	0.000	0.9	0.9	10	0

Project: **BIPR**
Client: BIPR
Data: **ABA Data**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.
pH of DI water used for paste pH read 6.1.

Sample Id.	Weight Received	Paste pH	S (Total)	S (Sulphide)	S (Sulphide)	Carbonate Leach S (Sulphate)	HCl Leachable S (Sulphate)	$S(BaSO_4)$	$S(del_{actual})$	S(del)	TAP	SAP	NP	Available NP
	(kg)	Unity	(% Leco)	(% Leco)	(% Calc)	(%)	(%)	(%)	(%)	(%)	(kg $CaCO_3$/t)	(kg $CaCO_3$/t)	(kg $CaCO_3$/t)	(kg $CaCO_3$/t)
Method	WEI-21	OA-ELE07	S-IR08	S-IR07	S-CAL06	S-GRA06	S-GRA06a	Calculated	Calculated	Calculated	Calculated	Calculated	OA-VOL08	Calculated
MDL		0.1	0.01	0.01	0.01	0.01	0.01						1	
Maximum		8.6	0.12	0.03	0.1	0.05	0.05	0.04	0.06	0.06	3.75	2.8	625	615
Minimum		6.8	0.005	0.005	-0.02	0.005	0.005	0.0042	-0.06	0	0.16	0.16	2	-8
Mean		7.72	0.027	0.012	0.012	0.0099	0.015	0.016	-0.016	0.0048	0.84	0.53	30.1	20.1
Standard Deviation		0.41	0.03	0.0081	0.026	0.0084	0.0094	0.0085	0.026	0.014	0.92	0.57	94.4	94.4
10 Percentile		7.2	0.01	0.005	-0.01	0.005	0.007	0.0084	-0.049	0	0.31	0.16	3.4	-6.6
25 Percentile		7.5	0.01	0.005	0	0.005	0.01	0.01	-0.03	0	0.31	0.16	7	-3
Median		7.7	0.01	0.01	0.005	0.005	0.01	0.015	-0.02	0	0.31	0.31	9	-1
75 Percentile		8	0.03	0.02	0.02	0.01	0.02	0.017	-0.0067	0	0.94	0.62	13	3
90 Percentile		8.3	0.066	0.026	0.04	0.02	0.026	0.028	0.014	0.014	2.06	0.94	31.2	21.2
Interquartile Range (IQR) [1]		0.5	0.02	0.015	0.02	0.005	0.01	0.0063	0.023	0	0.62	0.47	6	6
Variance		0.17	0.00087	0.000066	0.00069	0.00007	0.000089	0.000073	0.00069	0.00019	0.85	0.32	8903	8903
Skewness		-0.064	2.07	1.19	1.93	3.06	1.77	1.48	0.99	3	2.07	2.66	6	6
Coefficient of Variation (CoV) [2]		0.054	1.1	0.68	2.21	0.85	0.63	0.54	-1.65	2.87	1.1	1.08	3.13	4.69
Count		45	45	45	45	45	45	45	45	45	45	45	45	45

NPR < 1.0 or NPR = 1.0
1.0 < NPR < 2.0
NPR > 2.0 or NPR =2.0

% NPR < 1.0 or NPR = 1.0 of Total
% 1.0 < NPR < 2.0 of Total
% NPR > 2.0 or NPR =2.0 of Total

[1] Interquartile Range (IQR) = 75th percentile minus 25th percentile
[2] Coefficient of Variation (CoV) = standard deviation divided by mean
NOTE: If data was reported as < detection limit half the detection limit is shown in italics and was used in subsequent calculations.
NOTE: Data in blue is calculated.

% S (Sulphide) (calc) = % S (Total) - % S (Sulphate) Carbonate Leach
$\%S(BaSO_4)$ = Ba (ppm) * 0.0001 * 32.06 / 137.37
% S (del_{actual}) = %S(Total) - %S(Sulphide) Leco - %S(Sulphate) Carbonate Leach - $\%S(BaSO_4)$
% S (del) = % S (del_{actual}) unless < 0, then 0
TAP = % S (Total) * 31.25
SAP = % S (Sulphide + del) * 31.25
Unavailable NP = 10
Available NP = NP - Unavailable NP

Project: **BIPR**
Client: BIPR
Data: **ABA Data**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Total C (% Leco)	Inorganic C (%)	Inorganic CO_2 (%)	Excess C (%)	Total CaNP (kg $CaCO_3$/t)	Inorganic CaNP (kg $CaCO_3$/t)	(Ca) CaNP (kg $CaCO_3$/t)	(Ca+Mg) CaNP (kg $CaCO_3$/t)	TNNP (kg $CaCO_3$/t)	Adjusted TNNP (kg $CaCO_3$/t)	SNNP (kg $CaCO_3$/t)	Adjusted SNNP (kg $CaCO_3$/t)	TNPR	Adjusted TNPR	SNPR	Adjusted SNPR	Fizz Rating	Comparison of Fizz Rating & NP
Method	C-IR07	C-GAS05	C-GAS05	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Unity OA-VOL08	
MDL	0.01	0.05	0.2															
PORT #1	0.21	*0.025*	*0.1*	0.185	17.5	2.3	1.2	13.2	2.8	-7.2	2.8	-7.2	200	200	200	200	3	Disagree
PORT #2	0.36	0.3	1.1	0.06	30.0	25.0	123.9	306.7	48.4	38.4	48.7	38.7	78.4	62.4	157	125	3	Disagree
AIRSTRIP #1	0.6	*0.025*	*0.1*	0.575	50.0	2.3	16.0	39.9	7.7	-2.3	7.8	-2.2	25.6	0.001	200	200	3	Disagree
AIRSTRIP #2	0.57	*0.025*	*0.1*	0.545	47.5	2.3	9.7	20.9	2.7	-7.3	2.7	-7.3	9.6	0.001	9.6	0.001	3	Disagree
Q1	0.22	*0.025*	*0.1*	0.195	18.3	2.3	16.2	31.1	6.7	-3.3	6.8	-3.2	22.4	0.001	200	200	3	Disagree
Q2	0.44	0.29	1.1	0.15	36.7	25.0	16.2	99.4	31.8	21.8	31.8	21.8	200	200	200	200	3	Disagree
Q3	0.05	*0.025*	*0.1*	0.025	4.2	2.3	1.7	12.5	2.7	-7.3	2.8	-7.2	9.6	0.001	200	200	3	Disagree
Q4	0.44	0.26	1	0.18	36.7	22.7	20.5	85.9	26.7	16.7	26.8	16.8	86.4	54.4	200	200	3	Disagree
G5	1.73	1.34	4.9	0.39	144.2	111.4	86.7	179.3	131.7	121.7	131.8	121.8	422	390	200	200	3	Agree
G6	1.82	1.35	4.9	0.47	151.7	111.4	96.6	193.8	125.7	115.7	125.8	115.8	403	371	200	200	3	Agree
Q7	7.57	7.75	28.4	0	630.9	645.9	506.9	635.0	624.7	614.7	624.7	614.7	2000	1970	2000	1970	3	Disagree
Q8	0.32	0.05	0.2	0.27	26.7	4.5	139.6	253.6	29.7	19.7	29.8	19.8	96	64	200	200	3	Disagree
Q9	0.26	0.06	0.2	0.2	21.7	4.5	4.0	15.5	6.7	-3.3	6.8	-3.2	22.4	0.001	200	200	3	Disagree
Q10	0.14	*0.025*	*0.1*	0.115	11.7	2.3	5.7	25.1	10.1	0.1	10.7	0.7	11.7	1.07	34	3.09	3	Disagree
Q11	0.31	0.05	0.2	0.26	25.8	4.5	1.2	5.4	1.7	-8.3	1.8	-8.2	6.4	0.001	200	200	3	Disagree
Q12	0.31	*0.025*	*0.1*	0.285	25.8	2.3	1.0	16.6	1.8	-8.2	1.8	-8.2	200	200	200	200	3	Disagree
Q13	0.14	*0.025*	*0.1*	0.115	11.7	2.3	0.2	4.0	4.7	-5.3	4.7	-5.3	16	0.001	16	0.001	3	Disagree
Q15	0.33	0.14	0.5	0.19	27.5	11.4	5.7	25.5	15.7	5.7	15.8	5.8	51.2	19.2	200	200	3	Disagree
G16	0.28	*0.025*	*0.1*	0.255	23.3	2.3	10.2	53.1	4.4	-5.6	4.7	-5.3	8	0.001	16	0.001	3	Disagree
Q17	0.24	*0.025*	*0.1*	0.215	20.0	2.3	21.7	95.8	6.8	-3.2	7.6	-2.4	4.11	0.001	6.66	0.001	3	Disagree
Q18	0.23	*0.025*	*0.1*	0.205	19.2	2.3	16.2	92.4	19.4	9.4	20.4	10.4	13.4	7.04	33.6	17.6	3	Disagree
G19	0.54	*0.025*	*0.1*	0.515	45.0	2.3	24.5	71.0	6.4	-3.6	6.8	-3.2	11.2	0.001	200	200	3	Disagree
Q20	0.13	*0.025*	*0.1*	0.105	10.8	2.3	33.7	93.4	9.3	-0.8	10.2	0.2	3.47	0.8	4.65	1.07	3	Disagree
Q21	0.24	*0.025*	*0.1*	0.215	20.0	2.3	32.7	95.7	7.9	-2.1	9.5	-0.5	3.52	0.32	7.42	0.674	3	Disagree
Q22	0.36	*0.025*	*0.1*	0.335	30.0	2.3	41.7	92.8	8.8	-1.3	9.8	-0.2	8	0.001	200	200	3	Disagree
Q23	0.13	*0.025*	*0.1*	0.105	10.8	2.3	34.7	50.4	7.7	-2.3	7.7	-2.3	25.6	0.001	25.6	0.001	3	Disagree
Q24	0.23	*0.025*	*0.1*	0.205	19.2	2.3	16.5	42.8	7.7	-2.3	7.4	-2.6	25.6	0.001	12.8	0.001	3	Disagree
Q25	0.31	*0.025*	*0.1*	0.285	25.8	2.3	36.2	60.9	7.1	-2.9	7.4	-2.6	8.53	0.001	12.8	0.001	3	Disagree
Q26	0.1	*0.025*	*0.1*	0.075	8.3	2.3	81.4	142.8	9.4	-0.6	9.4	-0.6	16	0.001	16	0.001	3	Disagree
G27	0.22	*0.025*	*0.1*	0.195	18.3	2.3	24.7	70.4	7.4	-2.6	7.7	-2.3	12.8	0.001	25.6	0.001	3	Disagree
Q28	0.26	*0.025*	*0.1*	0.235	21.7	2.3	45.7	69.2	9.7	-0.3	9.7	-0.3	32	0.001	32	0.001	3	Disagree
Q29	0.26	0.1	0.4	0.16	21.7	9.1	31.7	51.1	7.7	-2.3	7.7	-2.3	25.6	0.001	25.6	0.001	3	Disagree
Q30	0.17	*0.025*	*0.1*	0.145	14.2	2.3	19.7	101.2	9.1	-0.9	9.7	-0.3	10.7	0.001	32	0.001	3	Disagree
Q31	0.21	*0.025*	*0.1*	0.185	17.5	2.3	46.4	79.8	9.1	-0.9	9.1	-0.9	10.7	0.001	10.7	0.001	3	Disagree
G32	0.11	*0.025*	*0.1*	0.085	9.2	2.3	34.0	81.3	8.4	-1.6	8.4	-1.6	14.4	0.001	14.4	0.001	3	Disagree
G33	0.13	0.09	0.3	0.04	10.8	6.8	27.0	64.8	4.1	-5.9	5.1	-4.9	3.2	0.001	6.5	0.001	3	Disagree
Q34A	0.14	*0.025*	*0.1*	0.115	11.7	2.3	34.5	94.6	5.3	-4.8	6.5	-3.5	2.4	0.001	3.55	0.001	3	Disagree
Q34B	0.25	*0.025*	*0.1*	0.225	20.8	2.3	54.2	91.2	7.2	-2.8	9.2	-0.8	3.56	0.001	12.6	0.001	3	Disagree
Q34C	0.53	*0.025*	*0.1*	0.505	44.2	2.3	35.0	86.0	8.8	-1.3	9.5	-0.5	8	0.001	20.8	0.001	3	Disagree
Q35	0.31	*0.025*	*0.1*	0.285	25.8	2.3	26.5	68.9	17.7	7.7	17.4	7.4	57.6	25.6	28.8	12.8	3	Disagree
Q35A	0.5	*0.025*	*0.1*	0.475	41.7	2.3	42.0	68.3	17.1	7.1	17.1	7.1	19.2	8.53	19.2	8.53	3	Disagree
G36	0.09	*0.025*	*0.1*	0.065	7.5	2.3	22.2	52.7	8.7	-1.3	8.7	-1.3	28.8	0.001	28.8	0.001	3	Disagree
Q37	0.27	*0.025*	*0.1*	0.245	22.5	2.3	33.7	56.4	8.7	-1.3	8.7	-1.3	28.8	0.001	28.8	0.001	3	Disagree
Q38	0.1	*0.025*	*0.1*	0.075	8.3	2.3	32.5	35.3	3.8	-6.2	3.7	-6.3	200	200	12.8	0.001	3	Disagree
Q39	0.29	*0.025*	*0.1*	0.265	24.2	2.3	44.0	71.5	9.1	-0.9	9.1	-0.9	10.7	0.001	10.7	0.001	3	Disagree

Project: **BIPR**
Client: BIPR
Data: **ABA Data**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Total C (% Leco)	Inorganic C (%)	Inorganic CO_2 (%)	Excess C (%)	Total CaNP (kg $CaCO_3$/t)	Inorganic CaNP (kg $CaCO_3$/t)	(Ca) CaNP (kg $CaCO_3$/t)	(Ca+Mg) CaNP (kg $CaCO_3$/t)	TNNP (kg $CaCO_3$/t)	Adjusted TNNP (kg $CaCO_3$/t)	SNNP (kg $CaCO_3$/t)	Adjusted SNNP (kg $CaCO_3$/t)	TNPR	Adjusted TNPR	SNPR	Adjusted SNPR	Fizz Rating Unity	Comparison of Fizz Rating & NP
Method	C-IR07	C-GAS05	C-GAS05	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	Calculated	OA-VOL08	
MDL	0.01	0.05	0.2															
Maximum	7.57	7.75	28.4	0.57	631	646	507	635	625	615	625	615	2000	1970	2000	1970		
Minimum	0.05	0.025	0.1	0	4.17	2.27	0.25	3.96	1.69	-8.31	1.84	-8.16	2.4	0.001	3.55	0.001		
Mean	0.5	0.28	1.03	0.22	41.6	23.5	43.5	88.8	29.3	19.3	29.6	19.6	99	83.9	126	114		
Standard Deviation	1.13	1.17	4.29	0.14	94.2	97.6	76.9	103	94.5	94.5	94.4	94.4	305	302	299	298		
10 Percentile	0.12	0.025	0.1	0.069	9.83	2.27	2.65	16	3.24	-6.76	3.18	-6.82	3.78	0.001	8.29	0.001		
25 Percentile	0.17	0.025	0.1	0.12	14.2	2.27	16.2	39.9	6.69	-3.31	6.84	-3.16	9.6	0.001	12.8	0.001		
Median	0.26	0.025	0.1	0.2	21.7	2.27	27	69.2	8.38	-1.62	8.69	-1.31	16	0.001	28.8	0.67		
75 Percentile	0.36	0.05	0.2	0.27	30	4.55	41.7	93.4	10.1	0.062	10.7	0.68	51.2	19.2	200	200		
90 Percentile	0.56	0.28	1.06	0.47	46.5	24.1	84.6	165	31	21	31	21	200	200	200	200		
Interquartile Range (IQR) [1]	0.19	0.025	0.1	0.16	15.8	2.27	25.5	53.6	3.38	3.38	3.83	3.83	41.6	19.2	187	200		
Variance	1.28	1.37	18.4	0.02	8879	9532	5917	10577	8925	8925	8914	8914	93109	91504	89164	88869		
Skewness	5.87	6.18	6.19	0.91	5.87	6.19	5.25	3.83	6	6	6	6	5.79	5.8	5.85	5.71		
Coefficient of Variation (CoV) [2]	2.27	4.18	4.15	0.64	2.27	4.15	1.77	1.16	3.23	4.9	3.19	4.82	3.08	3.61	2.37	2.61		
Count	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45		
NPR < 1.0 or NPR = 1.0													0	30	0	23		
1.0 < NPR < 2.0													0	1	0	1		
NPR > 2.0 or NPR =2.0													45	14	45	21		
% NPR < 1.0 or NPR = 1.0 of Total													0.00	66.67	0.00	51.11		
% 1.0 < NPR < 2.0 of Total													0.00	2.22	0.00	2.22		
% NPR > 2.0 or NPR =2.0 of Total													100.00	31.11	100.00	46.67		

[1] Interquartile Range (IQR) = 75th percentile minus 25th percentile
[2] Coefficient of Variation (CoV) = standard deviation divided by mean
NOTE: If data was reported as < detection limit half the detection limit is shown in italics and was used in subsequent calculations.
NOTE: Data in blue is calculated.

Total CaNP = % C * 10 * 100.09 / 12.01
Inorganic CaNP = % CO_2 * 10 * 100.09 / 44.01
(Ca) CaNP = (Ca(ppm) * 100.09 / 40.08) / 1000
(Ca+Mg) CaNP = ((Ca(ppm) * 100.09 / 40.08) + (Mg(ppm) * 100.09 / 24.31)) / 1000
TNNP = NP - TAP
Adjusted TNNP = (NP - 10) - TAP
SNNP = NP - SAP
Adjusted SNNP = (NP - 10) - SAP

TNPR = NP / TAP
Note: If % S(Total) < 0.01 then TNPR = 200
Note: If % S(Total) > 0.01 and NP < = 0 then TNPR = 0.001
Adjusted TNPR = (NP - 10) / TAP
Note: If % S(Total) < 0.01 then Adjusted TNPR = 200
Note: If % S(Total) > 0.01 and (NP - 10) < = 0 then Adjusted TNPR = 0.001
SNPR = NP / SAP
Note: If % S(Sulphide + del) < 0.01 then SNPR = 200
'Note: If % S(Sulphide + del) > 0.01 and NP < = 0 then SNPR = 0.001
Adjusted SNPR = (NP - 10) / SAP
Note: If % S(Sulphide + del) < 0.01 then Adjusted SNPR = 200
Note: If % S(Sulphide + del) > 0.01 and (NP - 10) < = 0 then Adjusted SNPR = 0.001

Project: **BIPR**
Client: BIPR
Data: **ICP Metals Data**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.
Rare earth elements may not be totally soluble in MS61 method.
Interference: Ca>10% on ICP-MS As, ICP-AES results shown.

Sample Id.	Silver Ag (ppm)	Aluminum Al (ppm)	Arsenic As (ppm)	Barium Ba (ppm)	Beryllium Be (ppm)	Bismuth Bi (ppm)	Calcium Ca (ppm)	Cadmium Cd (ppm)	Cerium Ce (ppm)	Cobalt Co (ppm)	Chromium Cr (ppm)	Cesium Cs (ppm)	Copper Cu (ppm)	Iron Fe (ppm)	Gallium Ga (ppm)	Germanium Ge (ppm)
Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
MDL	0.01	100	0.2	10	0.05	0.01	100	0.02	0.01	0.1	1	0.05	0.2	100	0.05	0.05
Crustal Abundance: From	0.037	4200	1	0.4	1	0.007	5100	0.035	11.5	0.1	2	0.4	4	3800	4	0.2
Crustal Abundance: To	0.11	88000	13	2300	3	0.01	312400	0.42	345	74	170	6	250	86500	30	8
PORT #1	*0.005*	45300	1.2	710	0.59	0.04	500	*0.01*	125	1.8	13	1.21	1.8	14600	10.35	0.26
PORT #2	*0.005*	74900	5.1	150	0.98	0.28	49600	0.04	43.2	47.4	77	0.59	184.5	96200	19.45	0.36
AIRSTRIP #1	*0.005*	45500	4.6	460	0.79	0.12	6400	0.04	30	6.1	29	1.14	10.5	17700	10	0.18
AIRSTRIP #2	*0.005*	30200	2	460	0.55	0.08	3900	0.02	25.3	3.1	13	0.9	4	12300	6.8	0.14
Q1	*0.005*	43300	1.5	450	0.85	0.08	6500	*0.01*	54.6	5	10	0.76	27.5	18600	10.95	0.22
Q2	0.31	63300	3	1470	1.44	0.23	6500	0.02	48.9	21.8	15	2.19	99.2	32400	13.75	0.26
Q3	*0.005*	45100	1.9	670	1.39	0.09	700	*0.01*	48.8	1.9	9	4.37	4.8	6000	9.73	0.16
Q4	*0.005*	68600	4.1	400	1.99	0.37	8200	0.06	84.2	15	44	2.76	2.5	32500	17.7	0.31
G5	0.05	61100	4.4	400	2.4	0.51	34700	0.03	62.3	11.1	46	5.05	20.2	29700	16.15	0.16
G6	0.06	70300	3	460	4.26	0.53	38700	0.04	71.3	12.6	48	6.24	23.1	33500	18.15	0.15
Q7	0.03	35100	9	180	1.31	0.14	203000	*0.01*	44.5	7	24	3.02	105.5	14600	9.6	0.11
Q8	0.15	75000	1.1	240	1.13	0.08	55900	0.09	36.9	41.7	27	0.94	254	93400	23.6	0.22
Q9	0.02	40900	0.9	620	1.25	0.11	1600	*0.01*	27.7	2.5	13	1.85	3.2	10900	8.32	0.13
Q10	0.03	42300	4.5	550	1.04	0.94	2300	0.02	31.3	3.4	34	1.57	13.9	12600	9.42	0.13
Q11	0.01	26800	1.8	1040	0.59	0.03	500	*0.01*	25	1.1	17	1.11	3.9	7700	6.54	*0.025*
Q12	0.02	50800	1.5	730	1.42	0.07	400	*0.01*	37.9	3	26	1.94	2.9	11800	11.45	*0.025*
Q13	0.01	17700	1.5	410	0.19	0.01	100	*0.01*	24.6	0.7	21	0.54	2.7	7100	3.79	*0.025*
Q15	0.01	40100	1.6	220	0.85	0.08	2300	0.02	37.3	5	26	1.29	1.9	15400	8.78	*0.025*
G16	0.07	78900	20.9	460	1.44	0.19	4100	0.06	48.7	15.1	94	3.58	20.6	31800	20.4	0.07
Q17	0.19	94000	2.3	700	1.35	0.21	8700	0.18	62.3	20.1	145	4.84	43	42600	22.7	0.12
Q18	0.08	87500	14.7	630	0.96	0.16	6500	0.07	61.4	18.2	160	4.41	28.4	45800	22.2	0.12
G19	0.08	72700	9.9	460	1.21	0.2	9800	0.07	43.8	13.1	92	3.23	22.8	30400	17.8	0.08
Q20	0.11	84800	10.6	460	1.25	0.23	13500	0.18	41.3	18.7	112	4.42	52.7	33100	20.9	0.09
Q21	0.12	88300	1	530	0.97	0.22	13100	0.09	68.2	16.7	141	4.98	43.5	39500	19.45	0.11
Q22	0.23	81400	17.6	340	1.09	0.21	16700	0.13	63.2	11.4	131	5.42	22	34300	19.85	0.1
Q23	0.03	71500	1.6	350	1.18	0.07	13900	0.05	52.4	4.2	17	0.47	11.9	18100	18.8	0.07
Q24	0.04	81600	7.7	810	0.92	0.04	6600	0.02	24.8	4.2	46	1.91	12.9	18200	18.15	*0.025*
Q25	0.04	78400	1.7	460	1.17	0.02	14500	0.03	36	8.2	27	1.77	8.5	22600	20.5	0.05
Q26	0.07	79600	2.1	1000	1.06	0.04	32600	0.06	44.6	17.2	79	2.01	17.2	36400	18.5	0.12
G27	0.06	77000	9.8	520	1.34	0.13	9900	0.07	41.6	11.8	78	2.94	20.5	30000	18.2	0.07
Q28	0.04	85600	1.7	800	1.33	0.16	18300	0.02	34.3	7.1	21	2.74	4.4	18800	23	0.08
Q29	0.05	84600	2.4	730	1.26	0.08	12700	0.03	40.7	4.9	17	3.42	6.6	15400	22.3	0.05
Q30	0.12	101500	2.3	660	2.69	0.33	7900	0.08	56.6	25.9	161	22.5	33	58300	27.9	0.14
Q31	0.07	89500	1.2	550	1.71	0.08	18600	0.05	28.5	8.8	28	7.97	10.3	21400	24.1	0.07
G32	0.08	88300	6.2	620	1.52	0.26	13600	0.08	44.4	13.8	68	4.52	28.4	29800	21.5	0.07
G33	0.06	74400	2	490	0.74	0.22	10800	0.03	63.1	8.6	87	3.39	20.1	18200	18.15	0.08
Q34A	0.11	90900	2.9	780	1.48	0.2	13800	0.1	77	20.1	126	5.25	52.3	39500	23.1	0.13
Q34B	0.14	83900	3.1	600	0.91	0.25	21700	0.09	51.9	9.6	45	3.16	24.5	29500	20.7	0.08
Q34C	0.14	75700	10.3	500	1.44	0.21	14000	0.07	54	14.2	118	8.55	17.2	32500	19.25	0.15
Q35	0.06	84100	*0.1*	1130	1.2	0.07	10600	0.06	43.8	7.7	39	1.24	7.7	15800	17.95	0.15
Q35A	0.05	76600	*0.1*	1520	1.54	0.02	16800	0.02	93.3	9.2	24	1.53	8	30000	22.8	0.16
G36	0.08	73700	3.9	550	1.51	0.2	8900	0.05	39.5	7.3	57	4.07	14.6	20300	19.6	0.12
Q37	0.07	76200	*0.1*	1380	1.44	0.08	13500	0.04	184.5	9.2	23	2.41	10.6	30700	23.7	0.24
Q38	0.06	72200	*0.1*	550	1.14	0.09	13000	0.03	54.6	1.1	19	0.96	1.9	5000	17.8	0.11
Q39	0.07	78700	*0.1*	1530	1.2	0.02	17600	*0.01*	186.5	10.9	33	1.19	14.6	35100	23.6	0.22

Project: **BIPR**
Client: BIPR
Data: **ICP Metals Data**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.
Rare earth elements may not be totally soluble in MS61 method.
Interference: Ca>10% on ICP-MS As, ICP-AES results shown.

Sample Id.	Silver Ag (ppm)	Aluminum Al (ppm)	Arsenic As (ppm)	Barium Ba (ppm)	Beryllium Be (ppm)	Bismuth Bi (ppm)	Calcium Ca (ppm)	Cadmium Cd (ppm)	Cerium Ce (ppm)	Cobalt Co (ppm)	Chromium Cr (ppm)	Cesium Cs (ppm)	Copper Cu (ppm)	Iron Fe (ppm)	Gallium Ga (ppm)	Germanium Ge (ppm)
Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
MDL	0.01	100	0.2	10	0.05	0.01	100	0.02	0.01	0.1	1	0.05	0.2	100	0.05	0.05
Crustal Abundance: From	0.037	4200	1	0.4	1	0.007	5100	0.035	11.5	0.1	2	0.4	4	3800	4	0.2
Crustal Abundance: To	0.11	88000	13	2300	3	0.01	312400	0.42	345	74	170	6	250	86500	30	8
Maximum	0.31	101500	20.9	1530	4.26	0.94	203000	0.18	186	47.4	161	22.5	254	96200	27.9	0.36
Minimum	0.005	17700	0.1	150	0.19	0.01	100	0.01	24.6	0.7	9	0.47	1.8	5000	3.79	0.025
Mean	0.068	68620	4.2	638	1.29	0.17	17411	0.05	55.6	11.3	55.1	3.34	29.4	27780	17.3	0.13
Standard Deviation	0.063	20302	4.7	335	0.63	0.17	30802	0.041	34.4	9.59	45.1	3.51	47.5	18700	5.8	0.077
10 Percentile	0.005	40420	0.42	344	0.76	0.034	1060	0.01	28	2.14	13.8	0.92	2.78	11260	9.04	0.035
25 Percentile	0.02	50800	1.5	460	0.97	0.08	6500	0.02	37.3	4.9	21	1.24	6.6	15400	11.4	0.07
Median	0.06	75000	2.3	550	1.21	0.13	10800	0.04	44.6	9.2	34	2.74	14.6	29500	18.5	0.12
75 Percentile	0.08	83900	4.6	730	1.44	0.22	16700	0.07	62.3	15	79	4.41	27.5	33100	21.5	0.16
90 Percentile	0.14	88300	10.1	1094	1.64	0.31	33860	0.09	81.3	20.1	129	5.35	52.5	41360	23.4	0.23
Interquartile Range (IQR) [1]	0.06	33100	3.1	270	0.47	0.14	10200	0.05	25	10.1	58	3.17	20.9	17700	10	0.09
Variance	0.004	412159364	22.1	112032	0.4	0.028	948772374	0.0017	1184	91.9	2038	12.3	2256	349693909	33.6	0.006
Skewness	1.8	-0.84	1.95	1.35	2.61	2.64	5.25	1.57	2.67	1.97	1.06	3.93	3.46	2.09	-0.64	0.99
Coefficient of Variation (CoV) [2]	0.93	0.3	1.12	0.52	0.49	0.96	1.77	0.83	0.62	0.85	0.82	1.05	1.61	0.67	0.34	0.6
Count	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45

0.31 NOTE: if data is boxed, then data is 3 times the maximum crustal abundance.

[1] Interquartile Range (IQR) = 75th percentile minus 25th percentile

[2] Coefficient of Variation (CoV) = standard deviation divided by mean

NOTE: If data was reported as < detection limit half the detection limit is shown in italics and was used in subsequent calculations.

Project: **BIPR**
Client: BIPR
Data: **ICP Metals Data**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.
Rare earth elements may not be totally soluble in MS61 method.

Sample Id.	Hafnium Hf (ppm)	Mercury Hg (ppm)	Indium In (ppm)	Potassium K (ppm)	Lanthanum La (ppm)	Lithium Li (ppm)	Magnesium Mg (ppm)	Manganese Mn (ppm)	Molybdenum Mo (ppm)	Sodium Na (ppm)	Niobium Nb (ppm)	Nickel Ni (ppm)	Phosphorus P (ppm)	Lead Pb (ppm)	Rubidium Rb (ppm)	Rhenium Re (ppm)
Method	ME-MS61	Hg-CV41	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
MDL	0.1	0.01	0.005	100	0.5	0.2	100	5	0.05	100	0.1	0.2	10	0.5	0.1	0.002
Crustal Abundance: From	0.3	0.03	0.01	40	10	5	1600	390	0.2	400	0.3	2	170	1	0.2	NA
Crustal Abundance: To	11	0.4	0.26	48000	115	66	47000	6700	27	40400	35	225	1500	80	170	NA
PORT #1	2.6	0.01	0.01	31400	69.9	5.1	2900	83	0.37	800	4	4	200	10.4	110	*0.001*
PORT #2	3.7	*0.05*	0.084	14300	19.7	39.2	44400	1290	0.69	11700	11.7	58.2	860	5.3	31.8	*0.001*
AIRSTRIP #1	2.5	0.01	0.018	16100	14.8	14.3	5800	232	0.57	11500	4.2	12	330	10	58.2	*0.001*
AIRSTRIP #2	2.6	0.01	0.011	15200	12.8	7.4	2700	158	0.37	6300	3.2	6.1	210	8.8	54.5	*0.001*
Q1	3.7	*0.05*	0.018	17800	26.7	10.7	3600	217	0.41	10200	7.8	4.5	500	12.9	70.8	*0.001*
Q2	4.5	0.01	0.025	40300	24.3	37.3	20200	976	0.43	8500	6.7	47.6	440	12.1	142	*0.001*
Q3	2.6	*0.05*	0.01	40600	23	5.9	2600	122	0.34	900	3.7	3	280	12.9	185.5	*0.001*
Q4	5.5	0.01	0.045	25900	41.9	30	15900	461	0.58	19800	12.4	24.9	720	11.2	136	*0.001*
G5	3.8	0.01	0.05	23900	31.8	43.1	22500	441	0.27	9100	9.8	26.6	400	7.1	132	*0.001*
G6	4.3	0.02	0.061	27100	37	48.9	23600	495	0.29	10400	11.4	29.1	420	7.1	153.5	*0.001*
Q7	2	0.01	0.039	17100	20.8	31.1	31100	463	0.17	3600	6.5	14.8	290	3.6	85.8	*0.001*
Q8	4.9	0.02	0.091	9000	16.1	24.8	27700	1600	0.88	19600	12.4	52.6	990	4.7	34	*0.001*
Q9	2.4	0.02	0.009	32700	14.2	4.3	2800	78	0.27	5100	2.8	3.9	150	8.1	118.5	*0.001*
Q10	3.8	*0.05*	0.012	27600	16.4	11.5	4700	115	0.54	6000	3.5	13.4	190	8.1	90.8	*0.001*
Q11	2.7	0.01	0.006	21700	13.1	1.4	1000	44	0.3	2300	2.4	4	80	6.7	79.5	*0.001*
Q12	3.4	0.01	0.022	35500	19.5	3.8	3800	53	0.31	5700	3.9	8.9	160	9.6	138	*0.001*
Q13	3.1	*0.05*	*0.0025*	16700	13.6	1.1	900	34	0.38	400	1.7	2.3	60	5.6	49.4	*0.001*
Q15	4.5	0.01	0.026	19300	19.1	8.2	4800	154	0.21	300	4.6	13.5	100	3.1	67.9	*0.001*
G16	3.6	0.01	0.036	18000	23.5	39.9	10400	354	0.8	14100	5.9	42.6	410	8.8	75	*0.001*
Q17	3.7	0.02	0.051	25700	29.9	44	18000	398	2.39	21500	7	57.1	620	24.7	80.8	*0.001*
Q18	3.8	0.01	0.043	19300	28.5	41.2	18500	405	2.85	21300	6.9	64.8	610	12.9	58.7	0.002
G19	3.7	0.02	0.032	14800	22.3	29.4	11300	359	1.11	19900	6	34.9	470	14	63.5	*0.001*
Q20	3.2	*0.05*	0.037	15800	20.5	42.5	14500	434	4.02	20100	5.8	51.3	460	18.6	65	0.002
Q21	3.8	0.02	0.039	17100	33.8	21.5	15300	379	2.52	24100	6.7	42	660	16.5	68.7	0.002
Q22	3.7	0.01	0.029	15000	32.2	27	12400	453	1.9	21100	6.3	28.5	930	23.5	66.2	*0.001*
Q23	4.5	0.01	0.045	6900	24.1	6.5	3800	235	1.19	34600	12.5	10.5	180	3.7	18.6	*0.001*
Q24	2.7	0.01	0.017	17700	11.8	30	6400	248	0.71	31900	4	14.2	280	9.2	59.8	*0.001*
Q25	3	*0.05*	0.013	16900	17.5	18.8	6000	232	0.5	29600	4.6	11.6	370	9.8	58.2	*0.001*
Q26	3.1	*0.05*	0.027	28700	20.5	8.1	14900	633	1.04	25300	3.3	29.3	830	13.9	59.4	*0.001*
G27	3	0.01	0.027	18100	19.8	32.4	11100	364	0.96	21500	5.1	32	450	11.6	63.1	*0.001*
Q28	2.6	*0.05*	0.018	18200	13.5	24	5700	267	0.47	36000	5.4	13	470	12.3	56.5	*0.001*
Q29	2.4	0.01	0.016	22500	17.9	36.2	4700	231	0.41	34400	5.1	8.7	410	10.7	61.6	*0.001*
Q30	3.7	*0.05*	0.05	26400	26	272	19800	600	2.02	17600	9.4	71.9	520	15	169	*0.001*
Q31	2	0.01	0.031	36600	12.5	62.7	8100	325	0.26	26200	5.3	15.7	660	20.5	131	*0.001*
G32	3.3	*0.05*	0.031	22100	20.7	42.7	11500	364	0.94	26300	6.3	36.6	520	14.6	82.1	*0.001*
G33	3.4	*0.05*	0.022	36800	31.7	18.5	9200	272	0.99	20300	3.4	27.8	370	21.3	123	*0.001*
Q34A	4	*0.05*	0.039	20100	37.6	52.9	14600	449	2.44	19300	7.9	49.7	640	14.7	80.2	*0.001*
Q34B	2.6	*0.05*	0.039	16900	25.7	26	9000	334	4.45	27000	4.4	15.6	600	16.9	63.8	*0.001*
Q34C	3.2	*0.05*	0.034	17800	24.9	56.4	12400	371	1.74	23300	6.6	35.5	440	13.8	95.4	0.003
Q35	2.9	*0.05*	0.017	38600	20.1	23.3	10300	265	0.2	30500	4.4	19.7	3410	19.6	91.3	0.003
Q35A	7.7	*0.05*	0.021	27300	43	25.4	6400	292	1.09	22800	20.5	10.7	1400	16	103.5	0.002
G36	3	*0.05*	0.021	24500	18	40.6	7400	251	0.74	22400	5.7	18	510	13.4	104	0.002
Q37	10.3	*0.05*	0.04	34300	88.4	40.8	5500	326	3	19900	25.2	13.6	1040	31.4	162.5	0.003
Q38	1.4	*0.05*	*0.0025*	23200	28.1	16.7	700	66	0.47	28000	3	1.6	290	24	57	0.003
Q39	11.4	*0.05*	0.032	30900	93.2	40.2	6700	324	3.5	20800	24.6	15.2	1150	22.9	137.5	0.003

Project: **BIPR**
Client: BIPR
Data: **ICP Metals Data**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.
Rare earth elements may not be totally soluble in MS61 method.

Sample Id.	Hafnium Hf (ppm)	Mercury Hg (ppm)	Indium In (ppm)	Potassium K (ppm)	Lanthanum La (ppm)	Lithium Li (ppm)	Magnesium Mg (ppm)	Manganese Mn (ppm)	Molybdenum Mo (ppm)	Sodium Na (ppm)	Niobium Nb (ppm)	Nickel Ni (ppm)	Phosphorus P (ppm)	Lead Pb (ppm)	Rubidium Rb (ppm)	Rhenium Re (ppm)
Method	ME-MS61	Hg-CV41	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
MDL	0.1	0.01	0.005	100	0.5	0.2	100	5	0.05	100	0.1	0.2	10	0.5	0.1	0.002
Crustal Abundance: From	0.3	0.03	0.01	40	10	5	1600	390	0.2	400	0.3	2	170	1	0.2	NA
Crustal Abundance: To	11	0.4	0.26	48000	115	66	47000	6700	27	40400	35	225	1500	80	170	NA
Maximum	11.4	0.05	0.091	40600	93.2	272	44400	1600	4.45	36000	25.2	71.9	3410	31.4	186	0.003
Minimum	1.4	0.01	0.0025	6900	11.8	1.1	700	34	0.17	300	1.7	1.6	60	3.1	18.6	0.001
Mean	3.74	0.03	0.03	23164	27.1	32.2	11013	361	1.11	17600	7.2	24.5	557	12.9	88.7	0.0013
Standard Deviation	1.87	0.019	0.019	8334	17.4	40	8920	297	1.09	10169	5.21	18.8	524	6.33	39.2	0.00067
10 Percentile	2.44	0.01	0.01	15080	13.5	5.42	2740	80	0.27	2820	3.24	4	168	5.42	55.3	0.001
25 Percentile	2.7	0.01	0.017	17100	17.9	11.5	4700	231	0.37	9100	4	10.7	290	8.8	59.8	0.001
Median	3.4	0.02	0.027	21700	22.3	27	9000	325	0.69	19900	5.8	15.7	450	12.3	79.5	0.001
75 Percentile	3.8	0.05	0.039	27600	29.9	40.6	14900	434	1.19	24100	7.8	35.5	640	16	118	0.001
90 Percentile	4.74	0.05	0.05	36160	40.2	46.9	21580	558	2.72	30140	12.4	52.1	966	22.3	140	0.0026
Interquartile Range (IQR) [1]	1.1	0.04	0.022	10500	12	29.1	10200	203	0.82	15000	3.8	24.8	350	7.2	58.7	0
Variance	3.49	0.00037	0.00035	69450525	303	1597	79574818	88022	1.19	103405000	27.1	354	274965	40.1	1539	0.00000045
Skewness	2.77	0.061	1.21	0.5	2.61	5.08	1.6	2.5	1.58	-0.18	2.21	0.83	3.88	0.75	0.67	1.81
Coefficient of Variation (CoV) [2]	0.5	0.64	0.63	0.36	0.64	1.24	0.81	0.82	0.98	0.58	0.72	0.77	0.94	0.49	0.44	0.51
Count	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45

0.31 NOTE: if data is boxed, then data is 3 times the maximum crustal abundance.

[1] Interquartile Range (IQR) = 75th percentile minus 25th percentile

[2] Coefficient of Variation (CoV) = standard deviation divided by mean

NOTE: If data was reported as < detection limit half the detection limit is shown in italics and was used in subsequent calculations.

Project: **BIPR**
Client: BIPR
Data: **ICP Metals Data**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.
Rare earth elements may not be totally soluble in MS61 method.

Sample Id.	Sulphur S (ppm)	Antimony Sb (ppm)	Scandium Sc (ppm)	Selenium Se (ppm)	Tin Sn (ppm)	Strontium Sr (ppm)	Tantalum Ta (ppm)	Tellurium Te (ppm)	Thorium Th (ppm)	Titanium Ti (ppm)	Thallium Tl (ppm)	Uranium U (ppm)	Vanadium V (ppm)	Tungsten W (ppm)	Yttrium Y (ppm)	Zinc Zn (ppm)	Zirconium Zr (ppm)
Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
MDL	100	0.05	1	1	0.2	0.2	0.05	0.05	0.2	50	0.02	0.1	1	0.1	0.1	2	0.5
Crustal Abundance: From	240	0.1	NA	0.05	0.5	1	0.8	NA	0.004	300	0.16	0.45	20	0.6	20	16	19
Crustal Abundance: To	2400	1.5	NA	0.6	6	2000	4.2	NA	17	13800	2.3	3.7	250	2.2	90	165	500
PORT #1	*50*	0.22	2.2	3	0.8	55.9	0.34	*0.025*	22.9	740	0.41	1	11	0.4	6	3	84.1
PORT #2	200	0.65	37	4	1.1	271	0.69	*0.025*	1.6	12200	0.1	1.2	419	0.4	27.3	63	125.5
AIRSTRIP #1	100	0.27	5.2	3	0.8	156	0.29	*0.025*	5.7	1670	0.27	0.9	42	0.5	7.8	27	84.9
AIRSTRIP #2	100	0.18	3.1	3	0.7	101	0.22	*0.025*	5.2	1110	0.26	0.8	23	0.4	5.8	13	87.5
Q1	100	0.21	4.7	3	0.9	242	0.41	*0.025*	13.7	2220	0.31	0.9	25	0.4	11.3	20	124.5
Q2	100	0.46	12.9	3	1.6	89.8	0.73	*0.025*	12.4	2610	0.89	2.1	98	1.2	15.8	131	148.5
Q3	*50*	0.22	1.6	3	1.7	37.4	0.53	*0.025*	13.6	430	1.08	1.5	11	0.6	5.4	12	82.7
Q4	*50*	1.19	10.6	3	4.1	56.1	1.09	*0.025*	16.3	3000	0.5	3.6	68	3	24.6	34	186
G5	200	0.62	12.1	2	3.4	71.2	0.94	*0.025*	13.3	2670	0.6	2.4	62	2.3	15.4	43	117
G6	100	0.68	13.3	2	4	66.6	1.12	*0.025*	16	3000	0.71	2.8	66	2.5	18.1	47	127.5
Q7	100	0.36	6	3	2.5	57.2	0.65	*0.025*	9.8	1390	0.29	1.7	29	1.7	10.6	8	62.4
Q8	100	0.26	32.7	3	1.9	320	0.88	*0.025*	1.9	13100	0.13	0.5	407	0.4	29.3	137	169
Q9	*50*	0.42	2.8	2	1.2	34.1	0.33	*0.025*	5	750	0.55	0.8	13	0.6	4.5	4	82.3
Q10	300	0.37	4.7	2	0.9	63.2	0.41	*0.025*	7	1190	0.45	1.4	26	0.9	8	16	130
Q11	200	0.52	1.5	1	1	39.5	0.36	*0.025*	6	500	0.36	1	11	0.5	3.2	2	87.8
Q12	*50*	0.77	4.2	2	1.8	43.6	0.45	*0.025*	8.5	930	0.59	1.6	19	0.8	6	3	111
Q13	*50*	0.34	1.9	2	0.4	25.6	0.15	*0.025*	3.1	560	0.19	0.8	8	0.3	4.4	*1*	107.5
Q15	*50*	0.66	4.4	1	1	19.9	0.4	*0.025*	7.3	1400	0.22	1.6	19	0.7	6.2	10	152.5
G16	100	0.3	12.6	2	1.5	178	0.49	*0.025*	7.9	2740	0.42	1.7	83	1.6	11.5	52	117.5
Q17	700	0.07	19.8	2	1.3	266	0.5	0.07	7.6	4010	0.5	2.1	130	0.8	10.5	72	128.5
Q18	500	0.05	19.7	2	1.3	236	0.48	0.05	7.8	3960	0.34	2.1	132	0.8	10.5	77	134
G19	200	0.1	11.9	1	1	262	0.48	0.05	6.9	3390	0.35	1.5	82	3.6	11.3	57	123
Q20	1300	0.45	14.6	2	1.1	297	0.45	0.05	6.9	2910	0.42	1.9	96	3.5	12.8	73	111
Q21	1100	*0.025*	15.6	2	1.1	337	0.48	0.07	7.9	3830	0.39	2	104	0.3	9.6	50	131
Q22	400	0.05	14.1	2	0.8	314	0.51	0.06	8.2	3380	0.43	1.9	91	0.5	10.1	67	124.5
Q23	100	0.06	6.5	2	3.2	135.5	0.98	*0.025*	6.3	1480	0.05	1.2	17	1.7	26.5	26	130.5
Q24	100	0.24	5.9	2	0.6	340	0.29	*0.025*	4.6	1650	0.3	1.6	39	0.5	6.1	40	90
Q25	300	0.06	4.7	2	0.8	396	0.33	*0.025*	7	1900	0.26	1.3	39	0.2	5.7	41	106.5
Q26	200	0.25	14.6	1	0.6	765	0.22	*0.025*	4.1	2680	0.34	0.8	95	0.3	9.5	60	105
G27	200	0.11	11.3	2	1	244	0.39	*0.025*	6.2	2590	0.35	1.4	71	1	10.2	51	102
Q28	*50*	0.15	4.2	2	1.1	636	0.52	*0.025*	3.4	1960	0.29	1.1	34	0.4	9.2	54	82.8
Q29	*50*	0.1	3.7	2	1	556	0.46	*0.025*	4.5	1750	0.35	1.4	27	0.3	7.8	52	82.5
Q30	400	0.07	22.2	2	2.6	246	0.81	*0.025*	7.6	5160	1.1	4.8	160	1.1	9.4	101	123.5
Q31	300	0.05	5.9	2	1.8	522	0.58	*0.025*	3.6	2220	0.74	2.6	50	0.3	9.3	57	65.1
G32	100	0.09	11.3	2	1.2	346	0.51	*0.025*	6.6	3090	0.45	1.7	79	0.9	10.4	57	107
G33	700	*0.025*	7.9	2	1.1	135.5	0.3	*0.025*	15.7	1420	0.62	3.9	35	0.8	9.8	31	105.5
Q34A	1300	*0.025*	17.5	2	1	326	0.55	0.08	9.9	4610	0.48	2.2	120	1	12.3	80	136
Q34B	900	0.07	10.4	2	1.1	526	0.35	0.11	5.8	2800	0.35	1.5	74	0.7	8.9	53	93.1
Q34C	400	0.05	12.2	2	1.2	344	0.52	*0.025*	6.7	3050	0.49	2.2	85	0.5	7	62	110
Q35	100	*0.025*	5.5	3	4.9	419	0.36	*0.025*	4.8	1300	0.34	2.4	29	0.2	22.3	37	99.6
Q35A	200	*0.025*	5.4	2	1.4	321	0.86	*0.025*	13.6	4420	0.41	2.9	51	0.4	10.9	74	318
G36	100	0.06	7.3	2	1.2	248	0.42	*0.025*	6.4	1860	0.47	2	49	0.7	7.4	41	94.6
Q37	100	*0.025*	7.9	2	2.9	156	0.93	*0.025*	56.4	3980	0.65	3.4	47	0.5	20.1	75	362
Q38	*50*	*0.025*	0.9	2	0.6	190	0.2	*0.025*	13.5	360	0.24	1.8	3	0.1	2.5	14	45.7
Q39	300	*0.025*	8	2	1.8	175.5	0.79	*0.025*	51.8	4790	0.58	1.7	60	0.4	18	81	423

Project: **BIPR**
Client: BIPR
Data: **ICP Metals Data**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.
Rare earth elements may not be totally soluble in MS61 method.

Sample Id.	Sulphur S (ppm)	Antimony Sb (ppm)	Scandium Sc (ppm)	Selenium Se (ppm)	Tin Sn (ppm)	Strontium Sr (ppm)	Tantalum Ta (ppm)	Tellurium Te (ppm)	Thorium Th (ppm)	Titanium Ti (ppm)	Thallium Tl (ppm)	Uranium U (ppm)	Vanadium V (ppm)	Tungsten W (ppm)	Yttrium Y (ppm)	Zinc Zn (ppm)	Zirconium Zr (ppm)
Method	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61	ME-MS61
MDL	100	0.05	1	1	0.2	0.2	0.05	0.05	0.2	50	0.02	0.1	1	0.1	0.1	2	0.5
Crustal Abundance: From	240	0.1	NA	0.05	0.5	1	0.8	NA	0.004	300	0.16	0.45	20	0.6	20	16	19
Crustal Abundance: To	2400	1.5	NA	0.6	6	2000	4.2	NA	17	13800	2.3	3.7	250	2.2	90	165	500
Maximum	1300	1.19	37	4	4.9	765	1.12	0.11	56.4	13100	1.1	4.8	419	3.6	29.3	137	423
Minimum	50	0.025	0.9	1	0.4	19.9	0.15	0.025	1.6	360	0.05	0.5	3	0.1	2.5	1	45.7
Mean	271	0.24	9.83	2.18	1.53	237	0.53	0.033	10.2	2817	0.44	1.82	72	0.9	11.3	46.9	127
Standard Deviation	324	0.26	7.68	0.61	1.02	176	0.24	0.018	10.5	2487	0.22	0.88	83.4	0.85	6.5	32	71.2
10 Percentile	50	0.025	2.44	2	0.74	41.1	0.29	0.025	3.8	744	0.23	0.84	11.8	0.3	5.52	5.6	82.6
25 Percentile	100	0.05	4.7	2	1	71.2	0.36	0.025	5.7	1400	0.3	1.2	26	0.4	7	20	90
Median	100	0.15	7.9	2	1.1	242	0.48	0.025	7	2590	0.41	1.7	50	0.6	9.8	50	111
75 Percentile	300	0.36	12.9	2	1.8	326	0.65	0.025	12.4	3380	0.5	2.1	85	1	12.3	63	130
90 Percentile	700	0.64	18.8	3	3.08	481	0.91	0.056	15.9	4534	0.69	2.86	126	2.06	21.4	78.8	162
Interquartile Range (IQR) [1]	200	0.31	8.2	0	0.8	255	0.29	0	6.7	1980	0.2	0.9	59	0.6	5.3	43	40
Variance	104715	0.066	58.9	0.38	1.03	30871	0.059	0.00034	111	6183108	0.049	0.78	6957	0.72	42.3	1022	5073
Skewness	2.1	1.62	1.67	0.5	1.76	0.94	0.86	2.68	3.45	2.85	1.2	1.31	3.19	1.98	1.31	0.7	2.91
Coefficient of Variation (CoV) [2]	1.19	1.05	0.78	0.28	0.66	0.74	0.46	0.56	1.03	0.88	0.51	0.49	1.16	0.94	0.57	0.68	0.56
Count	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45	45

0.31 NOTE: if data is boxed, then data is 3 times the maximum crustal abundance.

[1] Interquartile Range (IQR) = 75th percentile minus 25th percentile

[2] Coefficient of Variation (CoV) = standard deviation divided by mean

NOTE: If data was reported as < detection limit half the detection limit is shown in italics and was used in subsequent calculations.

Project: **BIPR**
Client: BIPR
Data: **Whole Rock by XRF**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Al_2O_3 (%)	BaO (%)	CaO (%)	Cr_2O_3 (%)	Fe_2O_3 (%)	K_2O (%)	MgO (%)	MnO (%)	Na_2O (%)	P_2O_5 (%)	SiO_2 (%)	SrO (%)	TiO_2 (%)	LOI (%)	Total (%)
Method	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06
MDL	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01		
PORT #1	9.43	0.09	0.05	*0.005*	2.2	4.08	0.64	*0.005*	0.16	0.053	81.46	0.01	0.1	1.59	99.87
PORT #2	13.82	0.02	7.09	*0.005*	14.01	1.65	7.17	0.16	1.54	0.179	48.23	0.03	2.22	3.63	99.75
AIRSTRIP #1	9.22	0.06	0.91	*0.005*	2.66	2.03	1.07	0.02	1.71	0.078	79.84	0.02	0.26	2.1	99.98
AIRSTRIP #2	6.03	0.06	0.53	*0.005*	1.78	1.9	0.55	0.01	0.91	0.052	85.78	0.01	0.15	1.6	99.37
Q1	8.78	0.05	0.92	*0.005*	2.81	2.3	0.71	0.02	1.54	0.116	80.72	0.03	0.37	1.36	99.73
Q2	12.47	0.18	0.9	*0.005*	4.76	5.05	3.54	0.12	1.27	0.102	67.47	0.01	0.43	3.68	99.99
Q3	9.18	0.08	0.07	*0.005*	0.83	5.23	0.56	*0.005*	0.17	0.067	82.56	0.01	0.02	1	99.79
Q4	14	0.05	1.16	*0.005*	4.84	3.19	2.74	0.05	2.86	0.156	66.87	0.01	0.55	3.45	99.93
G5	12.09	0.05	4.94	*0.005*	4.28	3	3.81	0.05	1.29	0.097	61.79	0.01	0.43	8	99.84
G6	12.69	0.05	5.07	*0.005*	4.5	3.2	3.7	0.05	1.33	0.091	60.24	0.01	0.47	8.41	99.82
Q7	6.42	0.02	28.87	*0.005*	2.01	1.88	4.9	0.05	0.46	0.066	25.07	0.01	0.2	29.1	99.06
Q8	13.8	0.03	8.22	*0.005*	13.93	1.13	4.61	0.21	2.63	0.224	50.45	0.03	2.38	2.05	99.70
Q9	8.07	0.07	0.18	*0.005*	1.47	4.06	0.56	*0.005*	0.71	0.037	83.32	0.01	0.07	1.3	99.87
Q10	9.03	0.07	0.32	*0.005*	1.87	3.67	0.93	*0.005*	0.91	0.051	81.42	0.01	0.2	1.42	99.91
Q11	5.1	0.12	0.05	*0.005*	1.03	2.64	0.27	*0.005*	0.36	0.026	89.01	0.01	0.02	1.09	99.74
Q12	9.48	0.08	0.04	*0.005*	1.61	4.33	0.72	*0.005*	0.79	0.044	80.83	0.01	0.1	1.7	99.74
Q13	3.33	0.05	*0.005*	*0.005*	0.93	1.99	0.24	*0.005*	0.08	0.021	92.75	*0.005*	0.05	0.55	100.01
Q15	7.48	0.02	0.29	*0.005*	2.07	2.33	0.9	0.01	0.1	0.039	84.25	*0.005*	0.19	2.19	99.88
G16	16.11	0.06	0.56	*0.005*	4.65	2.28	1.89	0.04	1.99	0.093	68.47	0.02	0.54	3.23	99.94
Q17	18.46	0.08	1.21	0.01	6.21	3.11	3.09	0.05	2.9	0.134	61.19	0.03	0.7	2.63	99.80
Q18	18.2	0.07	0.98	0.01	6.95	2.4	3.32	0.05	2.97	0.139	61.02	0.03	0.7	3.07	99.91
G19	14.59	0.06	1.38	*0.005*	4.56	1.92	2.04	0.04	2.82	0.111	68.82	0.03	0.61	2.96	99.95
Q20	15.72	0.05	1.8	*0.005*	4.66	1.91	2.4	0.04	2.63	0.1	67.23	0.03	0.53	2.35	99.46
Q21	17.35	0.06	1.73	0.01	5.75	2.03	2.55	0.04	3.15	0.149	64.54	0.04	0.6	1.69	99.69
Q22	15.11	0.04	2.2	0.01	4.82	1.79	2.08	0.05	2.77	0.19	68.16	0.03	0.52	2.11	99.88
Q23	13.25	0.04	1.79	*0.005*	2.44	0.84	0.62	0.02	4.5	0.045	75.08	0.02	0.19	1.02	99.86
Q24	15.42	0.09	0.89	*0.005*	2.56	2.18	1.08	0.02	4.29	0.065	71.19	0.04	0.22	1.75	99.80
Q25	14.66	0.05	1.88	*0.005*	3.13	2.02	1	0.02	3.91	0.081	71.46	0.04	0.25	1.47	99.98
Q26	14.92	0.11	4.13	*0.005*	5.1	3.34	2.46	0.07	3.27	0.172	65.02	0.08	0.39	0.73	99.80
G27	14.9	0.06	1.31	*0.005*	4.24	2.19	1.91	0.04	2.87	0.101	69.47	0.03	0.43	2.01	99.57
Q28	16.08	0.09	2.42	*0.005*	2.63	2.22	0.97	0.02	4.71	0.103	69.03	0.07	0.27	1.17	99.79
Q29	15.76	0.08	1.66	*0.005*	2.14	2.75	0.81	0.02	4.64	0.09	70.21	0.06	0.24	1.34	99.81
Q30	19.31	0.08	1.08	0.01	7.98	3.13	3.3	0.06	2.29	0.114	59.1	0.03	0.82	2.55	99.85
Q31	17.3	0.07	2.45	*0.005*	3.06	4.56	1.39	0.03	3.5	0.142	65.85	0.06	0.32	0.98	99.72
G32	16.04	0.07	1.71	*0.005*	4.04	2.59	1.87	0.03	3.41	0.109	67.84	0.04	0.47	1.76	99.98
G33	13.49	0.05	1.36	*0.005*	2.44	4.44	1.56	0.02	2.71	0.086	72.3	0.02	0.21	1.11	99.80
Q34A	16.7	0.09	1.8	0.01	5.58	2.45	2.47	0.05	2.6	0.134	65.15	0.03	0.74	2.1	99.90
Q34B	15.74	0.07	2.88	*0.005*	4.24	2.1	1.56	0.03	3.66	0.131	67.24	0.06	0.46	1.62	99.80
Q34C	15.91	0.07	2.02	*0.005*	4.92	2.35	2.3	0.04	3.37	0.1	65.59	0.04	0.53	2.35	99.60
Q35	17.67	0.14	1.53	*0.005*	2.35	5.19	1.88	0.02	4.54	0.729	62.73	0.05	0.2	2.15	99.18
Q35A	15.86	0.19	2.38	*0.005*	4.44	3.67	1.22	0.03	3.42	0.304	65.58	0.04	0.81	1.96	99.91
G36	15.49	0.07	1.26	*0.005*	2.94	3.14	1.35	0.02	3.29	0.112	70.5	0.03	0.31	1.38	99.90
Q37	15.53	0.16	1.85	*0.005*	4.43	4.42	1.03	0.03	2.97	0.227	66.93	0.02	0.67	1.23	99.50
Q38	15.01	0.07	1.85	*0.005*	0.73	2.97	0.16	*0.005*	4.08	0.072	74.29	0.03	*0.005*	0.55	99.83
Q39	15.93	0.19	2.44	*0.005*	5.14	3.94	1.25	0.03	2.98	0.25	65.42	0.02	0.83	1.12	99.55

Project: **BIPR**
Client: BIPR
Data: **Whole Rock by XRF**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Al_2O_3	BaO	CaO	Cr_2O_3	Fe_2O_3	K_2O	MgO	MnO	Na_2O	P_2O_5	SiO_2	SrO	TiO_2	LOI	Total
	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Method	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06	ME-XRF06
MDL	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01		
Maximum	19.3	0.19	28.9	0.01	14	5.23	7.17	0.21	4.71	0.73	92.8	0.08	2.38	29.1	
Minimum	3.33	0.02	0.005	0.005	0.73	0.84	0.16	0.005	0.08	0.021	25.1	0.005	0.005	0.55	
Mean	13.4	0.076	2.4	0.0057	3.99	2.88	1.89	0.038	2.42	0.12	69.4	0.028	0.46	2.72	
Standard Deviation	3.91	0.041	4.39	0.0017	2.75	1.08	1.43	0.039	1.37	0.11	11.5	0.018	0.46	4.31	
10 Percentile	7.72	0.04	0.11	0.005	1.53	1.89	0.56	0.005	0.4	0.044	60.6	0.01	0.082	1.01	
25 Percentile	9.48	0.05	0.9	0.005	2.2	2.03	0.9	0.02	1.29	0.067	65.2	0.01	0.2	1.3	
Median	14.9	0.07	1.53	0.005	4.04	2.59	1.56	0.03	2.77	0.1	68.2	0.03	0.39	1.75	
75 Percentile	15.9	0.08	2.2	0.005	4.82	3.67	2.47	0.05	3.37	0.14	75.1	0.04	0.55	2.35	
90 Percentile	17.3	0.13	4.62	0.01	6.03	4.43	3.64	0.056	4.21	0.21	83	0.056	0.78	3.56	
Interquartile Range (IQR) [1]	6.43	0.03	1.3	0	2.62	1.64	1.57	0.03	2.08	0.072	9.93	0.03	0.35	1.05	
Variance	15.3	0.0017	19.2	0.000003	7.58	1.18	2.04	0.0015	1.87	0.012	133	0.00032	0.21	18.5	
Skewness	-0.87	1.48	5.28	2.23	2.14	0.58	1.51	2.82	-0.21	3.99	-1.02	0.96	2.87	5.54	
Coefficient of Variation (CoV) [2]	0.29	0.54	1.82	0.3	0.69	0.38	0.75	1.04	0.56	0.89	0.17	0.64	1	1.58	
Count	45	45	45	45	45	45	45	45	45	45	45	45	45	45	

[1] Interquartile Range (IQR) = 75th percentile minus 25th percentile
[2] Coefficient of Variation (CoV) = standard deviation divided by mean
NOTE: If data was reported as < detection limit half the detection limit is shown in italics and was used in subsequent calculations.
NOTE: Data in blue is calculated.

Project: **BIPR**
Client: BIPR
Data: **QA/QC Data - Comparison on ICP Metals and Whole Rock Analyses**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Whole Rock Al * (ppm)	ICP Al (ppm)	Difference (%) [3]	Whole Rock Ba * (ppm)	ICP Ba (ppm)	Difference (%) [3]	Whole Rock Ca * (ppm)	ICP Ca (ppm)	Difference (%) [3]	Whole Rock Cr * (ppm)	ICP Cr (ppm)	Difference (%) [3]	Whole Rock Fe * (ppm)	ICP Fe (ppm)	Difference (%) [3]
PORT #1	49906	45300	-9.23	806	710	-11.92	357	500	39.92	34	13	-62.00	15388	14600	-5.12
PORT #2	73139	74900	2.41	179	150	-16.26	50672	49600	-2.12	34	77	125.08	97991	96200	-1.83
AIRSTRIP #1	48795	45500	-6.75	537	460	-14.40	6504	6400	-1.59	34	29	-15.23	18605	17700	-4.86
AIRSTRIP #2	31912	30200	-5.37	537	460	-14.40	3788	3900	2.96	34	13	-62.00	12450	12300	-1.20
Q1	46466	43300	-6.81	448	450	0.48	6575	6500	-1.14	34	10	-70.77	19654	18600	-5.36
Q2	65995	63300	-4.08	1612	1470	-8.82	6432	6500	1.05	34	15	-56.15	33293	32400	-2.68
Q3	48583	45100	-7.17	717	670	-6.49	500	700	39.92	34	9	-73.69	5805	6000	3.35
Q4	74092	68600	-7.41	448	400	-10.68	8290	8200	-1.09	34	44	28.62	33853	32500	-4.00
G5	63984	61100	-4.51	448	400	-10.68	35306	34700	-1.72	34	46	34.46	29936	29700	-0.79
G6	67159	70300	4.68	448	460	2.72	36235	38700	6.80	34	48	40.31	31475	33500	6.43
Q7	33976	35100	3.31	179	180	0.48	206332	203000	-1.61	34	24	-29.85	14059	14600	3.85
Q8	73033	75000	2.69	269	240	-10.68	58748	55900	-4.85	34	27	-21.08	97431	93400	-4.14
Q9	42709	40900	-4.23	627	620	-1.11	1286	1600	24.37	34	13	-62.00	10282	10900	6.01
Q10	47789	42300	-11.49	627	550	-12.28	2287	2300	0.57	34	34	-0.62	13079	12600	-3.67
Q11	26991	26800	-0.71	1075	1040	-3.24	357	500	39.92	34	17	-50.31	7204	7700	6.88
Q12	50171	50800	1.25	717	730	1.88	286	400	39.92	34	26	-24.00	11261	11800	4.79
Q13	17623	17700	0.44	448	410	-8.45	36	100	179.84	34	21	-38.62	6505	7100	9.15
Q15	39586	40100	1.30	179	220	22.81	2073	2300	10.97	34	26	-24.00	14478	15400	6.37
G16	85258	78900	-7.46	537	460	-14.40	4002	4100	2.44	34	94	174.77	32524	31800	-2.23
Q17	97695	94000	-3.78	717	700	-2.31	8648	8700	0.60	68	145	111.92	43435	42600	-1.92
Q18	96319	87500	-9.16	627	630	0.48	7004	6500	-7.20	68	160	133.85	48611	45800	-5.78
G19	77214	72700	-5.85	537	460	-14.40	9863	9800	-0.64	34	92	168.92	31894	30400	-4.69
Q20	83195	84800	1.93	448	460	2.72	12864	13500	4.94	34	112	227.38	32594	33100	1.55
Q21	91821	88300	-3.83	537	530	-1.38	12364	13100	5.95	68	141	106.08	40218	39500	-1.78
Q22	79966	81400	1.79	358	340	-5.10	15723	16700	6.21	68	131	91.46	33713	34300	1.74
Q23	70123	71500	1.96	358	350	-2.31	12793	13900	8.65	34	17	-50.31	17066	18100	6.06
Q24	81607	81600	-0.01	806	810	0.48	6361	6600	3.76	34	46	34.46	17906	18200	1.64
Q25	77585	78400	1.05	448	460	2.72	13436	14500	7.92	34	27	-21.08	21892	22600	3.23
Q26	78961	79600	0.81	985	1000	1.50	29517	32600	10.45	34	79	130.92	35671	36400	2.04
G27	78855	77000	-2.35	537	520	-3.24	9362	9900	5.74	34	78	128.00	29656	30000	1.16
Q28	85100	85600	0.59	806	800	-0.76	17296	18300	5.81	34	21	-38.62	18395	18800	2.20
Q29	83406	84600	1.43	717	730	1.88	11864	12700	7.05	34	17	-50.31	14968	15400	2.89
Q30	102194	101500	-0.68	717	660	-7.89	7719	7900	2.35	68	161	135.31	55815	58300	4.45
Q31	91556	89500	-2.25	627	550	-12.28	17510	18600	6.23	34	28	-18.15	21403	21400	-0.01
G32	84888	88300	4.02	627	620	-1.11	12221	13600	11.28	34	68	98.77	28257	29800	5.46
G33	71393	74400	4.21	448	490	9.42	9720	10800	11.11	34	87	154.31	17066	18200	6.64
Q34A	88381	90900	2.85	806	780	-3.24	12864	13800	7.27	68	126	84.15	39029	39500	1.21
Q34B	83300	83900	0.72	627	600	-4.30	20583	21700	5.43	34	45	31.54	29656	29500	-0.53
Q34C	84200	75700	-10.10	627	500	-20.25	14437	14000	-3.03	34	118	244.92	34412	32500	-5.56
Q35	93514	84100	-10.07	1254	1130	-9.88	10935	10600	-3.06	34	39	14.00	16437	15800	-3.87
Q35A	83935	76600	-8.74	1702	1520	-10.68	17010	16800	-1.23	34	24	-29.85	31055	30000	-3.40
G36	81977	73700	-10.10	627	550	-12.28	9005	8900	-1.17	34	57	66.62	20563	20300	-1.28
Q37	82189	76200	-7.29	1433	1380	-3.70	13222	13500	2.10	34	23	-32.77	30985	30700	-0.92
Q38	79437	72200	-9.11	627	550	-12.28	13222	13000	-1.68	34	19	-44.46	5106	5000	-2.07
Q39	84306	78700	-6.65	1702	1530	-10.09	17439	17600	0.93	34	33	-3.54	35951	35100	-2.37

Project: **BIPR**
Client: BIPR
Data: **QA/QC Data - Comparison on ICP Metals and Whole Rock Analyses**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Whole Rock Al * (ppm)	ICP Al (ppm)	Difference (%) [3]	Whole Rock Ba * (ppm)	ICP Ba (ppm)	Difference (%) [3]	Whole Rock Ca * (ppm)	ICP Ca (ppm)	Difference (%) [3]	Whole Rock Cr * (ppm)	ICP Cr (ppm)	Difference (%) [3]	Whole Rock Fe * (ppm)	ICP Fe (ppm)	Difference (%) [3]
Maximum			4.68			22.8			180			245			9.15
Minimum			-11.5			-20.3			-7.2			-73.7			-5.78
Mean			-2.84			-5.19			10.5			33			0.38
Standard Deviation			4.81			7.82			28.4			87.1			4.09
10 Percentile			-9.2			-14.4			-1.96			-59.7			-4.79
25 Percentile			-7.17			-10.7			-1.14			-38.6			-2.68
Median			-2.35			-4.3			3.76			-0.62			-0.53
75 Percentile			1.3			0.48			7.92			106			3.35
90 Percentile			2.79			2.38			33.7			147			6.24
Interquartile Range (IQR) [1]			8.47			11.2			9.06			145			6.04
Variance			23.2			61.2			808			7578			16.7
Skewness			-0.15			0.9			5.1			0.72			0.29
Coefficient of Variation (CoV) [2]			-1.7			-1.51			2.72			2.64			10.8
Count			45			45			45			45			45

[1] Interquartile Range (IQR) = 75th percentile minus 25th percentile
[2] Coefficient of Variation (CoV) = standard deviation divided by mean
[3] Difference (%) = (ICP - Whole Rock) * 100 / Whole Rock
20.00 If the difference between the whole rock and ICP analyses are greater than ±20% then difference is shown boxed.

* Element calculated from Whole Rock XRF analysis

Al (Whole Rock) = (Al_2O_3*2*10000*26.98)/(2*26.98+3*16)
Ba (Whole Rock) = (BaO*10000*137.34)/(137.34+16)
Ca (Whole Rock) = (CaO*10000*40.08)/(40.08+16)
Cr (Whole Rock) = (Cr_2O_3*2*10000*52.00)/(2*52.00+3*16)
Fe (Whole Rock) = (Fe_2O_3*2*10000*55.85)/(2*55.85+3*16)

Project: **BIPR**
Client: BIPR
Data: **QA/QC Data - Comparison on ICP Metals and Whole Rock Analyses**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Whole Rock K * (ppm)	ICP K (ppm)	Difference (%) [3]	Whole Rock Mg * (ppm)	ICP Mg (ppm)	Difference (%) [3]	Whole Rock Mn * (ppm)	ICP Mn (ppm)	Difference (%) [3]	Whole Rock Na * (ppm)	ICP Na (ppm)	Difference (%) [3]	Whole Rock P * (ppm)	ICP P (ppm)	Difference (%) [3]
PORT #1	33869	31400	-7.29	3860	2900	-24.86	39	83	114.34	1187	800	-32.60	231	200	-13.53
PORT #2	13697	14300	4.40	43241	44400	2.68	1239	1290	4.11	11425	11700	2.41	781	860	10.10
AIRSTRIP #1	16851	16100	-4.46	6453	5800	-10.12	155	232	49.78	12686	11500	-9.35	340	330	-3.05
AIRSTRIP #2	15772	15200	-3.63	3317	2700	-18.60	77	158	104.01	6751	6300	-6.68	227	210	-7.46
Q1	19093	17800	-6.77	4282	3600	-15.92	155	217	40.10	11425	10200	-10.72	506	500	-1.23
Q2	41921	40300	-3.87	21349	20200	-5.38	929	976	5.02	9422	8500	-9.78	445	440	-1.15
Q3	43415	40600	-6.48	3377	2600	-23.01	39	122	215.06	1261	900	-28.64	292	280	-4.23
Q4	26481	25900	-2.19	16524	15900	-3.78	387	461	19.05	21217	19800	-6.68	681	720	5.76
G5	24903	23900	-4.03	22977	22500	-2.08	387	441	13.89	9570	9100	-4.91	423	400	-5.50
G6	26564	27100	2.02	22314	23600	5.76	387	495	27.83	9867	10400	5.41	397	420	5.76
Q7	15606	17100	9.57	29551	31100	5.24	387	463	19.57	3413	3600	5.49	288	290	0.69
Q8	9380	9000	-4.05	27802	27700	-0.37	1626	1600	-1.62	19511	19600	0.46	977	990	1.28
Q9	33703	32700	-2.97	3377	2800	-17.09	39	78	101.43	5267	5100	-3.17	161	150	-7.10
Q10	30465	27600	-9.40	5609	4700	-16.20	39	115	196.98	6751	6000	-11.12	223	190	-14.63
Q11	21915	21700	-0.98	1628	1000	-38.59	39	44	13.63	2671	2300	-13.88	113	80	-29.49
Q12	35944	35500	-1.23	4342	3800	-12.49	39	53	36.87	5861	5700	-2.74	192	160	-16.67
Q13	16519	16700	1.09	1447	900	-37.82	39	34	-12.20	593	400	-32.60	92	60	-34.53
Q15	19342	19300	-0.22	5428	4800	-11.56	77	154	98.85	742	300	-59.56	170	100	-41.24
G16	18927	18000	-4.90	11398	10400	-8.76	310	354	14.27	14763	14100	-4.49	406	410	1.03
Q17	25817	25700	-0.45	18635	18000	-3.41	387	398	2.78	21514	21500	-0.06	585	620	6.03
Q18	19923	19300	-3.13	20022	18500	-7.60	387	405	4.59	22033	21300	-3.33	607	610	0.57
G19	15938	14800	-7.14	12303	11300	-8.15	310	359	15.89	20920	19900	-4.88	484	470	-2.97
Q20	15855	15800	-0.35	14474	14500	0.18	310	434	40.10	19511	20100	3.02	436	460	5.41
Q21	16851	17100	1.48	15378	15300	-0.51	310	379	22.34	23368	24100	3.13	650	660	1.51
Q22	14859	15000	0.95	12544	12400	-1.15	387	453	16.99	20549	21100	2.68	829	930	12.17
Q23	6973	6900	-1.05	3739	3800	1.63	155	235	51.72	33383	34600	3.64	196	180	-8.34
Q24	18096	17700	-2.19	6513	6400	-1.74	155	248	60.11	31825	31900	0.23	284	280	-1.29
Q25	16768	16900	0.79	6031	6000	-0.51	155	232	49.78	29006	29600	2.05	353	370	4.68
Q26	27726	28700	3.51	14836	14900	0.43	542	633	16.76	24259	25300	4.29	751	830	10.58
G27	18179	18100	-0.44	11519	11100	-3.64	310	364	17.50	21291	21500	0.98	441	450	2.10
Q28	18428	18200	-1.24	5850	5700	-2.56	155	267	72.38	34941	36000	3.03	449	470	4.57
Q29	22828	22500	-1.44	4885	4700	-3.79	155	231	49.14	34422	34400	-0.06	393	410	4.39
Q30	25983	26400	1.61	19902	19800	-0.51	465	600	29.12	16988	17600	3.60	497	520	4.53
Q31	37853	36600	-3.31	8383	8100	-3.37	232	325	39.88	25965	26200	0.91	620	660	6.51
G32	21500	22100	2.79	11278	11500	1.97	232	364	56.67	25297	26300	3.96	476	520	9.32
G33	36857	36800	-0.15	9408	9200	-2.21	155	272	75.61	20104	20300	0.97	375	370	-1.41
Q34A	20338	20100	-1.17	14896	14600	-1.99	387	449	15.95	19288	19300	0.06	585	640	9.45
Q34B	17432	16900	-3.05	9408	9000	-4.34	232	334	43.76	27152	27000	-0.56	572	600	4.96
Q34C	19508	17800	-8.75	13871	12400	-10.60	310	371	19.76	25000	23300	-6.80	436	440	0.83
Q35	43083	38600	-10.41	11338	10300	-9.15	155	265	71.09	33680	30500	-9.44	3181	3410	7.19
Q35A	30465	27300	-10.39	7358	6400	-13.01	232	292	25.68	25371	22800	-10.13	1327	1400	5.53
G36	26066	24500	-6.01	8142	7400	-9.11	155	251	62.05	24407	22400	-8.22	489	510	4.35
Q37	36691	34300	-6.52	6212	5500	-11.46	232	326	40.31	22033	19900	-9.68	991	1040	4.99
Q38	24654	23200	-5.90	965	700	-27.46	39	66	70.44	30268	28000	-7.49	314	290	-7.70
Q39	32706	30900	-5.52	7538	6700	-11.12	232	324	39.45	22107	20800	-5.91	1091	1150	5.41

Project: **BIPR**
Client: BIPR
Data: **QA/QC Data - Comparison on ICP Metals and Whole Rock Analyses**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Whole Rock K * (ppm)	ICP K (ppm)	Difference (%) [3]	Whole Rock Mg * (ppm)	ICP Mg (ppm)	Difference (%) [3]	Whole Rock Mn * (ppm)	ICP Mn (ppm)	Difference (%) [3]	Whole Rock Na * (ppm)	ICP Na (ppm)	Difference (%) [3]	Whole Rock P * (ppm)	ICP P (ppm)	Difference (%) [3]
Maximum			9.57			5.76			215			5.49			12.2
Minimum			-10.4			-38.6			-12.2			-59.6			-41.2
Mean			-2.51			-8.14			46			-5.71			-1.37
Standard Deviation			4.1			10.1			45.9			12.1			11.3
10 Percentile			-7.23			-21.2			4.76			-12.8			-14.2
25 Percentile			-5.52			-11.6			16.8			-9.35			-4.23
Median			-2.19			-4.34			39.5			-3.17			1.28
75 Percentile			-0.22			-1.15			60.1			2.05			5.41
90 Percentile			1.85			1.15			100			3.63			8.47
Interquartile Range (IQR) [1]			5.31			10.4			43.3			11.4			9.65
Variance			16.8			102			2108			147			128
Skewness			0.27			-1.37			2.03			-2.61			-1.93
Coefficient of Variation (CoV) [2]			-1.63			-1.24			1			-2.12			-8.25
Count			45			45			45			45			45

[1] Interquartile Range (IQR) = 75th percentile minus 25th percentile
[2] Coefficient of Variation (CoV) = standard deviation divided by mean
[3] Difference (%) = (ICP - Whole Rock) * 100 / Whole Rock
20.00 If the difference between the whole rock and ICP analyses are greater than ±20% then difference is shown boxed.
* Element calculated from Whole Rock XRF analysis

K (Whole Rock) = (K_2O*2*10000*39.09)/(39.09*2+16)
Mg (Whole Rock) = (MgO*10000*24.31)/(24.31+16)
Mn (Whole Rock) = (MnO*10000*54.94)/(54.94+16)
Na (Whole Rock) = (Na_2O*2*10000*22.99)/(22.99*2+16)
P (Whole Rock) = (P_2O5*2*10000*30.97)/(2*30.97+5*16)

Project: **BIPR**
Client: BIPR
Data: **QA/QC Data - Comparison on ICP Metals and Whole Rock Analyses**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Whole Rock Si * (ppm)	ICP Si (ppm)	Difference (%) [3]	Whole Rock Sr * (ppm)	ICP Sr (ppm)	Difference (%) [3]	Leco S (Total)** (ppm)	ICP S (ppm)	Difference (%) [3]	Whole Rock Ti * (ppm)	ICP Ti (ppm)	Difference (%) [3]
PORT #1	380797			85	56	-33.89	50	50	0.00	599	740	23.44
PORT #2	225459			254	271	6.83	200	200	0.00	13309	12200	-8.33
AIRSTRIP #1	373224			169	156	-7.76	100	100	0.00	1559	1670	7.14
AIRSTRIP #2	400992			85	101	19.44	100	100	0.00	899	1110	23.44
Q1	377338			254	242	-4.60	100	100	0.00	2218	2220	0.08
Q2	315399			85	90	6.20	50	100	100.00	2578	2610	1.25
Q3	385939			85	37	-55.77	100	50	-50.00	120	430	258.63
Q4	312594			85	56	-33.66	100	50	-50.00	3297	3000	-9.01
G5	288847			85	71	-15.80	100	200	100.00	2578	2670	3.57
G6	281601			85	67	-21.24	100	100	0.00	2818	3000	6.47
Q7	117194			85	57	-32.35	100	100	0.00	1199	1390	15.93
Q8	235836			254	320	26.14	100	100	0.00	14268	13100	-8.19
Q9	389492			85	34	-59.67	100	50	-50.00	420	750	78.72
Q10	380610			85	63	-25.26	300	300	0.00	1199	1190	-0.75
Q11	416091			85	40	-53.29	100	200	100.00	120	500	317.01
Q12	377852			85	44	-48.44	50	50	0.00	599	930	55.13
Q13	433574			42	26	-39.45	100	50	-50.00	300	560	86.82
Q15	393840			42	20	-52.93	100	50	-50.00	1139	1400	22.91
G16	320074			169	178	5.25	200	100	-50.00	3237	2740	-15.36
Q17	286042			254	266	4.86	700	700	0.00	4196	4010	-4.44
Q18	285247			254	236	-6.97	500	500	0.00	4196	3960	-5.64
G19	321710			254	262	3.28	200	200	0.00	3657	3390	-7.30
Q20	314277			254	297	17.08	1200	1300	8.33	3177	2910	-8.41
Q21	301702			338	337	-0.37	1000	1100	10.00	3597	3830	6.48
Q22	318624			254	314	23.78	400	400	0.00	3117	3380	8.42
Q23	350973			169	136	-19.88	100	100	0.00	1139	1480	29.93
Q24	332789			338	340	0.52	100	100	0.00	1319	1650	25.10
Q25	334051			338	396	17.08	300	300	0.00	1499	1900	26.77
Q26	303946			676	765	13.09	200	200	0.00	2338	2680	14.63
G27	324748			254	244	-3.81	200	200	0.00	2578	2590	0.47
Q28	322691			592	636	7.45	100	50	-50.00	1619	1960	21.09
Q29	328208			507	556	9.59	100	50	-50.00	1439	1750	21.63
Q30	276272			254	246	-3.03	300	400	33.33	4916	5160	4.97
Q31	307826			507	522	2.89	300	300	0.00	1918	2220	15.72
G32	317129			338	346	2.30	200	100	-50.00	2818	3090	9.67
G33	337978			169	136	-19.88	600	700	16.67	1259	1420	12.79
Q34A	304554			254	326	28.51	1200	1300	8.33	4436	4610	3.92
Q34B	314324			507	526	3.68	900	900	0.00	2758	2800	1.53
Q34C	306611			338	344	1.70	400	400	0.00	3177	3050	-4.01
Q35	293241			423	419	-0.90	100	100	0.00	1199	1300	8.42
Q35A	306564			338	321	-5.10	300	200	-33.33	4856	4420	-8.98
G36	329563			254	248	-2.24	100	100	0.00	1858	1860	0.08
Q37	312875			169	156	-7.76	100	100	0.00	4017	3980	-0.91
Q38	347280			254	190	-25.10	50	50	0.00	30	360	1101.00
Q39	305816			169	176	3.77	300	300	0.00	4976	4790	-3.73

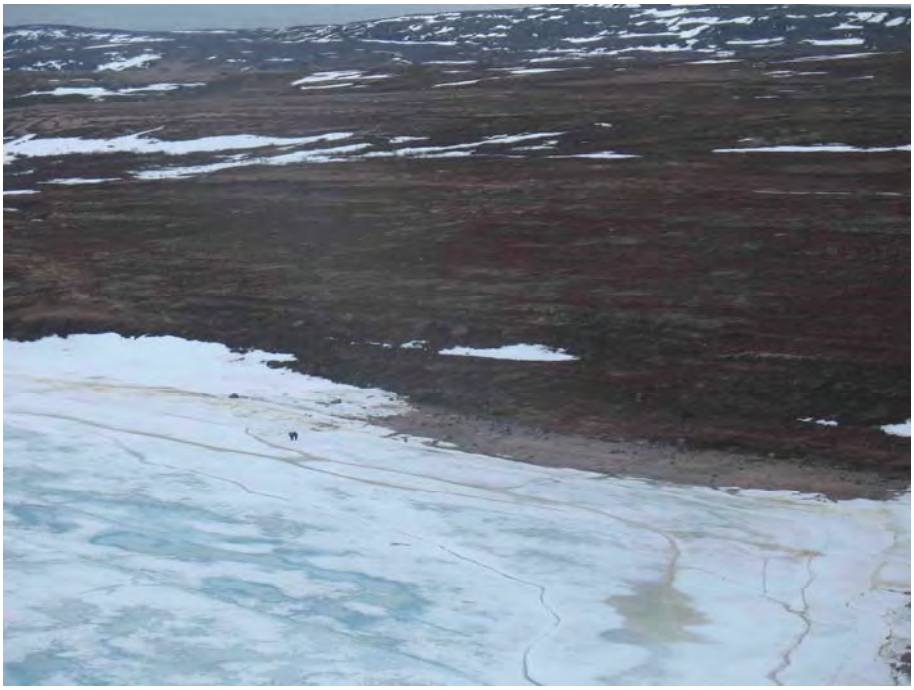
Project: **BIPR**
Client: BIPR
Data: **QA/QC Data - Comparison on ICP Metals and Whole Rock Analyses**
Comments: Sampled by MDAG personnel in with assistance of Dick Turner, SNC-Lavalin.

Sample Id.	Whole Rock Si * (ppm)	ICP Si (ppm)	Difference (%) [3]	Whole Rock Sr * (ppm)	ICP Sr (ppm)	Difference (%) [3]	Leco S (Total)** (ppm)	ICP S (ppm)	Difference (%) [3]	Whole Rock Ti * (ppm)	ICP Ti (ppm)	Difference (%) [3]
Maximum			NA			28.5			100			1101
Minimum			NA			-59.7			-50			-15.4
Mean			NA			-8.35			-2.37			47.3
Standard Deviation			NA			22.8			35.4			172
10 Percentile			NA			-44.8			-50			-8.27
25 Percentile			NA			-21.2			0			-0.91
Median			NA			-2.24			0			6.48
75 Percentile			NA			5.25			0			22.9
90 Percentile			NA			17.1			14			69.3
Interquartile Range (IQR) [1]			NA			26.5			0			23.8
Variance			NA			521			1250			29603
Skewness			NA			-0.71			1.22			5.58
Coefficient of Variation (CoV) [2]			NA			-2.74			-14.9			3.64
Count			0			45			45			45

[1] Interquartile Range (IQR) = 75th percentile minus 25th percentile
[2] Coefficient of Variation (CoV) = standard deviation divided by mean
20.00 If the difference between the whole rock and ICP analyses are greater than ±20% then difference is shown boxed.
[3] Difference (%) = (ICP - Whole Rock) * 100 / Whole Rock
* Element calculated from Whole Rock XRF analysis
Si (Whole Rock) = (SiO_2*10000*28.09)/(28.09+2*16)
Sr (Whole Rock) = (SrO*10000*87.62)/(87.62+16)
Ti (Whole Rock) = (TiO_2*10000*47.9)/(47.9+2*16)
**S (Total) = S (Leco %) * 10000

APPENDIX B. Photographs Selected from Approximately 200 Photographs Collected During Field Work

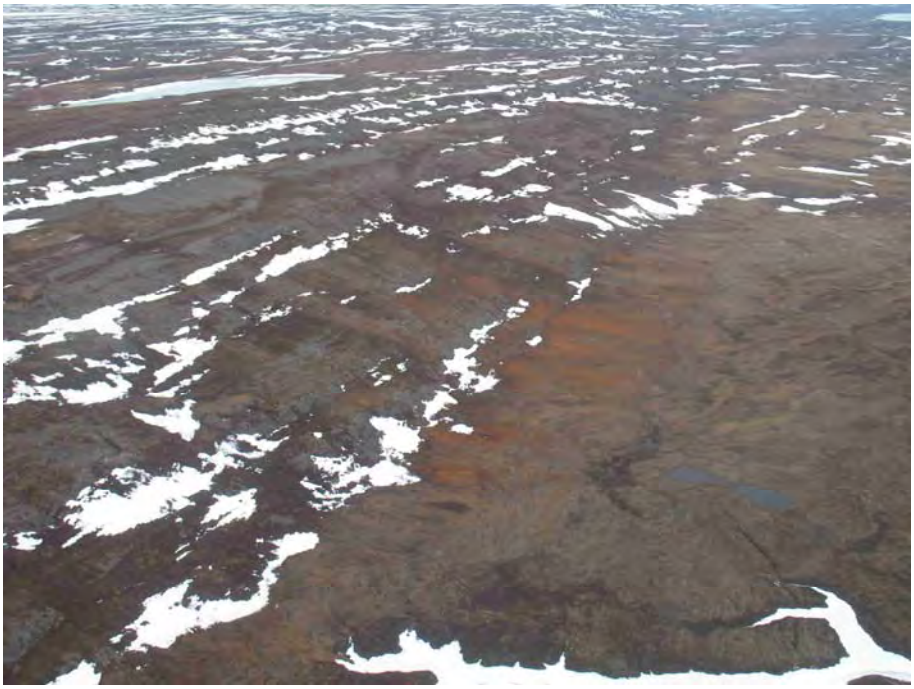
Bathurst Inlet – General Overview



Bathurst Inlet Port Area –
Foreshore with Grizzly Bear, and Proposed Airstrip to Center Left

Port Area – North End Looking South Along Gabbro Ridge and the Shoreline

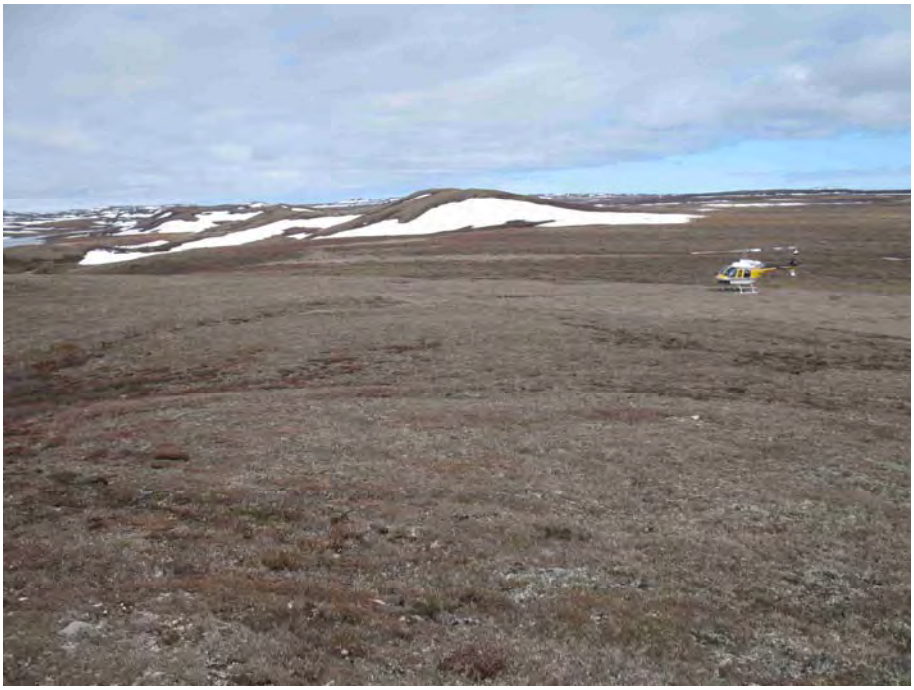
Port Area – Proposed Airstrip Looking Southeast



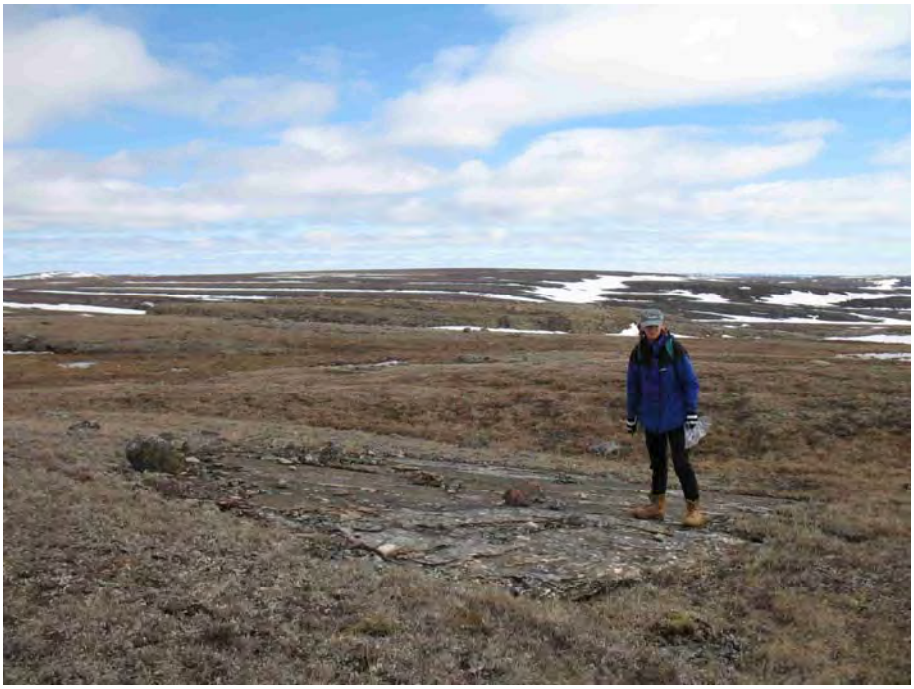
Iron-Stained Drainage from an Outcrop Away from the Proposed Road, Showing Some Rock in the Area May Be Geochemically Reactive

Proposed Quarry Q1

Proposed Quarries Q2 and Q3



Proposed Granular Pit G5

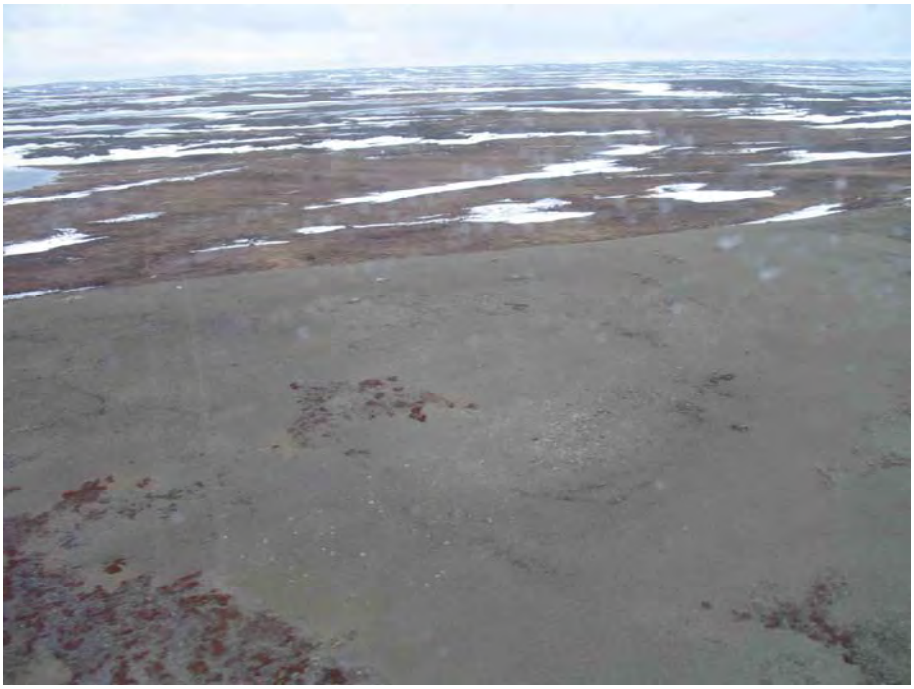


Proposed Quarry Site Q7

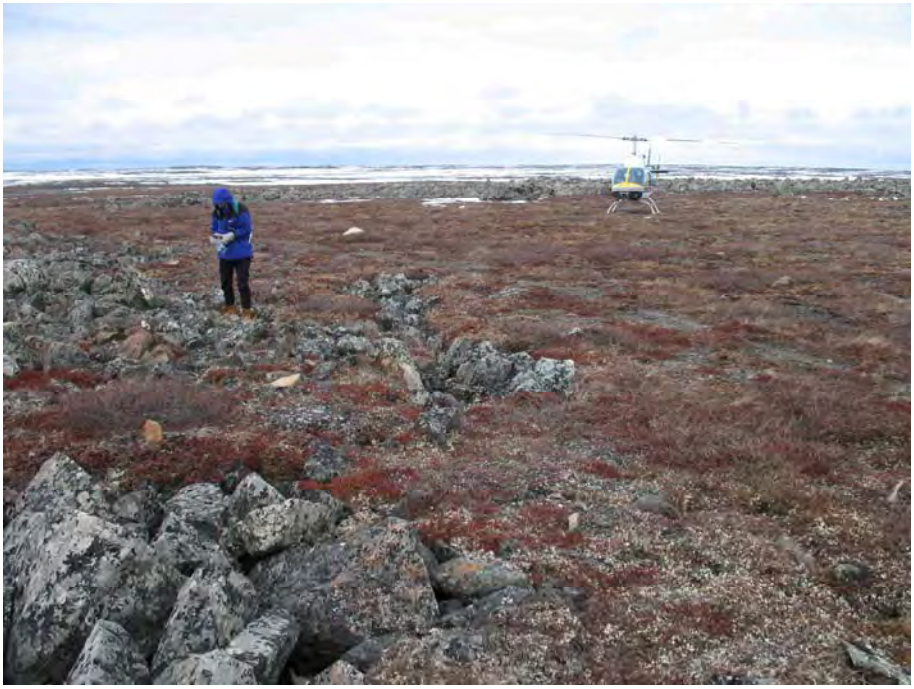
Proposed Quarry Site Q9

Proposed Quarry Site Q9 – Closeup of Rock Fragment

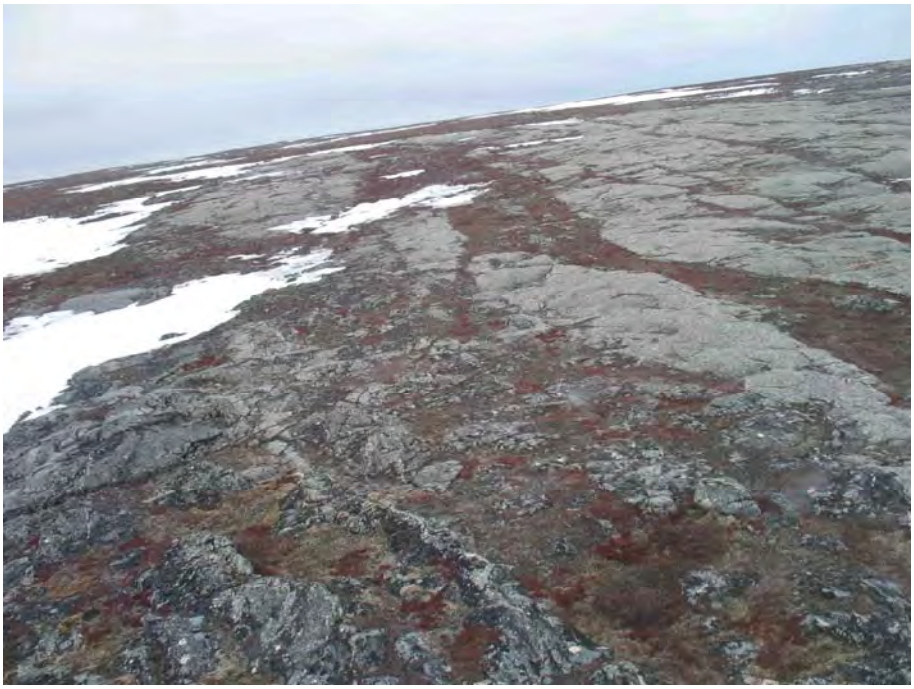
Proposed Quarry Site Q18



Proposed Granular Pit G19



Proposed Quarry Site Q22

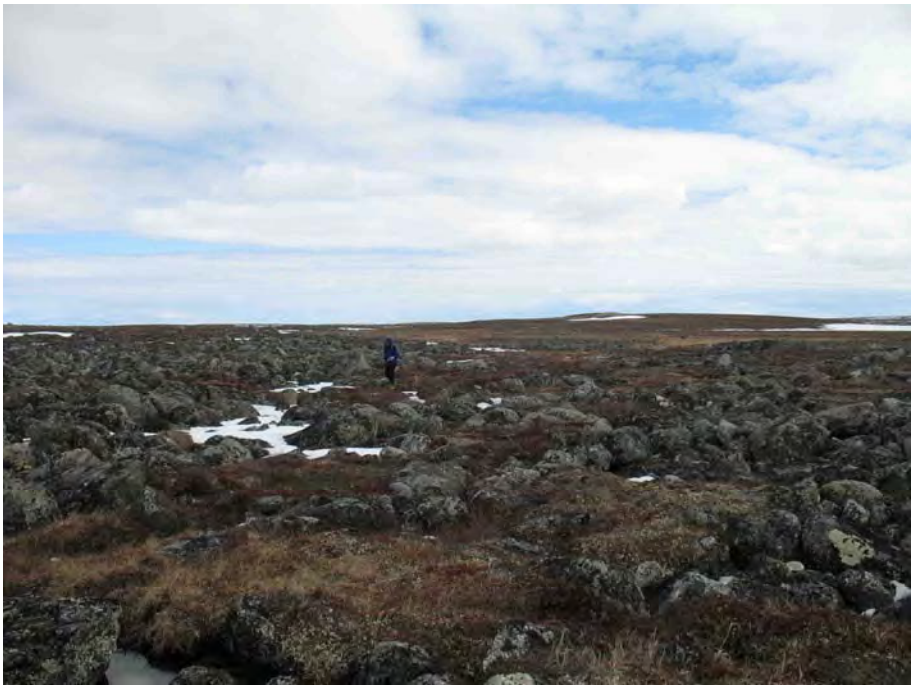


Proposed Quarry Site Q26

Proposed Quarry Site Q26 – Closeup of Rock

Proposed Granular Pit G27

Proposed Granular Pit G32



Proposed Quarry Site Q34A

Proposed Quarry Site 34 A – Closeup of Oxidized Rock

Proposed Quarry Site 38 – Mr. Dick Turner (SNC-Lavalin) to Left and Mr. Brian Doherty (pilot) to Right

Proposed Connection of Road to Contwoyto Lake Ice Road

APPENDIX C. Mineralogy of Two Selected Rock-Quarry Q Samples

C1. Mineralogy by Rietveld X-Ray Diffraction

QUANTITATIVE PHASE ANALYSIS OF TWO POWDER SAMPLES USING THE RIETVELD METHOD AND X-RAY POWDER DIFFRACTION DATA.

(Project : BIPR)

Francois Landry – Kevin Morin
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Vancouver, BC V6T 1Z4

September 12, 2007

EXPERIMENTAL METHOD

The two samples Q7 and Q34A were reduced into fine powder to the optimum grain-size range for X-ray analysis (<10μm) grinding under ethanol in a vibratory McCrone Micronising Mill for 7 minutes. Step-scan X-ray powder-diffraction data were collected over a range 3-80°2θ with CoKα radiation on a standard Siemens (Bruker) D5000 Bragg-Brentano diffractometer equipped with an Fe monochromator foil, 0.6 mm (0.3°) divergence slit, incident- and diffracted-beam Soller slits and a Vantec-1 strip detector. The long fine-focus Co X-ray tube was operated at 35 kV and 40 mA, using a take-off angle of 6°.

RESULTS AND DISCUSSION

The X-ray diffractograms were analyzed using the International Centre for Diffraction Database PDF-4 using Search-Match software by Siemens (Bruker). X-ray powder-diffraction data were refined with Rietveld program Topas 3 (Bruker AXS). The results of quantitative phase analysis by Rietveld refinement are given in Table 1. These amounts represent the relative amounts of crystalline phases normalized to 100%. The Rietveld refinement plots for the samples are shown in Figures 1 – 2.

Table 1. Results of quantitative phase analysis (wt. %)

Mineral	Ideal formula	Q7	Q34A
Quartz	SiO_2	12.9	44.5
Muscovite	$KAl_2AlSi_3O_{10}(OH)_2$	8.0	4.3
Biotite		0.8	12.2
Clinochlore	$(Mg,Fe^{2+})_5Al(Si_3Al)O_{10}(OH)_8$	4.7	2.8
K-feldspar	$KAlSi_3O_8$	4.3	
Plagioclase	$NaAlSi_3O_8 – CaAl_2Si_2O_8$	4.1	35.7
Dolomite	$CaMg(CO_3)_2$	19.4	
Calcite	$CaCO_3$	45.9	0.4
Actinolite **?**	$Ca_2(Mg,Fe^{2+})_5Si_8O_{22}(OH)_2$		0.1
Total		100.0	100.0

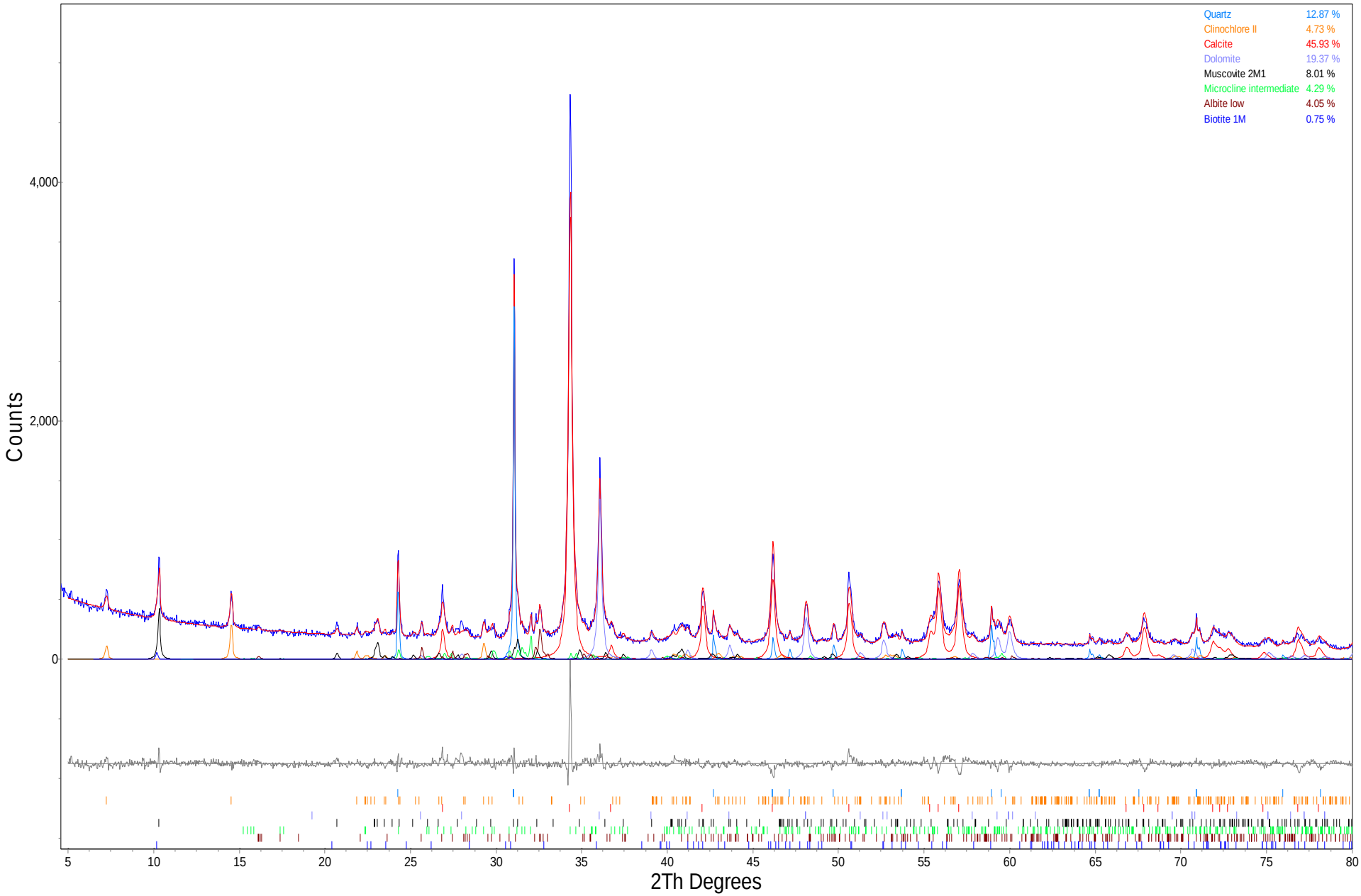

Figure 1. Rietveld refinement plot of sample **Rescan Q7** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

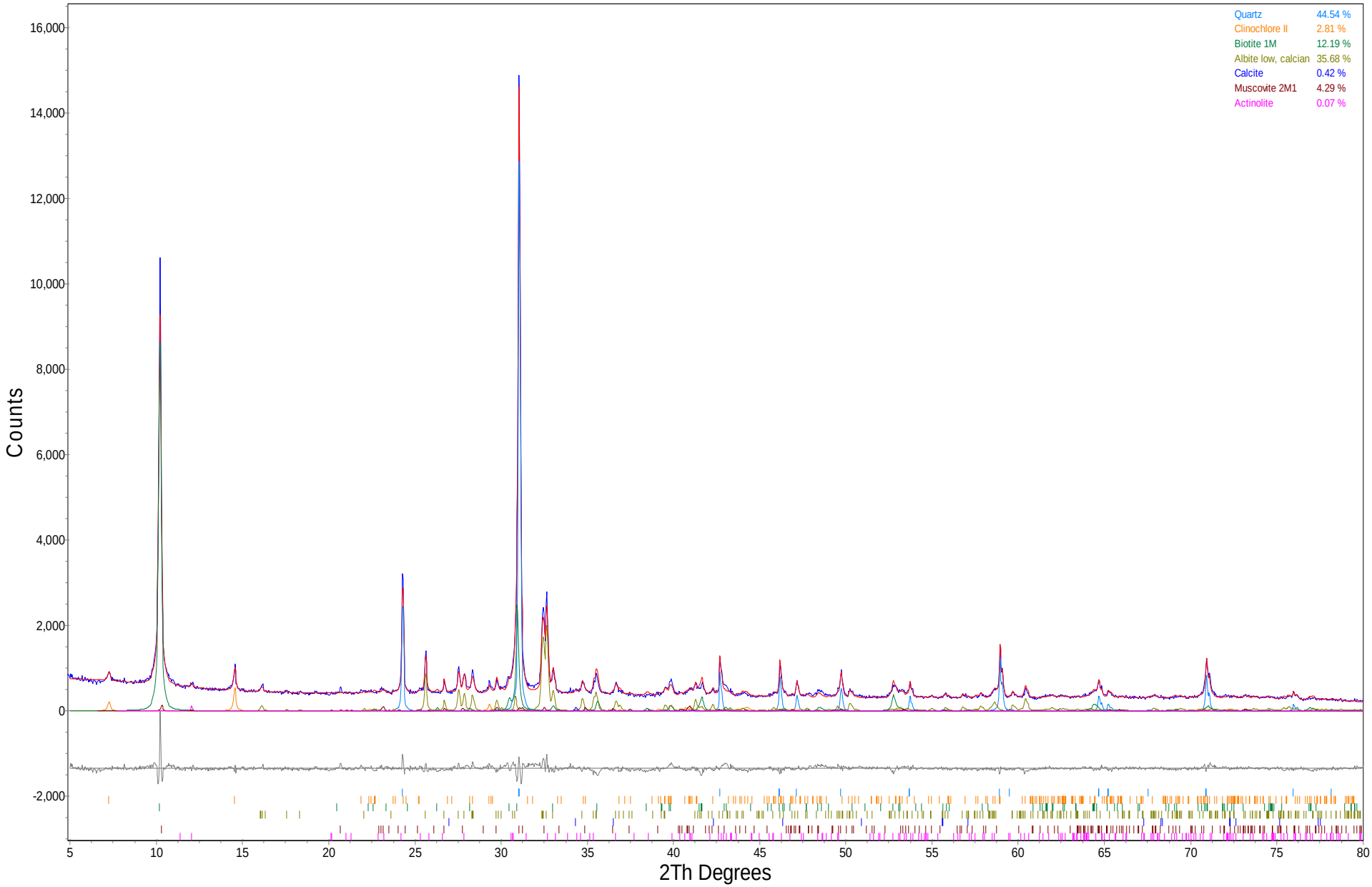

Figure 2. Rietveld refinement plot of sample **Rescan Q34A** (blue line - observed intensity at each step; red line - calculated pattern; solid grey line below – difference between observed and calculated intensities; vertical bars, positions of all Bragg reflections). Coloured lines are individual diffraction patterns of all phases.

C2. Mineralogy by Optical Petrographics

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Harris
EXPLORATION
SERVICES

MINERALOGY AND GEOCHEMISTRY

534 ELLIS STREET, NORTH VANCOUVER, B.C., CANADA V7H 2G6 TELEPHONE (604) 929-5867

Report for: Mine Drainage Assessment Group,
8035 Redtail Court,
SURREY, B.C.
V3W 0N4

Report 07-60

October 11, 2007

Introduction:

2 samples of assay rejects, numbered Q7 and Q34A, were forwarded from Chemex Labs at the request of Kevin Morin. Small portions of each were prepared for petrographic examination as polished thin sections (Slides 07-57507 and 508 respectively).

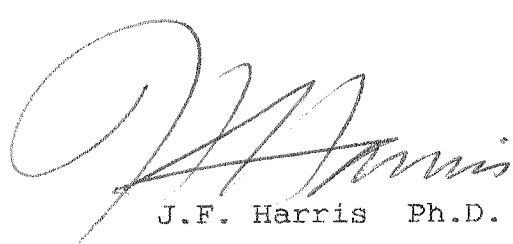
Summary:

Sample Q7 is composed dominantly of fine-grained carbonate rock, with a minor component of andesitic volcanic aspect.

Sample Q34A is a plagioclase/quartz/biotite rock of meta-igneous aspect.

Both samples contain only very low traces of sulfides (chalcopyrite and pyrrhotite), and would, therefore, appear to have negligible acid-generating potential. The carbonate-rich composition of Sample Q7 bestows major excess buffering capacity.

Individual sample descriptions are attached.



J.F. Harris Ph.D.

SAMPLE Q7 (Slide 07-57507)

Estimated mode

Carbonate	82
Plagioclase)	15
Quartz)	
Sericite	2
Biotite	trace
Rutile	trace
Chalcopyrite	trace

The rock fragments making up this polished thin section range in size from 0.05 - 8.0 mm.

They consist dominantly of siltstone-like rocks of carbonate-rich composition, mainly ranging in grain size from 1 - 100 microns.

The principal accessory is plagioclase, with possible minor quartz. This occurs as scattered, small, angular grains in fine-grained carbonate matrices which, by increasing abundance of feldspar, grade to granular intergrowths of plagioclase with accessory carbonate and minor micas. The latter rocks have the appearance of andesitic volcanics, whilst the carbonate-rich variants are probably slightly tuffaceous limestones.

The off-cut shows widespread effervescence with 10% HCl, indicating that much of the carbonate is calcite. A proportion of dolomite may be an additional constituent in the finer-grained variants.

The sulfide content of this polished section is extremely low, being confined to one or two minute specks of disseminated chalcopyrite 10 - 30 microns in size.

SAMPLE Q34A (Slide 07-57508)

Estimated mode

Quartz	25
Plagioclase	550
Biotite	17
Sillimanite	1
Sericite	2
Fe oxides	trace
Pyrrhotite	trace
Chalcopyrite	trace
Carbonate	trace

The rock fragments making up this polished thin section range in size from 5 mm or so down to fines of a few microns.

This sample shows totally different lithology to Q7, consisting of fragments of fresh, granulitic or gneissose metamorphic rocks, composed essentially of varigranular intergrowths of plagioclase and lesser quartz, with biotite as the principal accessory. Sillimanite is a distinctive minor constituent, and there is also a little sericite and rare traces of Fe oxides.

Sulfides are extremely minor, being confined to a few scattered disseminated grains of pyrrhotite and/or chalcopyrite 1 - 300 microns in size.

The lithotype making up this polished thin section appears devoid of endogenic carbonate, though one or two tiny discrete fragments of carbonate rock, similar to that in Q7, were seen. These may be exotic material incorporated in the sample.

Appendix D-7
Wildlife Baseline Studies, 2001 - 2002

Author: **Rescan Environmental Services Ltd.**
Date: **September 2007**

the BATHURST INLET PORT AND ROAD PROJECT

Bathurst Inlet Port and Road Project

Nunavut, Canada

Wildlife Baseline Studies, 2001-2002

Prepared by:

Rescan™ Environmental Services Ltd.
Vancouver, British Columbia, Canada

September 2007

EXECUTIVE SUMMARY

Executive Summary

Wildlife studies were conducted in 2001 and 2002 in support of the Bathurst Inlet Port and Road (BIPR) Project. The BIPR Project includes a marine port facility on Bathurst Inlet, a shipping route and a 211-km all-weather road westwards to a terminus at Contwoyto Lake. The wildlife baseline studies collected a large, geo-referenced database on wildlife locations, densities and migration patterns that can be used to assess the potential impact of the project on wildlife resources.

The principal study method used for inventories was regular fixed-wing aerial surveys for large mammals including caribou, muskoxen, Arctic wolves, foxes, grizzly bears and wolverines within a 10 km-wide corridor along the proposed road route. Surveys were conducted over a 12-month period in 2001 and 2002. Low-level helicopter surveys of carnivore den sites were also conducted in the summer of 2001 and were accompanied by ground surveys of den features. A small mammal trapping survey was conducted in August 2001, and a ground survey of wildlife along the road route was conducted by snowmobile in April 2002. Finally, a helicopter survey of raptor nesting habitat was conducted in July 2002. To supplement field surveys, wildlife data in the project area was also obtained from radio collar work conducted on caribou, wolves and grizzly bears and associated analyses of satellite imagery carried out as part of the West Kitikmeot/Slave Study (WKSS).

The density of caribou in the project area varied seasonally, reflecting the northward migration of caribou through the area in spring and southward migration through the area in late summer and early autumn. No caribou were observed during either aerial survey in July 2001. Densities of caribou increased in August 2001, as caribou began their southward migration and reached an average maximum of 0.60 animals/km^2 in late September, 2001. By November 2001, most caribou had reached their winter grounds at the tree-line well south of the project area and no further observations were recorded. The highest density (0.86 animals/km^2) was recorded in late March of 2002 when caribou began to return to the project area. Significant numbers were also recorded during May 2002 when pregnant cows were travelling towards the calving grounds northeast of Contwoyto Lake. Densities fell between May and early July 2002 as caribou moved through the Project area. No cows with calves were observed in early June 2002, indicating that the migration to the calving grounds was nearly completed by early June. The relatively low densities observed in June and July 2002 indicated that most calving took place north of the Project area. The highest densities of caribou in 2001 and 2002 were observed immediately east of Contwoyto lakes in survey blocks 18E to 21E; these survey blocks received relatively high use during the southern migration in the summer of 2001 and the northern migration in March 2002.

Muskoxen were observed at low densities (an average of 0.3 animals/10 km^2) in the project area throughout the year, reflecting their lack of seasonal migration. An average of 8 animals was observed during each sighting, which suggests that approximately six herds of muskoxen may use habitat within 5 km of the proposed road. Unlike caribou, the distribution of muskox herds within the Project area was not obviously linked spatially to Contwoyto Lake. Instead,

muskoxen were scattered along the road route with relatively high densities observed 30-50 km from Bathurst Inlet (blocks 4E and 5E), 130 – 160 km (blocks 14E - 16E) and at block 19E close to the eastern shore of Contwoyto Lake, 180 – 190 km along the road route.

Summer surveys for carnivore dens found 23 dens in the Project area including 13 Arctic wolf, 2 fox (1 Arctic fox and 1 coloured fox), one wolverine, and two grizzly bear. No dens were found within the easternmost 70 km of the road. Wolf dens were located on elevated sites such as eskers, with substrates consisting of sandy or sandy loam soil stabilized by vegetation. Nearly all wolf dens were on slopes, and approximately half were situated on or near the top of the slope. There was no preferred aspect correlating with den locations. The remains of prey found at den sites were dominated by caribou, followed by ground squirrel. Like wolves, most of the fox dens were built on eskers in soil containing sand, and there was no preferred site aspect. The prey remains found in the proximity of fox dens were similar to those of wolves. A single wolverine den that was found was located in a matrix of rocks at the top of a hill near the proposed camp on the southeastern shore of Contwoyto Lake, and was surrounded by caribou remains. The two grizzly bear dens were located along the eastern section of the road, but neither appeared to have been used for overwintering. Data from the radio-collar program of the WKSS indicated that there is little grizzly bear denning occurring within the project area.

Wolves were observed in the project area from July to November, 2001, and in March and early July, 2002; however, they were not observed in May or early June, 2002. This pattern may reflect their migration south in autumn and north in spring to follow caribou, but it may also reflect the reduced sightability of wolves over snow and in close proximity to their dens. Coloured foxes were observed during aerial surveys of the project area in November 2001 and in March and May 2002, and were also incidentally observed by members of the project team during summer. There was only one incidental sighting of an Arctic fox. These patterns may reflect migratory behaviour of foxes searching for prey or the difficulty of observing foxes from the air. Wolverines were observed during aerial surveys in September 2001 and March 2002, and incidental ground observations were made during the summer of 2001, but detectability of wolverines from the air is low, and this pattern may not reflect their prevalence. Grizzly bears were observed during aerial surveys of the Project area during late August and September 2001, and in May, June and July 2002. Grizzly bears were also seen by ground observers in July and August 2001. Radio-collar data collected on grizzly bears by the WKSS indicated that 14 bears used areas in the vicinity of the proposed road route. Of those, eight males and three females used areas within 6 km of the road route.

During surveys for raptor nests, 59 raptors belonging to five species were observed, including: rough-legged hawk (34), peregrine falcon (18), gyrfalcon (3), raven (3) and bald eagle (1). A total of 108 nest sites were observed. Twenty two of the 108 sites were in occupied territories, of which 18 nests with eggs and two nests with young were observed. In two sites, the likely presence of a nest was inferred from territorial behaviour of parents. Seven of the 108 sites were not occupied territories and did not have nests. The remaining seventy-nine were potential sites, some of which were used as perches. The highest concentration of raptor nesting sites was observed in blocks 1E to 4E, which were located near Bathurst Inlet.

Executive Summary

The small-mammal trapping survey caught 22 animals over 900 trap nights of effort distributed over seven types of habitat. Red-backed voles were the only species caught; their catch-per-unit-effort was greatest in rocky habitat, followed by the riparian zones along streams. No species of lemming were caught, most likely because lemming populations were at the low ebb of their population cycle in 2001.

Eleven species of waterfowl and other non-raptorial bird species were observed during aerial surveys of the Project area. Waterfowl were the most common type of non-raptorial bird and Canada geese were the dominant species of waterfowl. Incidental observations in the summer of 2001 resulted in 44 sightings for a total of 236 birds, the most common of which was the Canada goose.

ACKNOWLEDGEMENTS

Acknowledgements

This report was produced by Rescan™ Environmental Services Ltd. (Rescan). The report was written by Mark Fraker, Ian Ross, Jason Kerr, François Landry, Michael McGurk, Christine Kent and Hugh Blair. John Chételat, Fiona Danks, Jason Kerr, Mark Fraker, John Franklin, Colin Niptanatiak, Ian Ross, David Sateana and George Taptuna conducted the fieldwork. Report production was coordinated by Amanda Broda.

Citation:
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1. INTRODUCTION

1. Introduction

1.1 Overview

This report presents the results of terrestrial wildlife baseline studies conducted in 2001 and 2002 within the Bathurst Inlet Port Road (BIPR) Project Area. Baseline studies on terrestrial wildlife are designed to collect information on:

- wildlife use of the Project area;
- sensitive areas and sensitive temporal periods for wildlife; and
- species of conservation concern.

Baseline information on terrestrial wildlife provide information necessary to assess the potential environmental effects of the construction and the operation of the Project.

Studies on terrestrial wildlife involved extensive ground work in the summer of 2001, including esker surveys, description of denning habitat, assessment of small mammal populations, and wildlife sightings. Aerial surveys for large mammals were conducted on a regular basis over a 12 month period within a 10 km corridor centred on the proposed road route. Winter ground work by snowmobile was completed in April 2002. A survey of raptor nesting habitat was conducted in July 2002. An assessment of grizzly bear habitat suitability within 30 km of the route was also completed.

The specific objectives, methodologies, and results of the terrestrial wildlife studies are presented in this report, which is divided into five chapters; the first chapter presents and discusses results on caribou and muskoxen, the second on den sites and carnivores, the third on small mammals, the fourth on raptors, and the last chapter on waterfowl and other birds.

1.2 Study Area

The BIPR Project is located in the Kitikmeot region of Nunavut. The Project proposes to construct and operate a marine port facility on Bathurst Inlet, located about 40 km south of the community of Bathurst Inlet. The port will operate during the open-water shipping season. A 211 km all-weather road will be constructed from Bathurst Inlet to a terminus at Contwoyto Lake. This road will connect the port facility with inland mining operations for transporting fuel and supplies to these operations.

Habitat use and wildlife movement occurs across a range of spatial scales. Large mammals of the Arctic often travel long distances in their daily and seasonal movement patterns. Home ranges of some species (*e.g.*, caribou and grizzly bears), can cover thousands of square kilometres, while smaller animals (*e.g.*, voles and ground squirrels) may be limited to small home ranges. Habitat features or residences such as nests or dens are limited to specific locations in which direct impacts from projects may be apparent. Therefore, the BIPR wildlife baseline studies were conducted within 5 kilometres of the proposed road for mammals and

within 3 kilometres of the proposed road for raptors (Figure 1.2-1). Incidental observations of all species were recorded during all surveys. Both study areas encompass the proposed port site and the proposed road. The study area boundaries were developed so that the range of potential direct and indirect disturbances to wildlife could be examined.

1.3 Data Sources

The following reports and literature were used to prepare this baseline study report:

- Rescan Baselines Studies (2001-02)
- Canadian Endangered Species Conservation Council (CESCC) Status Reports
- Committee on the Status of Endangered Species in Canada (COSEWIC) Assessment and Status Reports
- Published literature on general ecology and population dynamics of Valued Ecosystem Components (VEC)
- Department of Resources, Wildlife, and Economic Development (RWED) reports, (Government of the NWT) reports
- GeoWest Ecosystem Mapping for Bathurst Inlet Port and Road Project
- Satellite-collar data from the Bathurst caribou herd (WKSS)
- Satellite-collar data from wolf studies (Walton *et al.* 2001)
- Satellite-collar data from barren-ground grizzly bears (RWED, WKSS)

1.4 Objective

The main objective of this report is to present the baseline information collected on valued ecosystem components (VECs) in the study area. The specific objectives of each wildlife study are laid out in their respective sections.

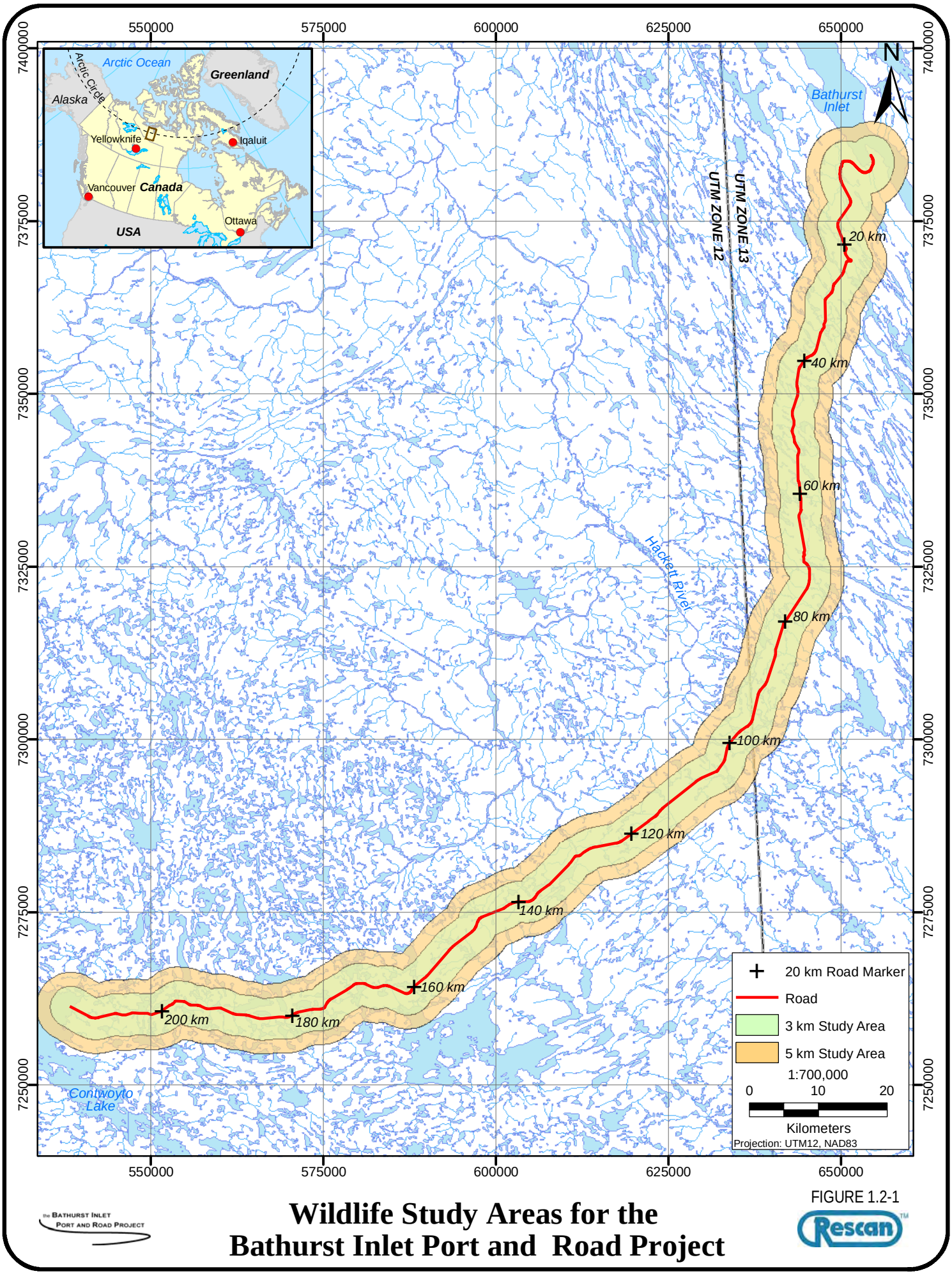


FIGURE 1.2-1

Wildlife Study Areas for the Bathurst Inlet Port and Road Project

The Bathurst Inlet Port and Road Project

Rescan™

2. CARIBOU AND MUSKOXEN

2. Caribou and Muskoxen

2.1 Introduction

Caribou *(Rangifer tarandus)*, the keystone species of the central Arctic barren-grounds, were the focus of the large mammal component of the wildlife baseline studies. All carnivores as well as people depend on caribou. Caribou are highly migratory, with calving and summering on the tundra and wintering in the taiga hundreds of kilometres to the south. Although caribou from three herds may occur in the Bathurst Inlet Port and Road project area, by far the majority of the caribou in the area are members of the Bathurst Herd. Caribou from the Dolphin-and-Union herd may occur in the western parts of the project area in winter, and animals from the Queen Maud (Ahiak) herd may enter the project area from the east. People in settlements throughout the entire range of the caribou rely heavily on these animals, which use the project area during some parts of the year.

Muskoxen *(Ovibos moshatus)* are the only other large ungulate occupying the barren-grounds. Unlike caribou, they do not migrate. They have value to people in the project area for both food and as a species sought after by guided sport hunters.

2.2 Objectives

The overall objective of this chapter is to present information on the distribution, habitat use, and ecology of caribou and muskoxen in the project area. Specific objectives of the field program were to:

1. Establish transects to permit approximately 20% coverage of the area extending 5 km on each side of the proposed road alignment;
2. Conduct aerial surveys in all seasons of the year, with an emphasis on late spring, summer, and early fall, when the largest numbers of large mammals can be expected to be present in the project area; and
3. Conduct a ground survey under late-winter / early-spring conditions to record relative abundance and diversity as evidenced from tracks on the snowscape.

2.3 Methods

Fixed-wing aerial surveys were flown during July, August, September, and early November. To minimize costs, aircraft that were in the project area to support the project (transporting people and supplies) were used as much as possible. As a consequence, surveys were flown with three different aircrafts: a DeHavilland Single Otter, a DeHavilland Twin-Otter, and a DeHavilland Turbo-Beaver. The use of helicopters was impractical owing to their low endurance and the lack of refuelling sites.

During July and August 2001, 10-km long transects were laid out at 5-km intervals centred on and running perpendicular to the proposed road alignment. With two observers viewing 0.5-km survey strips on each side of the aircraft, the level of coverage was approximately 20% of the project corridor. The pilot and a navigator followed the survey route using maps and wildlife

sightings were plotted according to time and distance flown. From September 2001 to the end of the project, the aircraft used were equipped with GPS units, and two or three survey lines roughly parallel with the road alignment were flown. The GPS units permitted the observers to fly from waypoint to waypoint, minimizing the challenge of navigating at low altitude over the tundra. In September 2001, three lines were flown because the aircraft was able to refuel at George Lake, one over the road alignment and the other two inside the outer limits of the 10 km corridor. From November 2001 to July 2002, refuelling at George Lake was not possible, limiting the aircraft's endurance to the fuel on board, and consequently, only the two outer survey lines were flown. The three different types of flight lines flown during the survey are presented in Figure 2.3-1.

For analysis of caribou occurrence in the project area, the numbers of caribou observed were converted to a density (*i.e.*, number/km^2). Polygons (survey blocks) were defined at approximately 10 km intervals by drawing lines perpendicular to the road alignment (Figures 2.3-2 to 2.3-3). The amount of survey effort (coverage by the observers in km^2) was determined during each survey in each block (Appendix 2.3-1) and divided into the number of caribou seen in each block to arrive at a density figure that could be compared among the surveys, regardless of the intensity of survey coverage at any given time. The results are portrayed on maps (Figures 2.3-2 to 2.3-3) as stacked columns for each survey block. Muskoxen densities were also calculated and reported as number of muskoxen per 10 km^2, due to their low numbers.

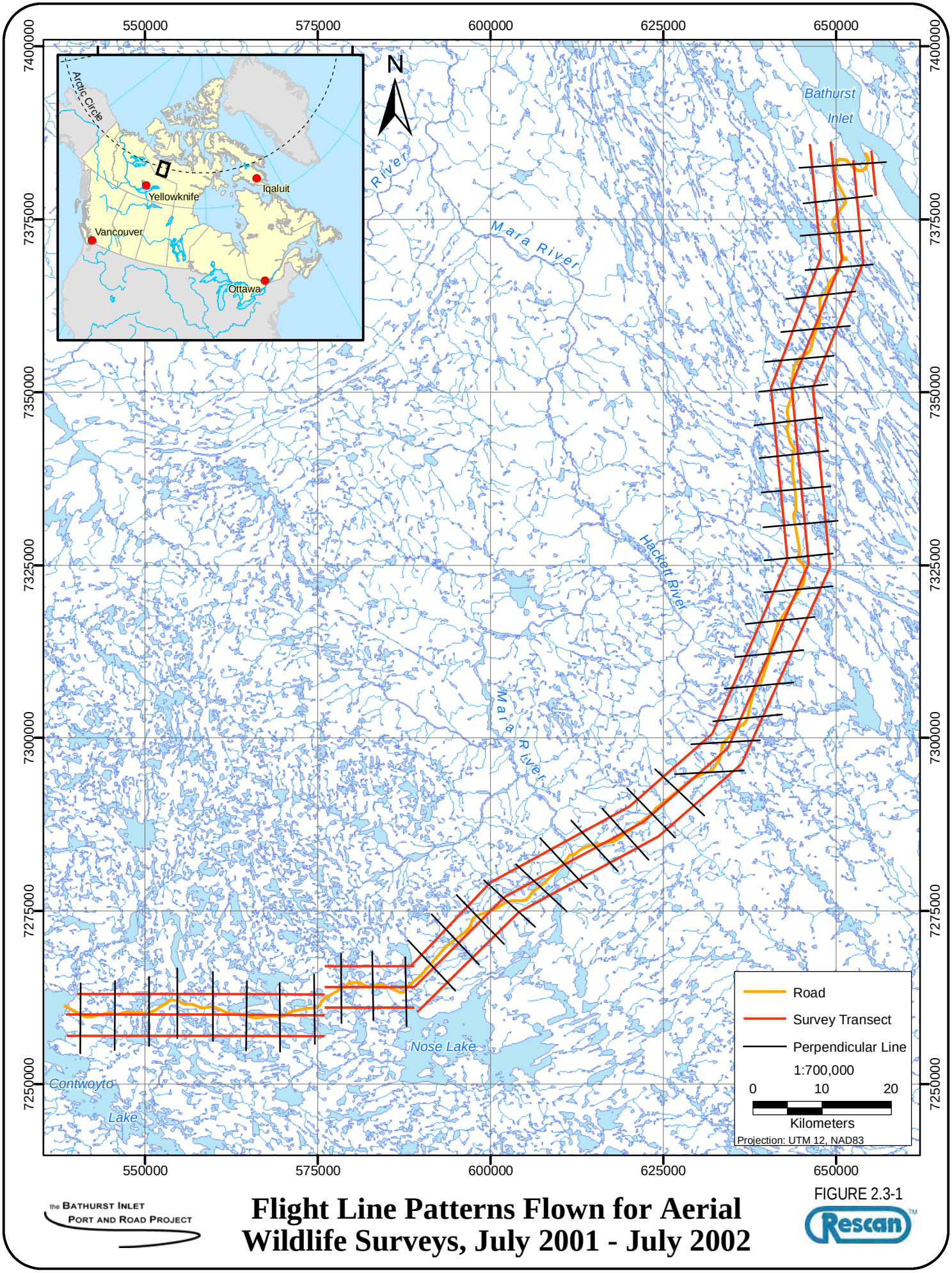
Starting in September, each observer had a hand-held GPS unit equipped with a remote antenna. Thus the position of the aircraft at the time of sightings could be accurately recorded by entering waypoints into the GPS unit. At this time, the survey lines were redrawn so that three transect lines ran parallel to the road alignment within the 10-km corridor. This minimized the amount of time spent off-transect in turns. Wildlife sightings were recorded as waypoints, the details recorded (written or spoken into a tape recorder), and the waypoint data downloaded.

The aerial surveys were flown at an altitude of 150 m (500 ft), at airspeeds of 80-100 knots. Transect width was determined using a clinometer. Observers recorded information directly into a notebook and/or into a tape recorder. In addition to wildlife observations, information such as possible den sites or heavily used caribou trails were also recorded (Plate 2.3-1).

In addition to aerial and ground observations made by the wildlife biologists, during July and August 2001, project personnel, such as fish biologists, botanists, and geotechnical specialists who were working throughout the project area, recorded incidental observations on standard data forms that they were provided. In late April 2002, the entire road route was surveyed from the ground by snow machine.

2.4 Results and Discussion

Seven aerial surveys were conducted in 2001: two in July, two in August, two in September, and one in early November, and four aerial surveys in 2002: one in March, one in May, one in June, and one in July. Detailed information can be found in Appendix 2.4-1.



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Flight Line Patterns Flown for Aerial Wildlife Surveys, July 2001 - July 2002

FIGURE 2.3-1

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Plate 2.3-1. Heavily used caribou trails at the nadlok (near Southeast corner of block 21E).

2.4.1 Caribou

The numbers of caribou observed during each aerial survey per survey block are presented in Appendix 2.4-2 and the densities are presented in Appendix 2.4-3. No caribou were observed during aerial surveys in July 2001 (Table 2.4-1), when the majority were north of the project area. However, the incidental sightings tell a somewhat different story. In July, various people associated with the project reported 11 sightings totalling 760 animals. These apparently different results can be reconciled by realizing that at this time, caribou were moving through the project area in groups of a few 10s to 100s. It just happened that no groups were observed during these aerial surveys. In addition, scattered individuals (not recorded in the incidental observation results) were observed during helicopter surveys for carnivore den sites; these few scattered animals would have been difficult to detect from a fixed-wing aircraft flying at an altitude of 150 m.

During the period 1996 to 2000, Gunn *et al.* (2002) found that during the post-calving and summering period (mid-June through July), satellite-collared caribou dispersed over a broad area that included the project area. Movement patterns differed considerably among years, however, for example, in 1996, most cows travelled west from the calving grounds, before moving south and west of Contwoyto Lake. But in 2000, the collared cows moved more directly southward from the calving grounds and remained clumped in the vicinity of Nose Lake during early July.

The number of caribou in the project area increased during August and September 2001, with the largest number observed during the late September survey (Table 2.4-1). In August, a total of 1,632 caribou were reported during 29 sightings made incidentally to other work. Many of these sightings were of groups beginning their southward migration. Satellite-collared cows were

610000 620000 630000 640000 650000 660000

7380000 7370000 7360000 7350000 7340000 7330000 7320000 7310000 7300000

N

km 0
km 20
km 40
km 60
km 80
km 100

Bathurst Inlet

Mara River

Hackett River

20 km Marker
Esker
Proposed Road
1:250,000
0 5 10
Kilometres
Projection: UTM 12, NAD83

Raptor Nests
- Active
- Old
- Potential

Winter Ground Sightings
- Wolf

Incidental Wildlife Sightings
- Wolf
- Wolverine
- Grizzly

Aerial Wildlife Sightings
- Wolf
- Wolverine
- Grizzly

Incidental Muskox Sightings - Herd Size
- 1-2
- 3-10
- 11-30

Aerial Muskox Sightings - Herd Size
- 1-2
- 3-10
- 11-30

Den Sites
- Arctic Fox
- Coloured Fox
- Fox
- Fox or Wolf
- Grizzly Bear
- Wolf
- Wolverine

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Incidental and Aerial Wildlife Sightings, Raptor Nest and Den Locations, and Aerial Survey Results for Caribou, Bathurst Inlet Port and Road Project, July 2001 - July 2002

FIGURE 2.3-2

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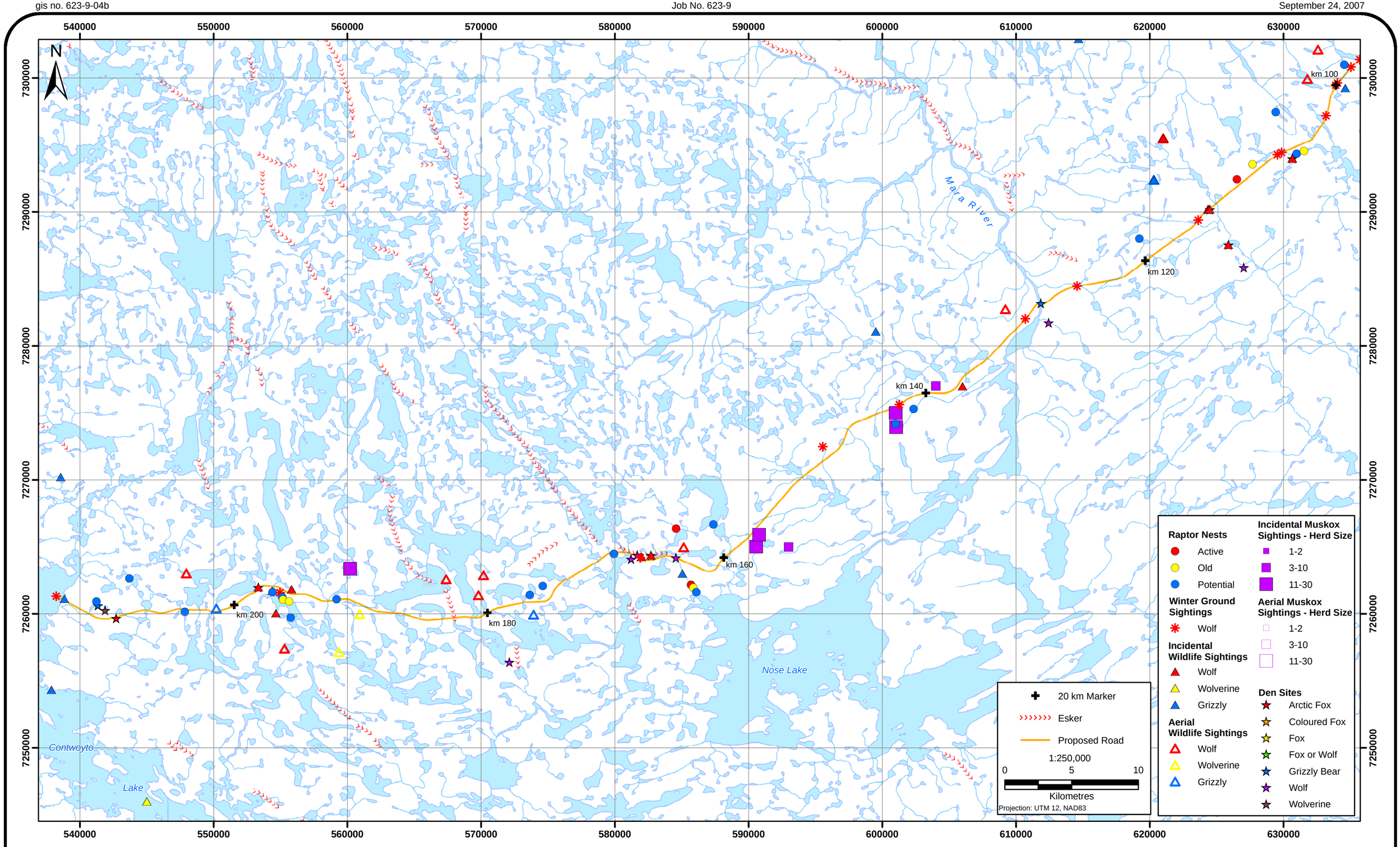

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Incidental and Aerial Wildlife Sightings, Raptor Nest and Den Locations, and Aerial Survey Results for Caribou, Bathurst Inlet Port and Road Project, July 2001 - July 2002

FIGURE 2.3-3

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generally widely dispersed over a very broad area during August and September (Gunn *et al*., 2002). The distribution during this period generally extended to the tree-line on the southwest and as far as George Lake to the northeast, but not to Bathurst Inlet. During August and September, 2001, caribou were widely distributed in the study area, in general, but with few in the northern blocks, near Bathurst Inlet. On 23 August, several hundred caribou were observed moving southward at the "nadlok" in the northwest corner of block 21E. The trails, well-worn into the tundra, tell of repeated use over probably thousands of years (Plate 2.3-1). A hunter's cabin on the land south of the nadlok further suggests that caribou can be reliably expected in this area during fall.

By October, nearly all of the caribou could be expected to be well south of the project area on the rutting areas, which are more-or-less centred on the tree-line (Gunn *et al.*, 2002). No caribou were seen during the November aerial survey. From November through February for all of the years 1996 to 2000, the satellite-collared cows were all well south and/or west of the project area, generally inside the tree-line (Gunn *et al*., 2002).

The highest density of caribou (0.86 animals/km^2) was observed during late March, which corresponds to the time when wolves that have wintered hundreds of kilometres to the south also return (Walton *et al.*, 2001). In late March 2000, however, Gunn *et al*. (2002) found the satellite-collared animals still on the winter range and well south of the tree-line.

During the winter ground survey from 23-28 April 2002, there were 11 sightings totalling 108 caribou, plus 81 records of caribou tracks (Appendix 2.4-4). This time would have been early in the spring migration of cows to the calving grounds (Gunn *et al*., 2002).

However, significant numbers were recorded during an aerial survey in late May 2002 (Table 2.4-1). At that time, the pregnant cows would be travelling toward or gathering on the calving grounds east of Contwoyto Lake and well north of the proposed road (Figure 2.4-1). A much smaller number of caribou was seen during the early June survey, which took place close to the peak of calving, by which time most of the pregnant cows would have been outside the survey area. In early July, relatively few caribou were present.

Gunn *et al.* (2002) show detailed maps of the spring migration of satellite-collared cows for each of the years 1996-2000. In three of those years, virtually all of the collared caribou crossed Contwoyto Lake. In 1998, in contrast, all of the collared cows traveled east of the lake, but did not cross it. In 2000, the spring migration moved over a very broad front that included all of Contwoyto Lake as well as areas to the far east of Bathurst Inlet.

During the early June survey, the number of caribou recorded during the aerial survey of the project area had dropped from 1,329 in late May to just 130. This indicates that the migration to the calving grounds was nearly completed by early June, with few stragglers still en route.

During the survey on 7 June, which should have been the peak of calving, no cows with calves were observed. Thus in 2002, it appears that virtually all of the calving took place north and east of the project area.

Table 2.4-1
Observations of Caribou Made during Aerial and Ground Surveys, July 2001 - July 2002

Caribou	# of Observations		# of Animals Observed		Average
	Aerial (on transect)	Ground observations	Aerial (on transect)	Ground observations	Density (#/km^2)
21-Jul-01	0		0		0.00
29-Jul-01	0		0		0.00
9-Aug-01	44		107		0.25
Summer Ground Observations		29		1,632	
21-Aug-01	61		107		0.25
7-Sep-01	39		196		0.33
20-Sep-01	39		355		0.60
7-Nov-01	0		0		0.00
22-Mar-02	33		346		0.86
Winter Ground Observations		11		108	
28-May-02	24		1,329		0.80
7-Jun-02	26		130		0.32
7-Jul-02	11		103		0.25
Total	**277**	**40**	**2,673**	**1,740**	**0.33**

Gunn *et al.* (2002) show the distribution of satellite-collared cows during the calving period, 1-15 June for the years 1996 – 2000. In those years, the majority of collared cows were consistently north of the Burnside River during calving. There were, however, occasional stragglers in some of those years that may have calved outside of the main area. It is noteworthy that the calving grounds of the Bathurst Herd have shifted significantly in recent years. Historically, the Bathurst Herd has calved east of Bathurst Inlet (Heard and Williams, 1992), but in recent years, these animals have consistently used the area immediately north of the Burnside River (Figure 2.4-1).

The aerial survey results suggest a heavy use of areas relatively close to Contwoyto Lake during both the northward spring migration and the southward fall migration. The densities observed on 22 March, 7 June, 21 August, and 7 and 20 September, in blocks 18E –21E suggest that these areas are particularly well used (Figure 2.3-3 and Appendix 2.4-3). Block 8E may also receive relatively high level of use by migrating caribou (Figure 2.3-3). As might be expected, a large feature such as Contwoyto Lake appears to exert a large influence of the migration movements of the Bathurst caribou.

2.4.2 Muskoxen

Muskoxen were seen during all aerial surveys (Table 2.4-2 and Appendix 2.4-5). The greatest number of sightings during any survey was in early September 2001, when a total of 45 animals were seen although only one animal was seen during the survey later in the month. Some of the animals that were resident in the study area during summer likely had moved off at this time. During both surveys in July and August 2001 a number of animals were observed.

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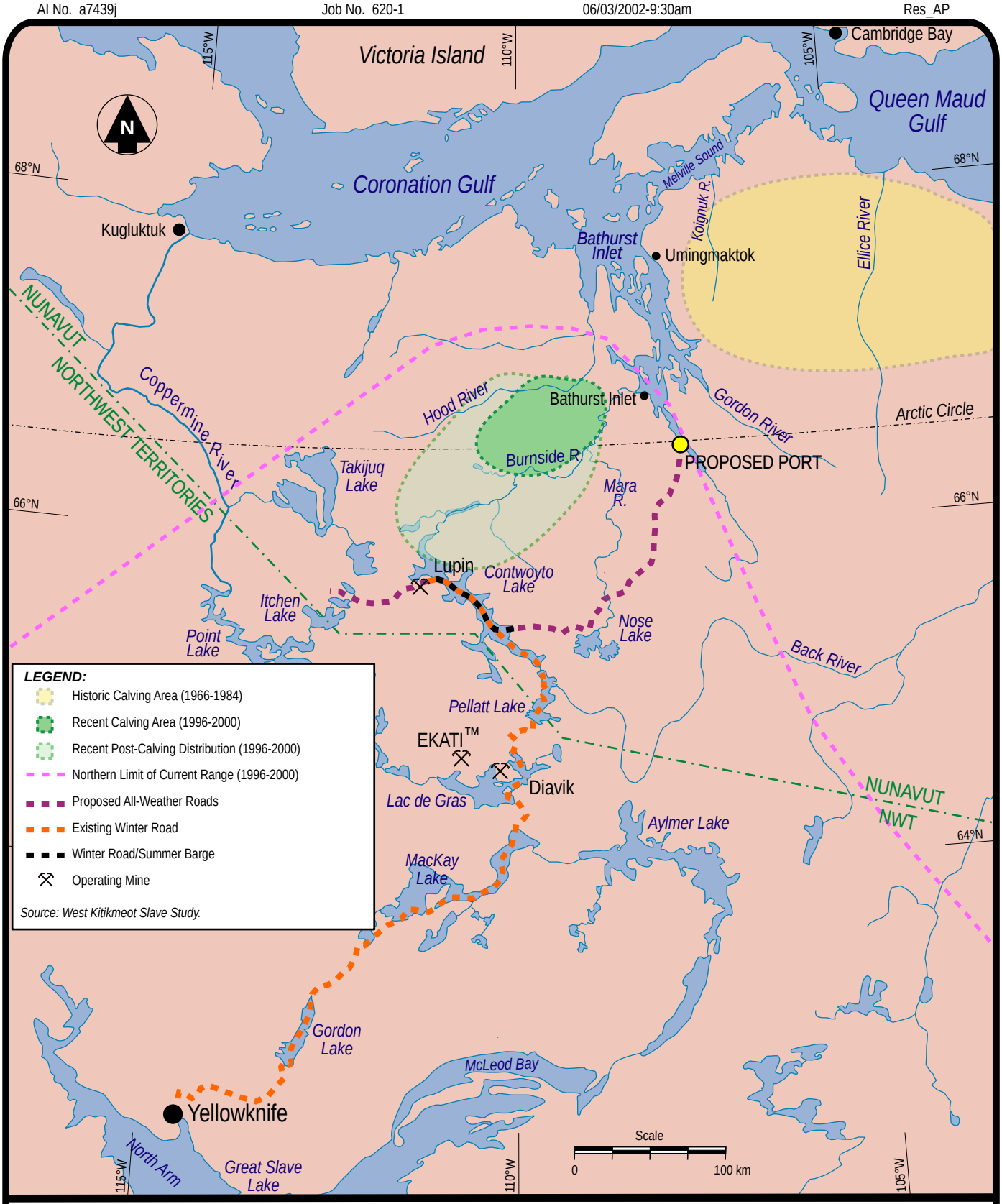

Current and Historic Calving Areas of the Bathurst Caribou Herd in Relation to the Project Area

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FIGURE 2.4-1

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A total of 18 muskox "on-transect" sightings were made during aerial surveys, with another seven reported "off-transect" (Table 2.4-2). An additional 10 incidental observations were reported during summer 2001 (Appendix 2.4-6). The number of herds of muskoxen in the study area is not clear, but it is suspected that perhaps six herds of muskoxen use habitats within 5 km of the road alignment.

Muskoxen densities were highest in survey blocks 4E and 19E, with densities ranging from 1.0 to 1.7 muskoxen per 10 km^2 (Appendix 2.4-7). Survey blocks 5E, 14E and 16E also had high numbers of muskoxen when incidental sightings were included (Figures 2.3-2 and 2.3-3).

The detectability of muskoxen from the air perhaps merits some comment. Unlike individual caribou, which are cryptically coloured, muskoxen are dark and contrast with their environment, even during summer. Furthermore, they often occur in groups of up to 20-30, and the members of these groups will aggregate if they are disturbed, as may happen when an aircraft flies nearby. Thus their conspicuous colour, summer or winter, and their occurrence in small herds, whose members tend to move together in the presence of any disturbance, tend to make muskoxen more easily detected than other large tundra mammals.

Table 2.4-2
Observations of Muskox and Muskox Sign Made during Aerial and Ground Surveys, July 2001 - July 2002

	Number of Observations				Number of Animals Observed					
	Aerial Surveys		Incidental Ground Observations		Aerial Surveys		Incidental Ground Observations		Total	Average Density
Muskox	**On Transect**	**Off Transect**	**Animal**	**Sign**	**On Transect**	**Off Transect**	**Animal**	**Sign**	**Animals**	**(#/10 km^2)**
21-Jul-01	2	1			14	4			18	0.3
29-Jul-01	1	1			16	8			24	0.4
Summer ground observations			**10**	**0**			**106**	**0**	**106**	
9-Aug-01	2	0			24	0			24	0.6
21-Aug-01	3	1			22	5			27	0.05
7-Sep-01	4	4			8	37			46	0.1
20-Sep-01	0	0			0	0			1	0
7-Nov-01	3	0			32	0			32	0.7
22-Mar-02	1	0			11	0			11	0.3
Winter ground observations			**0**	**10**			**0**	**10**	**10**	
28-May-02	1	0			5	0			31	0.1
7-Jun-02	0	1			0	0			32	0
7-Jul-02	1	0			13	0			29	0.3
Total	**18**	**7**	**10**	**10**	**145**	**54**	**106**	**10**	**391**	**0.3**

3. DEN SITES AND CARNIVORES

3. Den Sites and Carnivores

3.1 Introduction

Carnivores, which include grizzly bears, Arctic foxes, coloured foxes, Arctic wolves, and wolverines, all require dens for reproduction, avoiding inclement weather and insects, and, in the case of grizzlies, hibernation. In the Arctic, ice-rich permafrost, which dominates large parts of the landscape, is unsuited to den construction. Suitable substrates in which to dig dens must be well drained but sufficiently coherent to permit den systems to be dug without collapsing. In many cases, the root mats from vegetation above and around the dens helps to maintain the den structure. Areas that are suited to denning are important to the conservation of Arctic carnivores. In addition to providing carnivore den sites, areas suitable for denning are also generally suitable for ground squirrels, which are prey for all carnivores.

3.2 Objectives

The primary objective of this chapter is to present information on surveys of eskers and other potential carnivore denning areas that show the presence and status of carnivore denning in the study area. Wolf, fox, grizzly bear and wolverine dens were all of interest. In addition to locating den sites, observations of carnivores were recorded during aerial surveys. A separate effort was made to evaluate the habitat in the study area for capability to support grizzly bears. Specific study objectives were to:

1. determine prospective areas to be searched for carnivore dens, using maps, existing aerial photos, and observations made during aerial surveys;
2. conduct helicopter surveys of potential denning habitat (*e.g.,* eskers, river banks, and lake shores) within 5 km either side of the proposed road alignment in summer 2001; and
3. evaluate grizzly bear habitat using satellite imagery and existing information on habitat use.

3.3 Methods

A low level aerial survey was conducted within the 10-km project corridor by helicopter, searching all features that might have provided suitable denning sites for wolves, foxes, grizzly bears and wolverines. These features included eskers, other deposits of granular material, and the banks around lakes and along streams (Plate 3.3-1). When a den was located, the helicopter landed nearby, and information about the vegetation, prey remains, and physical features *(i.e.,* slope, aspect, soil texture) that characterized the site were recorded. In addition, the numbers of openings were counted and the den was classified as active or inactive, according to the presence or absence of fresh prey remains or scats, tracks, digging, and the presence of animals. GPS locations were recorded for each site.

3.4 Results and Discussion

Dens of Arctic wolves *(Canis lupus)*, coloured foxes *(Vulpes vulpes)*, Arctic foxes *(Alopex lagopus)*, wolverine *(Gulo gulo)*, and grizzly bears *(Ursus arctos)* were identified (see

Appendix 3.4-1 for details). All den sites are presented in Figures 2.3-2 to 2.3-4. No den sites were identified within the first 70 km of the road (Figure 2.3-2).

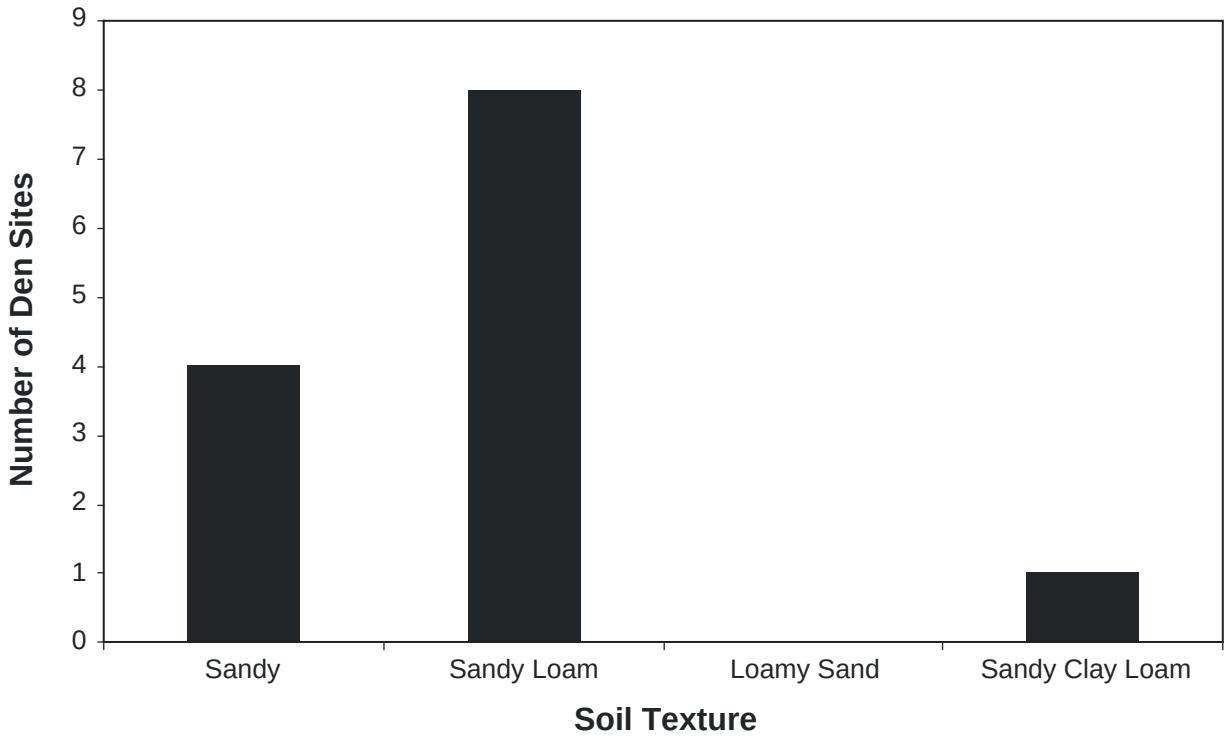
Plate 3.3-1. A wolf den located on the side of a deposit of glacial material, as spotted from a helicopter.

3.4.1 Wolves

Thirteen Arctic wolf dens were located: 11 active, 1 inactive, and 1 unknown. These dens were located along the entire road with some concentrations within three survey blocks. Survey block 12E had three dens and 17E had four (Figure 2.3-3). Nine dens were located on eskers, two on isolated sandy mounds, and one on a moraine. Wolves dug 12 of the dens in sites with sandy or sandy loam substrates (Figure 3.4-1). The other den was dug in sandy clay loam. Given the sandy nature of most den sites, vegetation was essential in maintaining the structure of the dens (Plate 3.3-1). Coarse fragments were either absent or comprised only a small proportion of the den site substrate.

The mean dimensions of wolf den entrances were 39.4 cm wide and 52.5 cm high (Table 3.4-1). Dimensions of entire den sites were taken at three locations. They ranged from 11-18 m long and 9-12 m wide; the areas ranged from 132-168 m^2 (Table 3.4-2).

Nearly all (12/13) den sites were located on slopes, with about half situated on or near the top (Figure 3.4-2). The other den sites were equally split between mid-slope and lower-slope positions. One den was situated on an isolated sandy mound with no apparent slope. The den sites were evenly distributed with respect to aspect (Figure 3.4-3). Slopes varied in steepness from zero to 85%, with a mean of 24.4%.



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Soil Texture of Arctic Wolf Den Sites, Summer 2001

FIGURE 3.4-1

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Table 3.4-1
Den Opening Averages and Ranges for Arctic Wolves and Foxes, Summer 2001

	Wolf		Fox	
	Den Opening Width (cm)	Den Opening Height (cm)	Den Opening Width (cm)	Den Opening Height (cm)
Average	39.4	52.5	42.6	53.1
Minimum	17.8	17.8	20.3	30.5
Maximum	101.6	127	63.5	71.1

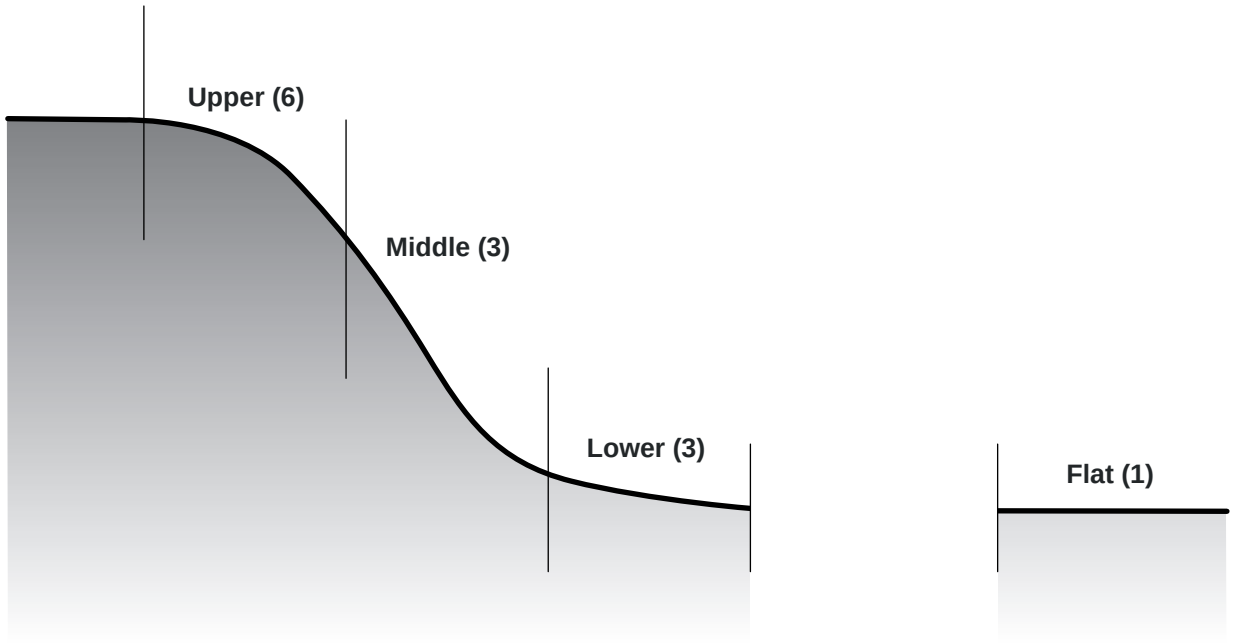
Table 3.4-2
Measurements of Three Arctic Wolves and One Arctic Fox Den Site Areas, Summer 2001

	Wolf			Fox
	Den 1	Den 2	Den 3	Den 1
Length (m)	14	18	11	14
Width (m)	12	9	12	8
Total Area (m^2)	168	162	132	112

More than half (9/13) of the dens located on slopes in the project area were situated in the upper third. This is consistent with observations by many other biologists (*e.g.*, Ballard and Dau, 1983; Lawhead, 1983; Mech, 1970). Why wolves should select such sites for their dens has been a matter of some speculation. Visibility of the surrounding area may be one factor, which would permit wolves to spot potential prey and intruders (Lawhead, 1983). An upper slope position also implies better drainage (Mech, 1970). In the Arctic, an exposed upper slope position may also result in sublimation and wind-clearance of snow, which might otherwise contribute water to the dens.

The substrates at den sites all contained a large component of sand, which would ensure good drainage. Because sand lacks structural integrity, the presence of vegetation, which provides root complex that helps to bind the soil, is undoubtedly important. The vegetation around wolf dens is conspicuously more luxuriant than elsewhere on the tundra because of the enhanced nutrients from wolf urine and feces. Thus there appears to be a positive feedback situation where the presence of wolves leads to enhanced plant growth, which leads to more stable substrate and better denning conditions.

Dens were found in all four quadrants of the compass, and thus aspect appears to be unimportant to the wolves of the Bathurst region. Others (*e.g.*, Ballard and Dau, 1983; Lawhead, 1983; Murie, 1944) have reported that wolves tend to situate their dens on aspects where insolation is above average. Lawhead (1983) found aspects of wolf dens in south-central Alaska to be in all quadrants, but there was an overall tendency for them to be oriented southwesterly. Perhaps in lower latitudes, where the sun sets at night during summer, aspect is more important than in higher latitudes, where the sun is available 24 h/day.



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Number of Slope Position of Identified Arctic Wolf Den Sites, Summer 2001

FIGURE 3.4-2

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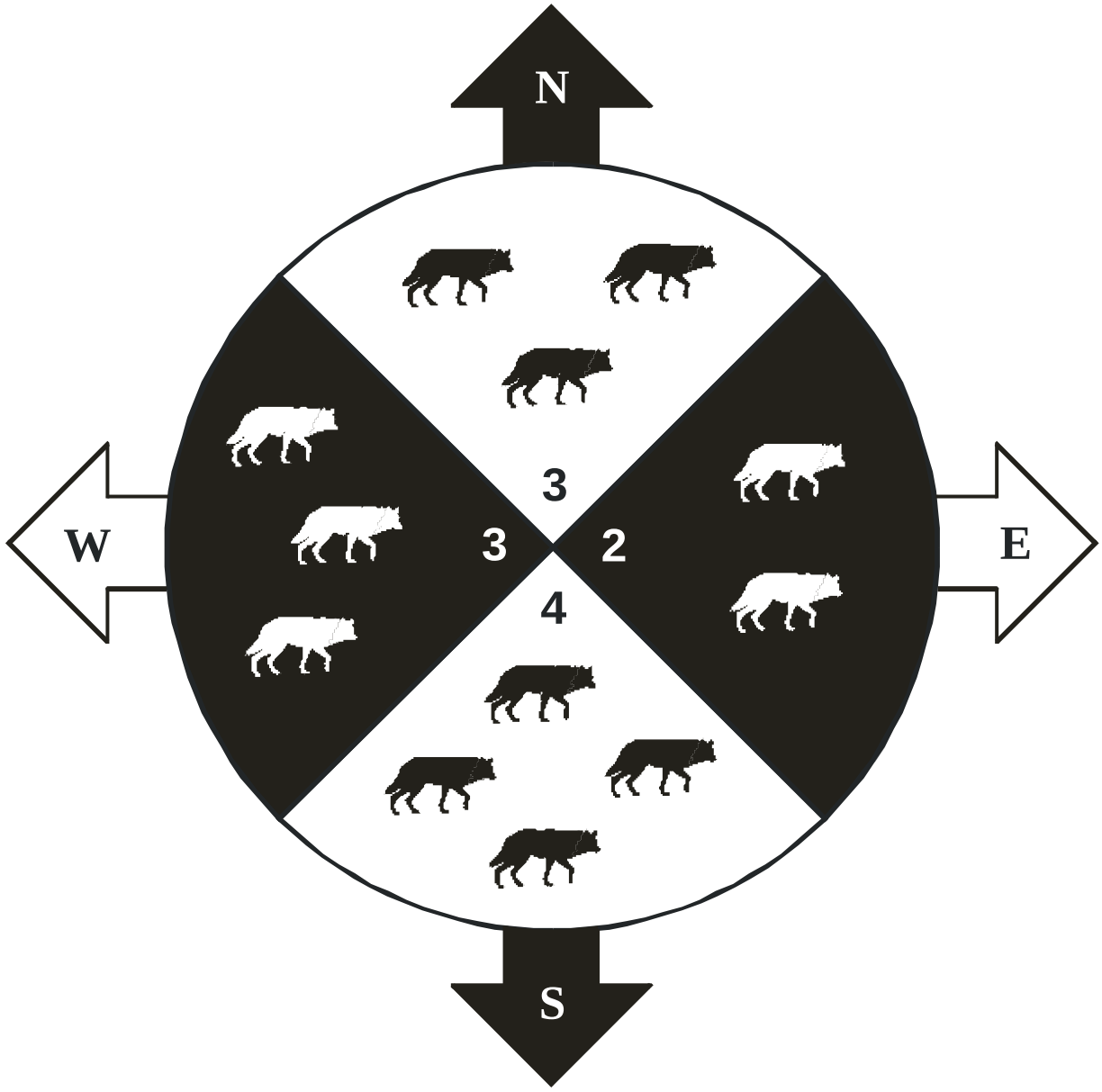

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Number and Aspect of Identified Arctic Wolf Den Sites, Summer 2001

FIGURE 3.4-3

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Prey remains were present at 9 of 13 den sites. Caribou remains occurred at six sites, ground squirrel at four, and an unidentified bone at one. Caribou remains, often of calves, not only had the greatest frequency of occurrence, but also represented the largest volume of food, as well. No scat analyses were conducted, so that only those species of prey that would be large enough for remains to be conspicuous but not too large for the wolves to carry would be represented. Small mammals, such as lemmings, might not normally result in remains except in scat, while bones of muskoxen might be too large and heavy to be transported easily. Although it is expected that caribou should make up the bulk of the diet of the wolves in the Bathurst region, other prey may be important at particular times.

Over their wide geographic range, the diets of wolves differ according to the species available, particularly species of large mammal (Mech, 1970). By virtue of their body size and their social organization into packs, wolves are adapted to preying on large mammals. However, they are also opportunistic and feed on a variety of small and medium-sized birds and mammals. In northern Greenland, where caribou have been extirpated, Marquard-Petersen (1998) found that wolves fed mainly on muskoxen, with a significant contribution by lemmings and Arctic hare. He also found that geese were significant in one area where substantial numbers of geese were nesting.

In the Bathurst project area in 2001, the cyclic lemming populations were at their nadir (lowest density in their cycle, see Chapter 5). In such a year, lemmings would make no significant contribution to the prey resource. But when their populations reach high levels, lemmings could be a significant resource. In addition to providing a source of food, they might also provide opportunities for wolf pups to practice prey-catching techniques.

Walton *et al.* (2001) studied the movements of satellite-collared wolves that denned near the Bathurst study area. These wolves made very large movements over the course of the year. The mean straight-line distance between the summer den site and the furthest location on the winter range was 508 km in 1997-1998 and 265 km in 1998-1999.

Most wolves that live in the range of migratory caribou do not den close to the calving grounds (Heard and Williams, 1992). These authors maintain that wolves tend to den in areas near the treeline, where caribou are more reliably available throughout the denning period, when the young pups are unable to travel great distances, and where caribou are readily available in September, when the food requirements of growing pups are greatest. From the standpoint of the caribou, however, they tend to select calving areas that are “spaced away” from wolf dens (Bergerud, no date). Because caribou remain on the calving grounds *per se* for only the month of June, the calving grounds do not provide a reliable, easily captured prey base (*i.e.*, young calves) for wolves throughout the dependency period of the pups.

Heard and Williams (1992) also suggest that the greater development of root systems by trees and shrubs near treeline creates den sites with more stable substrates, all other things being equal. As noted previously, den sites in the generally nutrient-poor tundra are made conspicuous by the luxuriant vegetation, particularly grasses that grow in these situations as a consequence of fertilization by wolf urine and faeces. The root systems that support the den site vegetation also help to improve and maintain the structural integrity of the den tunnel systems.

The satellite-collared wolves tracked by Walton *et al.* (2001) arrived on their summer ranges in 1998 between 8 April and 11 May (median date 01 May) and in 1999 between 31 March and 12 May (median date 18 April). They left their summer ranges between 20 – 29 October in 1997 (median date 26 October) and 11 October – 6 December in 1998 (median date 3 November). In 1998, the only year for which there are both arrival and departure dates, the median residence time would be 186 days, or six months.

The observations obtained from this study on Arctic wolves were consistent with the pattern observed by Walton *et al.* (2001). Arctic wolves were seen during systematic aerial surveys in July, August, September, and November, and March and early July 2002, but not during late May or early June (Table 3.4-3). Five wolves and 17 occurrences of sign were encountered on the winter ground survey in late April 2002. It may be that in late May and early June, the calving period, wolves may have been drawn to the vicinity of calving caribou, or possibly, the light-coloured wolves were difficult to detect against the snow from the survey altitude of 150 m.

It is known from the low-level helicopter denning surveys that wolves were present during July and August in greater numbers than the fixed-wing surveys would suggest. Perhaps the failure to detect them during the fixed-wing aerial surveys reflects the difficulty of seeing wolves from the survey altitude (150 m). Also, many wolves may have been in dens at the time of the survey, and if they were near their dens and were disturbed by the survey aircraft, they may have entered the dens during the flyover.

3.4.2 Coloured Foxes and Arctic Foxes

In the study region, two species of fox occur: the coloured fox, often referred as the red fox, but which may also occur as the silver fox (black with light hair tips) and cross fox (reddish with one black stripe down the back and another across the shoulder), and the Arctic fox, which is usually white during winter and chocolate brown during summer. Only two fox dens were identified. The den in survey block 9E belonged to a coloured fox and the one in survey block 21E belonged to an Arctic fox (Figures 2.3-2 and 2.3-3, respectively).

The coloured fox dug its den on an esker and the arctic fox den was situated on the edge of a drained lake. As with wolf dens, the fox dens were dug in soils that contained a large amount of sand (Figure 3.4-4).

One den was situated in the upper half of the slope on which it was located, the other in the lower half (Figure 3.4-5). As with wolves, the aspect of identified fox dens appears unimportant to foxes in this area (Figure 3.4-6). Presumably, foxes and wolves denning in the same region have very similar needs regarding den-site attributes.

The mean dimensions of fox den entrances were 20.9 cm wide and 21.7 cm high (Table 3.4-1). The dimensions of the entire Arctic fox den site were 8 x 14 m, with an area of 112 m^2 (Table 3.4-2).

Table 3.4-3
Observations of Wolves and Wolf Sign made during Aerial and Ground Surveys, July 2001 - July 2002

	Number of Observations				Number of Animals Observed				
	Aerial Surveys		Incidental Ground Observations		Aerial Surveys		Incidental Ground Observations		Total
Wolf	**On Transect**	**Off Transect**	**Animal**	**Sign**	**On Transect**	**Off Transect**	**Animal**	**Sign**	**Animals**
21-Jul-01	2	0			2	0			2
29-Jul-01	0	0			0	0			0
Summer ground observations			**20**	**3**			**45**	**3**	**48**
9-Aug-01	0	1			0	1			1
21-Aug-01	0	0			0	0			0
7-Sep-01	1	0			1	0			1
20-Sep-01	2	0			8	0			8
7-Nov-01	3	0			4	0			4
22-Mar-02	2	0			3	0			3
Winter ground observations			**5**	**17**			**11**	**17**	**28**
28-May-02	0	0			0	0			0
7-Jun-02	0	0			0	0			0
7-Jul-02	1	0			1	0			1
Total	**11**	**1**	**25**	**20**	**19**	**1**	**56**	**20**	**96**

Prey remains found around fox dens were of caribou (especially calves), ptarmigan, and Arctic ground squirrel (Plate 3.4-1). Caribou remains were the most abundant. Foxes probably scavenge caribou killed by wolves or grizzlies much of the time. In his study of the coloured fox in Sweden, Englund (1965) found that this species consumed nearly every species of bird and mammal in his study area, plus many insects and berries. It is likely that both fox species in the Bathurst study area consumed a variety of the species that occurred there, depending on availability.

Although no lemming or other small mammal remains were found near fox dens, small mammals can be very important prey in years of small mammal population abundance. Elton (1942) discovered that peaks in coloured fox abundance occurred every four years, which coincided with the cyclic peaks in small mammal numbers. A similar correlation has been demonstrated between the Arctic fox and lemmings (Speller, 1972; MacPherson, 1969; Chitty, 1950). In this study, lemmings were virtually non-existent during the summer of 2001, which may have limited the fox populations, even though caribou and other potential food species were present.

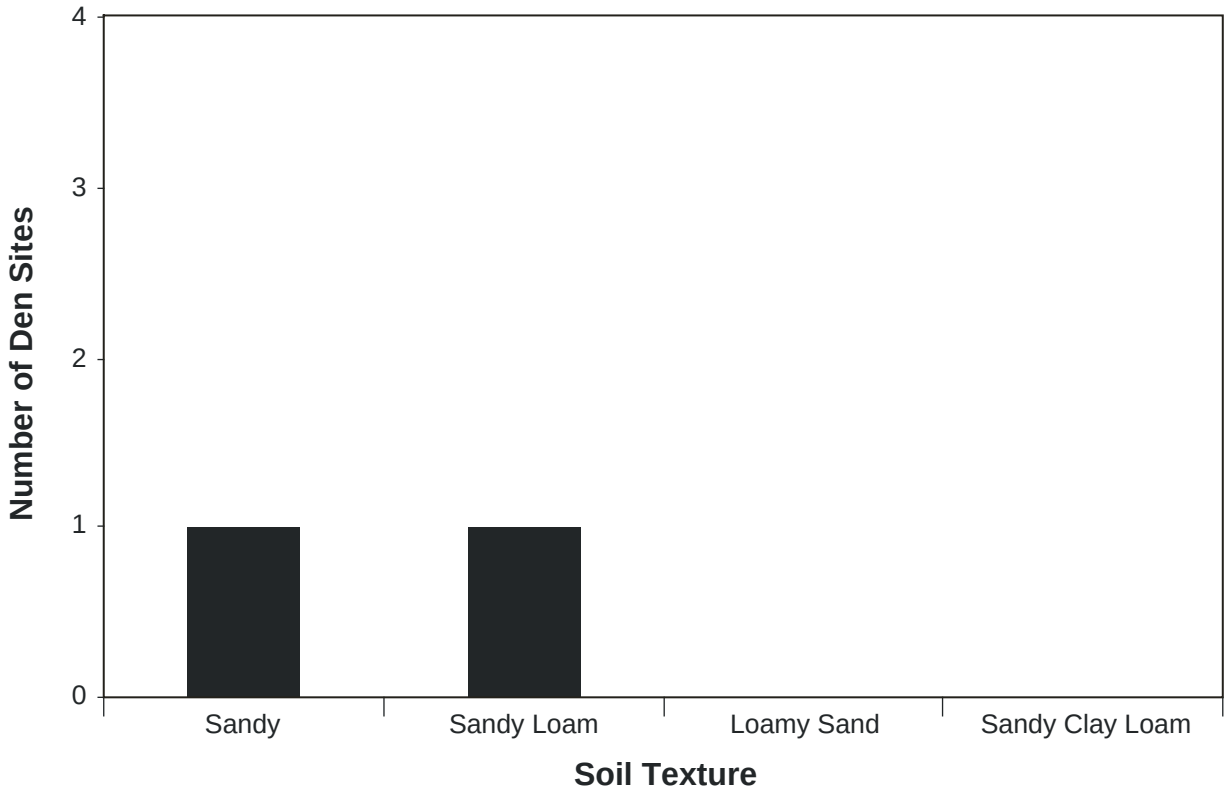
Eight observations of single coloured foxes were recorded during aerial surveys in November 2001 and March and May 2002, but no aerial observations were made during summer and early fall (Table 3.4-4). However, four incidental sightings of coloured foxes indicate they were present in summer. There was one incidental sighting of an Arctic fox.

In winter, Arctic foxes may move great distances in search of food. Some leave the barrens and move out to the coast and on to the sea ice, where they scavenge seal kills made by polar bears. Bathurst Inlet, however, is within an area of low polar bear abundance, so that the number of seals killed would be small, thus limiting the potential availability of seals. Arctic foxes may also follow caribou herds, feeding on the remains of caribou killed by wolves (Clarke, 1940).

Plate 3.4-1. Prey remains found at a coloured fox den.

Table 3.4-4
Observations of Coloured Foxes and Coloured Fox Sign made during Aerial and Ground Surveys, July 2001 - July 2002

	Number of Observations				Number of Animals Observed				
	Aerial Surveys		Incidental Ground Observations		Aerial Surveys		Incidental Ground Observations		Total
Coloured Fox	**On Transect**	**Off Transect**	**Animal**	**Sign**	**On Transect**	**Off Transect**	**Animal**	**Sign**	**Animals**
21-Jul-01	0	0			0	0			0
29-Jul-01	0	0			0	0			0
Summer ground observations			**1**	**0**			**1**	**0**	**1**
9-Aug-01	0	0			0	0			0
21-Aug-01	0	0			0	0			0
7-Sep-01	0	0			0	0			0
20-Sep-01	0	0			0	0			0
7-Nov-01	5	0			5	0			5
22-Mar-02	3	0			3	0			3
Winter ground observations			**0**	**4**			**0**	**4**	**4**
28-May-02	0	0			0	0			0
7-Jun-02	0	0			0	0			0
7-Jul-02	0	0			0	0			0
Total	**8**	**0**	**1**	**4**	**8**	**0**	**1**	**4**	**13**



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Soil Texture of Arctic and Coloured Fox Den Sites, Summer 2001

FIGURE 3.4-4

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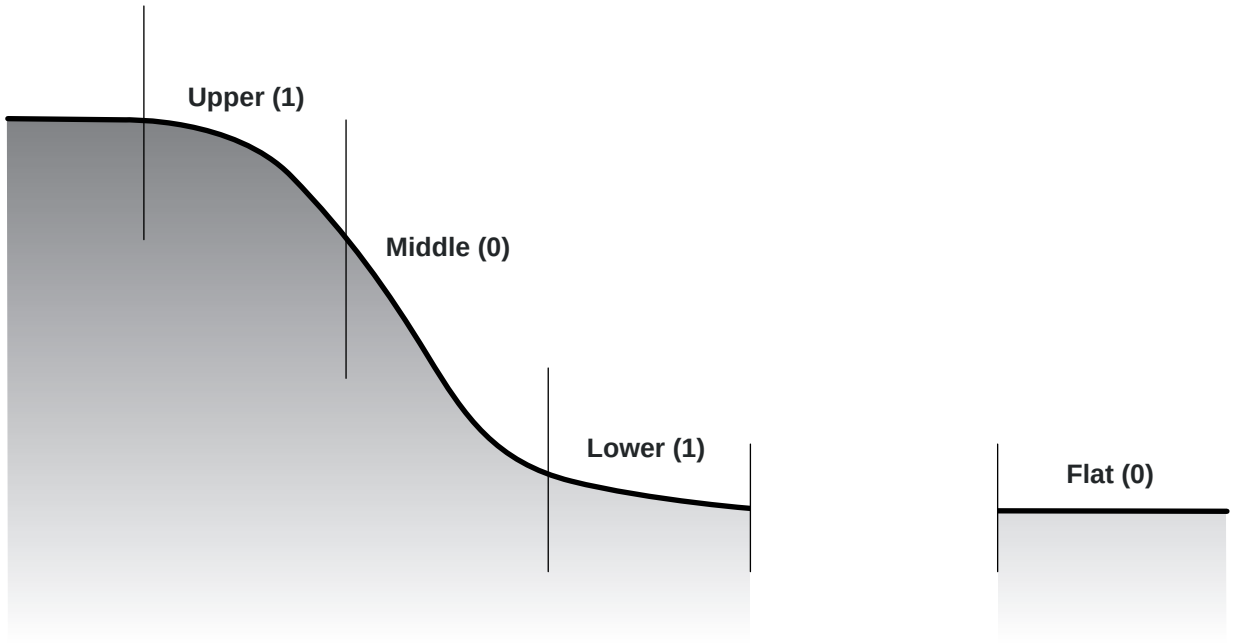

Number of Slope Position of Identified Arctic and Coloured Fox Den Sites, Summer 2001

FIGURE 3.4-5

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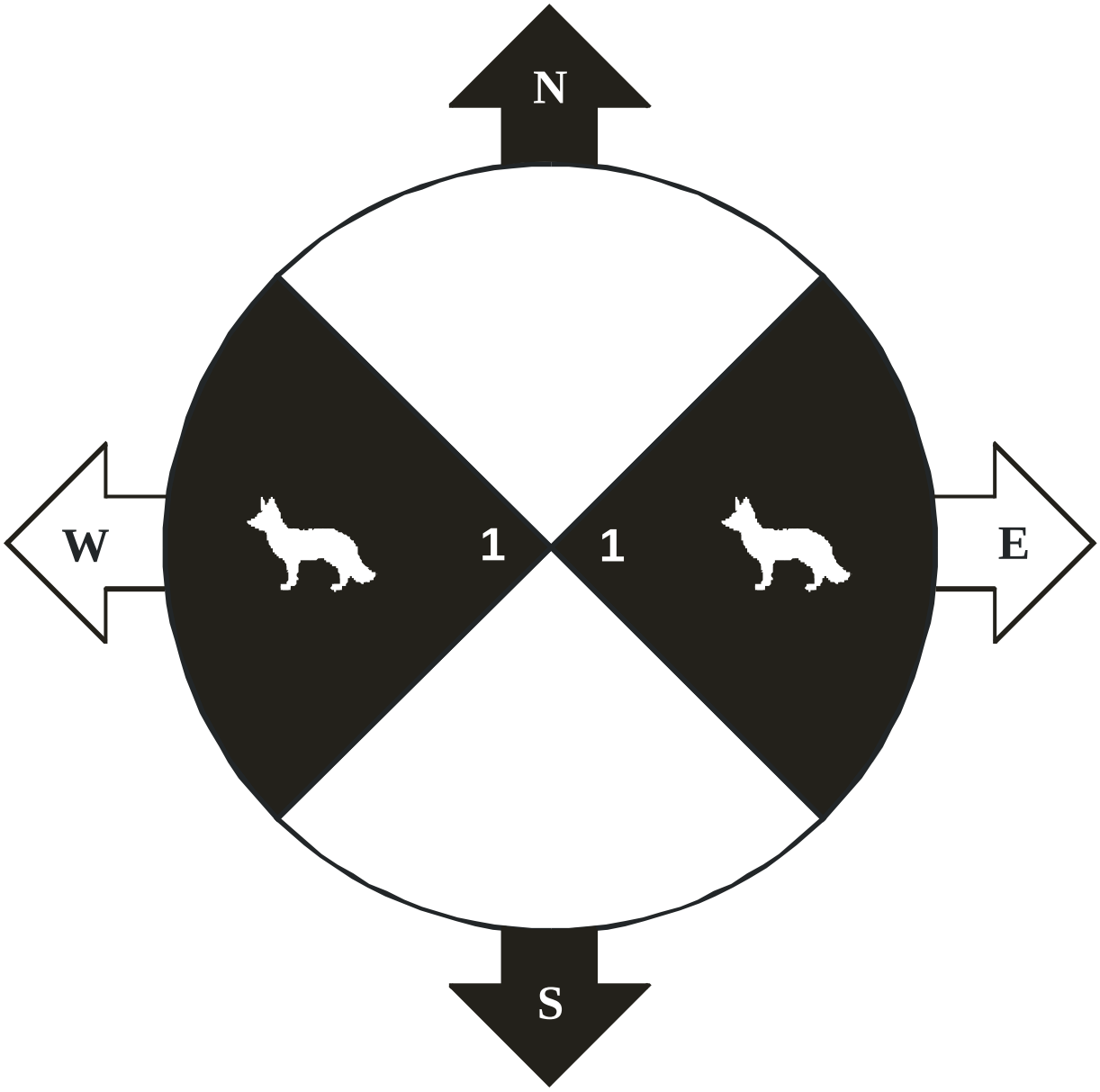

Number and Aspect of Identified Arctic and Coloured Fox Den Sites, Summer 2001

FIGURE 3.4-6

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3.4.3 Wolverine

The single wolverine den located was situated near the proposed southern Contwoyto camp site in a jumble of large rocks at the top of a small hill (Figure 2.3-3). Tunnels were dug in amongst the rocks (Plate 3.4-2). This site is similar to that described by Lee and Niptanatiak (1996) at a location southeast of Kugluktuk. These authors visited this denning area during late winter in three consecutive years and found it occupied in each year. Magoun and Copeland (1998) also describe similar denning areas and behaviour for wolverines in northwestern Alaska. Thus, it might be expected that this den site would continue to be used by wolverines in future years.

Plate 3.4-2. Wolverine den in rocks.

Numerous caribou remains were found around the den site. In southern Norway, Landa *et al.* (1997) reported that although reindeer (= caribou) were the most important prey of wolverines, small mammals (*i.e.*, lemmings, voles, and red-backed voles) were also important. In fact, the survival rate of young wolverines was significantly higher in years when small mammal populations were also high. Ptarmigan and hares are also important in Finland (Pulliainen, 1988).

Two wolverines were observed during aerial surveys on 20 September 2001 and 22 March 2002 (Table 3.4-5). Four additional observations were made from the ground during the summer. During the ground surveys in late April 2002, six wolverine tracks were encountered between Contwoyto Lake and Bathurst Inlet. Because of the wolverine's relatively small size, they are probably difficult to detect from the air, except when the ground is snow-covered, so it is likely that wolverines were present, but could not be detected during aerial surveys.

During a period of very warm weather in late July 2001, a wolverine was observed near George Lake (outside the study area) taking refuge on a snow bank, where it alternated between resting and playfully sliding on the snow.

Table 3.4-5
Observations of Wolverines and Wolverine Sign made during Aerial and Ground Surveys, July 2001 - July 2002

	Number of Observations				Number of Animals Observed				
	Aerial Surveys		Incidental Ground Observations		Aerial Surveys		Incidental Ground Observations		Total
Wolverine	**On Transect**	**Off Transect**	**Animal**	**Sign**	**On Transect**	**Off Transect**	**Animal**	**Sign**	**Animals**
21-Jul-01	0	0			0	0			0
29-Jul-01	0	0			0	0			0
Summer ground observations			**4**	**0**			**4**	**0**	**4**
9-Aug-01	0	0			0	0			0
21-Aug-01	0	0			0	0			0
7-Sep-01	0	0			0	0			0
20-Sep-01	1	0			1	0			1
7-Nov-01	0	0			0	0			0
22-Mar-02	1	0			1	0			1
Winter ground observations			**0**	**6**			**0**	**6**	**6**
28-May-02	0	0			0	0			0
7-Jun-02	0	0			0	0			0
7-Jul-02	0	0			0	0			0
Total	**2**	**0**	**4**	**6**	**2**	**0**	**4**	**6**	**12**

3.4.4 Grizzly Bear

Grizzly bears occur throughout the Slave Geologic Province (SGP), and are known to occur in the vicinity of the proposed road route. Federally, they are a species of Special Concern (a species that is particularly sensitive to human activities or natural events but is not an endangered or threatened species; COSEWIC, 2002). In NWT and in Nunavut, they have been designated Sensitive (a species that is not at risk of extinction or extirpation but may require special attention or protection to prevent them from becoming at risk; RWED, 2000; CESCC, 2001). Grizzly bears have low ecological resiliency, are sensitive to human activity, and are frequently displaced by industrial developments (McLellan, 1990; Ross, 2002; Weaver *et al.*, 1996). Bears living in the central Canadian Arctic may be at relatively elevated risk because they naturally occur at low density and because on the open tundra landscape they may be more vulnerable to disturbance (R. Mulders, RWED, pers. comm.; Ross, 2002). Consequently, an evaluation of grizzly bear habitat in the vicinity of the proposed road route was undertaken.

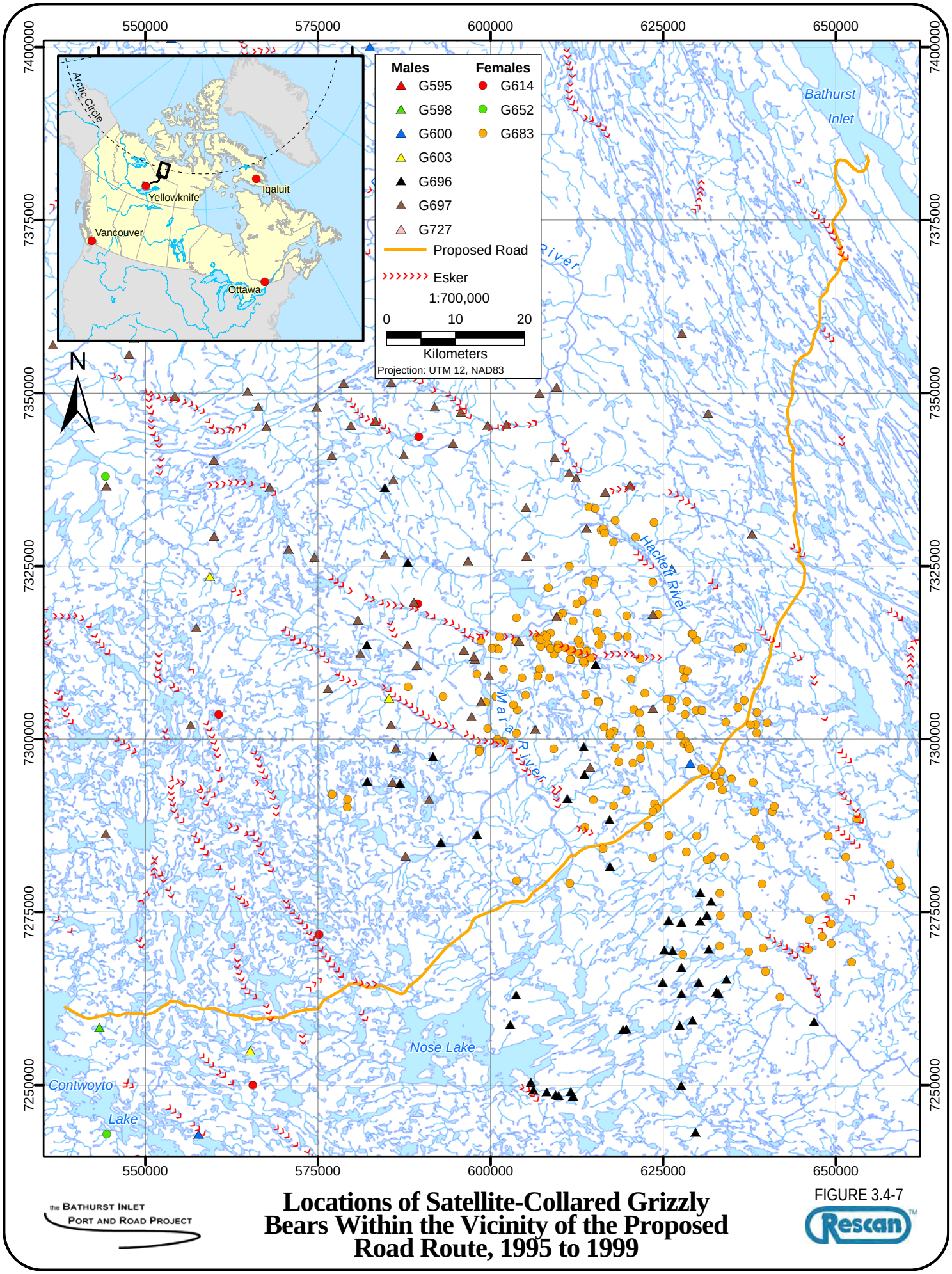
Between 1995 and 1999, as part of a cooperative project among the Department of Resources, Wildlife and Economic Development (RWED), the West Kitikmeot/Slave Study (WKSS), university, and industry, 81 grizzly bears across the SGP were captured and fitted with satellite radiocollars, and >8,000 telemetry locations were recorded (McLoughlin, 2000). Fourteen collared bears, ten males and four females, used areas in the vicinity of the proposed road route (Figure 3.4-7). Of these, at least eight males and three females used areas within 6 km of the proposed route, or had locations on both sides of the route.

It is critical to note that this represents only the known movements of those bears which were captured as a part of this study. Satellite uplinks were often unsuccessful and intervals between successful location fixes typically ranged from two to seven days (R. Mulders, RWED, pers. comm.), indicating that undocumented movements of these bears occurred. In addition, other uncollared bears were known to occupy this area, including the portion near the proposed port facility on Bathurst Inlet where no bears happened to be captured (R. Mulders, RWED, pers. comm.; and observations from this study). Clearly, there were more interactions between grizzly bears and the proposed road route than are indicated in Figure 3.4-7.

3.4.4.1 Grizzly Bear Denning

Two grizzly bear dens were found. One was located in the bank of the Mara River and the other was on a slope leading to a lake near the western end of the proposed road. The first den had probably been excavated in 2000, based on the condition of the disturbed vegetation, but had never been used (Plate 3.4-3). The den near the road terminus had been excavated beneath a large rock, and because the entrance tunnel had a downward slope, this may not have been an overwintering den.

The West Kitikmeot/Slave Study Society research program included research on grizzly bear denning ecology in the general region of this study (McLoughlin *et al.*, 2002). They followed 81 grizzlies that had been instrumented with satellite radio-collars to determine den site location and



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Locations of Satellite-Collared Grizzly Bears Within the Vicinity of the Proposed Road Route, 1995 to 1999

FIGURE 3.4-7

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timing of entrance into and emergence from dens. The locations permitted them to visit each den site to record physical details.

Plate 3.4-3. Partially excavated grizzly bear den along Mara River.

They visited 56 den sites. Most (25) faced south, followed by west (13) and east (10); only eight faced north. Others (*e.g.*, Banci and Moore, 1997; Reynolds *et al.*, 1976) who have studied denning in Arctic grizzly bears have also found a pronounced tendency for den sites to have a southerly aspect. The benefit of a southern exposure may be either insulation (*i.e.*, warmth) at emergence in the spring (and possibly at denning in the fall) or the accumulation of an insulating layer of snow that would result from the prevailing northerly winds, or both.

McLoughlin *et al.* (2002) also found that bears chose den sites on relatively steep slopes, averaging 25°. Pearson (1975) and Lentfer *et al.* (1972), working in the southwestern Yukon and on Kodiak Island, Alaska, respectively, also reported that den sites tended to be on steep slopes. Steep slopes may permit the bears to construct horizontal or even upward-sloping tunnels, which would result in a warm-air "trap" in the hibernation chamber (Harding, 1976).

Dwarf birch was present at 44 of 52 sites in the central Arctic for which vegetation data were collected, and roots of this species often hung down from the den ceiling (McLoughlin *et al.*, 2002). Other typical dry-habitat species, such as crowberry, cranberry, and Labrador tea were also recorded frequently at grizzly den sites. The root mats of this shrubby vegetation were important for maintaining the integrity of the den structures. In contrast to the relatively sparse vegetation around the dens in this study, Pearson (1975) found that large shrubs invariably concealed the openings of dens in the southwestern Yukon. The reason for this, Pearson believed, was to promote the accumulation of an insulating layer of snow.

The substrates at the den sites studied by McLoughlin *et al.* (2002) were well drained and contained a large component of sand, as well as coarser material, including cobble- and boulder-sized stones. However, the grizzly bear dens studied by McLoughlin *et al.* (2002) were short lived. By mid-summer about 80% (44/56) had partially or completely collapsed. Thus, it appears that most bears must usually dig new dens each year. In the southwestern Yukon, Pearson (1975) reported that some dens may be used for several years.

In conclusion, eskers are not important for grizzly bear denning in the area along the proposed Bathurst Road, nor does there appear to be much denning anywhere within the study corridor. Grizzlies are present in the project area from late spring through early fall, but where they go to den is unknown.

3.4.4.2 Grizzly Bear Observations

In 2001, grizzly bears were observed along aerial survey transects during late August and late September, but not during the July, early August, early September, or November surveys (Table 3.4-6; Figures 2.3-2 to 2.3-3). Twelve incidental sightings of a total of 21 individuals were reported during July and August 2001. Grizzlies certainly were present throughout the summer, but would have been in hibernation by November 2001. No grizzlies were seen during either the late March aerial survey or the late April ground survey in 2002. Because grizzly tracks would have been readily identifiable during the ground survey, the failure to detect tracks at that time is particularly significant and suggests that the bears were still hibernating at the time. However, grizzlies had emerged by late May 2002, when one group of three was observed. Two additional sighting were reported in early June and early July 2002; the first of a sow and two cubs and the second of a lone individual.

Table 3.4-6
Observations of Grizzly Bears and Grizzly Bear Sign made during Aerial and Ground Surveys, July 2001 - July 2002

	Number of Observations				Number of Animals Observed				
	Aerial Surveys		Incidental Ground Observations		Aerial Surveys		Incidental Ground Observations		Total
Grizzly Bear	**On Transect**	**Off Transect**	**Animal**	**Sign**	**On Transect**	**Off Transect**	**Animal**	**Sign**	**Animals**
21-Jul-01	0	1			0	3			3
29-Jul-01	0	0			0	0			0
Summer ground observations			**12**	**3**			**21**	**3**	**24**
9-Aug-01	0	0			0	0			0
21-Aug-01	1	0			1	0			1
7-Sep-01	0	0			0	0			0
20-Sep-01	2	1			2	1			3
7-Nov-01	0	0			0	0			0
22-Mar-02	0	0			0	0			0
Winter ground observations			**0**	**0**			**0**	**0**	**0**
28-May-02	1	0			3	0			3
7-Jun-02	1	0			3	0			3
7-Jul-02	1	0			1	0			1
Total	**6**	**2**	**12**	**3**	**10**	**4**	**21**	**3**	**38**

4. RAPTORS

4. Raptors

4.1 Introduction

The Project area supports raptors such as golden eagles, rough-legged hawks, peregrine falcons, gyrfalcons, and snowy and short-eared owls. Eagles, hawks, and falcons typically breed in areas with suitable cliff or hill habitat (Godfrey, 1986; Klohn-Crippen Consultants, 1993), and they tend to exhibit fidelity to nesting sites (Newton, 1979).

Raptors are commonly used as indicators of environmental quality. Occupying a top trophic level, they are indicative of general ecological integrity; impacts on raptor populations could be reflected throughout the ecosystem (Kennedy, 1980). They are also known to be sensitive to disturbance, particularly during breeding. Declines in raptor populations have been attributed to human activities and developments (*e.g.*, Craighead and Mindell, 1981).

The *tundrius* subspecies of the peregrine falcon (the subspecies most likely to occur in the Project area) is listed as "Special Concern" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), whereas the status of the *anatum* subspecies was recently upgraded from "Endangered" to "Threatened" (COSEWIC, 1999). Peregrine populations in the Canadian Arctic (*tundrius* subspecies) have increased in recent years in response to the decline in use of organochloride pesticides in their wintering areas (Shank *et al.*, 1993), but they are still listed as "may be at risk" within the NWT (RWED, 2000). The gyrfalcon is a high-profile species and the official bird of the NWT. The gyrfalcon is also of interest as one of the few possible year-round resident bird species in the study area (Platt, 1976; Kuyt, 1980; Poole and Bromley, 1988*a*). Both peregrines and gyrfalcons are listed by CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) under Appendix I, indicating that globally they are threatened with extinction that may be influenced by trade. Within the NWT, gyrfalcons, rough-legged hawks, bald eagles, and golden eagles are listed as "secure" (RWED, 2000). In Nunavut, the gyrfalcons and the rough-legged hawks are designated "secure" (*i.e.*, not at risk, may not be at risk, or not sensitive), the golden eagle "sensitive" (*i.e.*, not at risk, may not be at risk but may require special attention or protection), and the bald eagle "accidental" (*i.e.*, occurring infrequently and unpredictably; CESCC, 2001).

Ravens are passerines, but have been called "functional raptors" (Poole and Bromley, 1988*b*) and are included in this section. Ravens commonly nest on cliffs, which may preclude falcons from using those sites. Conversely, raven stick nests may be usurped and used by gyrfalcons (Poole and Bromley, 1988*a*).

4.2 Objectives

The objective of the raptor survey was to identify raptors breeding in the project area by conducting aerial and ground surveys of occupied and potential cliff nesting sites within 3km of the road route.

4.3 Methods

Raptor surveys were scheduled for early July, in order to capture the period after peregrines and rough-legged hawks had begun nesting, but before ravens and gyrfalcons had fledged. Raptor surveys were conducted with a Bell 206 helicopter and a crew consisting of the pilot and a single observer. The proposed road route was flown, and potentially-suitable raptor nesting habitat (cliffs and steep outcrops) within 3 km of the Road route was investigated. At each potential site, the helicopter was flown along the cliff at about the level of the top of the cliff and at a speed of 10-20 km/hour. Where cliffs were high or terrain was complex, a second pass was made. The observer watched for flushing raptors as well as sign of activity including whitewash and occupied or vacant stick nests and scrapes. Tight canyons where flying was unsafe were surveyed on foot. Locations of all observations were recorded using GPS.

Potential raptor sites were classified as to status and species (Tables 4.2-1 and 4.2-2). Where possible, counts of eggs and young were conducted using image-stabilizing binoculars. However, effort was made to minimize disturbance by staying distant from occupied nests and by keeping visits brief, so in some cases counts were incomplete.

Table 4.2-1
Site Descriptions from Raptor Survey Observations

Status code	Description
OE	Occupied territory; nest with eggs
OY	Occupied territory; nest with young
OT	Occupied territory; eggs or young not seen
NS	Territory not confirmed; nest not seen
UU	Unoccupied and unproductive

Table 4.2-2
Number and Species of Occupied and Unoccupied Raptor Nests

Species	Code	# of Occupied Nests	# of Old Nests	Total
common raven	CORA	1	0	1
gyrfalcon	GYRF	2	0	2
peregrine falcon	PEFA	9	6	15
rough-legged hawk	RLHA	10	13	23
Total		**22**	**19**	**41**

Note: There were 2 occupied territories where nests or young were not seen.

A subjective evaluation of site quality was made, using a numeric value from 1 to 6. Ratings of "1" were the best, and only occupied or formerly-occupied sites can achieve this high of a rating. Ratings of "6" were the worst and were judged to be unsuitable for nesting. Rating criteria included height (taller is better), slope (steeper is better), aspect (north is worst), rock stability, and presence of ledges and overhangs.

4.4 Results and Discussion

The survey was conducted during July 1-4, 2002 under ideal weather conditions. A total of 108 observations were made (Appendix 4.3-1). Of these, 22 involved occupied territories: 18 nests with eggs, two nests with young, and two where productive nests could not be found although adult birds demonstrated territorial behaviour (Table 4.3-1). Seven adult raptors were observed for which no nest association was documented, and three adults were associated with nests found later (included above). Nineteen formerly-occupied nests were observed. The remaining 60 sites were cliffs or outcrops which showed no sign of raptor nesting, but which were rated as potential nesting sites (Table 4.3-1). Some of these had been used as perches.

Table 4.3-1
Evaluation of Nesting Sites

Subjective Site Evaluation*	Occupied Nests	Old Nests	Potential Nesting Sites	Total
1	22	3		24
2		16	13	29
3		1	16	17
4			14	14
5			16	16
6			1	1
Total	**22**	**19**	**60**	**101**

***1 =best (only occupied or formerly occupied sites can get this high of a rating) to 6 = worst (not suitable for nesting).**

Rough-legged hawks were the most commonly seen raptor. Ten active nests were observed along with eight adult birds where nests could not be found. Six nests contained four eggs each, and two held five. Clutch size could not be counted for two nests. Thirteen old rough-legged hawk nests were also recorded.

There were nine occupied peregrine territories, including eight nests with eggs. Four nests contained four eggs each, but total counts could not be made of the other four clutches. Six previously occupied peregrine scrapes were also found.

Other raptors were scarce during this survey. Only two occupied gyrfalcon territories were located, including one active nests with young. One occupied raven nest was found containing nearly-fledged young. No golden eagles or nests were observed. However, an immature bald eagle was seen about 22 km from Bathurst Inlet.

In addition, one Canada goose cliff nest, with eggs, was observed.

One highly concentrated raptor nesting site was noted during the aerial survey (Figures 2.3-2 to 2.3-3). This concentration was located in aerial survey blocks 1E to 4E near Bathurst Inlet where eight rough-legged hawk nests, seven peregrine nests, and one gyrfalcon nest were observed.

5. SMALL MAMMALS

5. Small Mammals

5.1 Introduction

Small mammals (*i.e.*, voles and lemmings) are the primary prey of the smaller carnivores, such as foxes and weasels, and they can be important even to wolves and wolverines, particularly the young. Elton (1942) was one of the first to recognize that Arctic small mammal populations can undergo large, regular cycles of abundance. This he deduced from the fluctuations in fur returns to Hudson's Bay Company trading posts in the Arctic, which showed a pattern of high numbers of furbearers, such as foxes, every four years. These fluctuations occur synchronously over large areas and have stimulated a lot of research by ecologists about the mechanisms that regulate animal population size (Krebs, 1964).

5.2 Objectives

The objective of small mammal trapping was to determine presence and relative abundance of various small mammal species in the project region by setting up trapping lines in a wide variety of habitat types within a 5 km buffer zone on either side of the proposed road alignment.

5.3 Methods

Small mammal trapping was conducted over a three-week period in August 2001. Traplines with 50 traps per line were established in a wide variety of habitats throughout the Project area and within the 5 km buffer zone on either side of the road alignment. A number of separate traplines (2-5) in different locations were established for each habitat type. Habitat areas chosen were sufficiently large for 50 traps approximately 10 m apart to be set. Trap locations were marked with "inukshuks" or flagging tape. Traplines were set in late afternoon (Plate 5.3-1) or evening and checked the following morning. Traps were baited with a small amount of a peanut butter and bacon grease mixture and were cleaned and rebaited each time they were set.

Any mammals trapped were identified and, if necessary, collected for later identification. The number and species of animals collected at each trapline, the habitat type, and the GPS location were recorded. Any traps that had been set but that were empty were noted.

Traplines were established in the following habitats:

1. Rocky heath
2. Birch/shrub heath
3. Soliflucted heath
4. Rocky habitat
5. Sedge fen
6. Lakeshore riparian
7. Stream riparian

Plate 5.3-1. David Sateana and Fiona Danks setting traps.

5.4 Results and Discussion

Table 5.4-1 provides a summary of the results of the small mammal trapping. Appendix 5.4-1 shows the complete data. Trapping was conducted in a total of seven different habitat types. The number of traps set in each habitat type varied from 50 to 250 traps. This variation was due to the frequency of visits and presence of the various habitat types.

Table 5.4-1
Summary of Small Mammal Trapping Results

Habitat Type	Effort (trap nights)	Total animals caught	Catch per unit effort (CPUE)[1]	Red-backed Vole (#)	Catch per unit effort (CPUE)[1]	Notes
Rocky heath	100	6	6	6	6	
Heath (birch)	200	1	0.7	1	0.7	2 set but empty
Soliflucted heath	250	1	0.4	1	0.4	
Rocky habitat	200	10	5	10	5	
Fen (sedge)	50	0	0	0	0	
Lakeshore Riparian	50	2	4	2	4	
Stream Riparian	100	2	2	2	2	
TOTALS	900	22	3	22	3	

[1]CPUE is expressed as number of animals caught (x) /number of trap nights(y) x 100 (=x/y*100).

The trapping effort totalled 900 trap nights (tn). A total of 22 animals were caught. Red-backed voles (*Clethrionomys rutilus*) were the only mammal trapped. No collared or brown lemmings were caught, although, winter nests of both species were found, particularly in heath and rocky

heath habitats, indicating their presence within the study region (Plate 5.4-1). In addition, lemmings, probably brown lemmings, were observed along stream shorelines by the fisheries teams during the trapping period.

Plate 5.4-1. Winter nest of brown lemming.

The greatest number of red-backed voles were recorded in rocky areas (5.3/100 tn), with 6/100 tn in rocky heath and 5/100 tn in predominantly rocky habitat. Lower numbers of animals were trapped in the other habitat types (<4 animals/100 tn): in riparian areas 2.7 animals/100 tn were caught, and in birch and solifluction heath habitats 0.5 animals/100 tn were captured. No animals were caught in fen habitats.

Lemming populations were apparently at their nadir in summer 2001. Krebs (1964) reported CPUEs of 27 and 14 for brown and collared lemmings, respectively, at Baker Lake, Nunavut, during population highs, which contain similar habitat types to our project area. Among the species that become conspicuously more abundant when lemmings are abundant are snowy owls and Arctic foxes. No snowy owls were seen and just a few Arctic foxes. During periods of abundant small mammals, conspicuously larger number of predators, including snowy owls, Arctic and coloured foxes, jaegers, ravens, falcons and hawks would be expected.

6. WATERFOWL AND OTHER BIRDS

6. Waterfowl and Other Birds

6.1 Introduction

Although few species of birds remain in the Arctic during winter, a relatively large number of species and millions of individuals migrate to the Arctic to breed during summer. Although the focus of the 2001-2002 wildlife program was on mammals, with a specific effort made only for raptors (see Chapter 4), some data were nonetheless collected on waterfowl and other birds (in addition to raptors).

6.2 Objectives

The overall purpose of this section is to report the presence of waterfowl and other birds in the study area as opportunities presented themselves. The specific objectives were to:

1. Record the presence of waterfowl and other birds that were seen during aerial surveys; and
2. Record observations of waterfowl and other birds that were made incidental to other work.

6.3 Methods

Fixed-wing aerial surveys were flown during July, August, September, and early November in 2001 and during March, May, June, and July 2002 (see Chapter 2, caribou and muskoxen, for details). Incidental sightings were made by the wildlife crew and others during ground work throughout the project.

6.4 Results

Seven aerial surveys were conducted in 2001: two in July, two in August, two in September, and one in early November. Detailed information can be found in Appendix 6.4-1.

During the fixed-wing aerial surveys, 11 species of waterfowl and other birds were identified:

- Red-throated Loon *Gavia stellata*
- Tundra Swan *Cygnus columbianus*
- Canada Goose *Branta canadensis*
- Sandhill Crane *Grus canadensis*
- Yellow-billed Loon *G. adamsii*
- Greater White-fronted Goose *Anser albifrons*
- Golden Eagle *Aquila chrysaetos*
- Arctic Tern *Sterna paradisaea*
- Snow (Blue) Goose *Chen caerulescens*
- Rough Legged Hawk *Buteo lagopus*
- Common Raven *Corvus corax*

Waterfowl were by far the most common birds observed during aerial surveys, and of them, Canada geese were clearly the most abundant (Table 6.4-1).

Table 6.4-1
Summary of Waterfowl and Other Bird Sightings during Aerial Surveys, 2001

Date	Species Code	Common Name	No. Sightings	No. of Individuals
21 July	B-TUSW	Tundra Swan	1	2
	B-UDUC	Unspecified Duck	1	8
	B-UGOO	Unspecified Goose	2	55
	B-RLHA	Rough-legged Hawk	1	2
	B-UGUL	Unspecified Gull	4	5
29 July	B-CAGO	Canada Goose	1	6
	B-TUSW	Tundra Swan	1	2
	B-UGOO	Unspecified Goose	3	35
	B-ARTE	Arctic Tern	1	25
9 August	B-TUSW	Tundra Swan	1	2
	B-UDUC	Unspecified Duck	1	28
	B-UGOO	Unspecified Goose	1	25
21 August	B-SACR	Sandhill Crane	1	1
7 September	B-RTLO	Red-throated Loon	1	1
	B-YBLO	Yellow-billed Loon	1	1
	B-CAGO	Canada Goose	30	692
	B-GWFG	Greater White-fronted Goose	4	38
	B-SNGO	Snow Goose	2	39
	B-TUSW	Tundra Swan	3	21
	B-UDUC	Unspecified Duck	9	28
	B-UGOO	Unspecified Goose	3	38
	B-GOEA	Golden Eagle	1	1
	B-SACR	Sandhill Crane	1	2
	B-UGUL	Unspecified Gull	11	55
	B-CORA	Common Raven	1	6
20 September	B-TUSW	Tundra Swan	7	49
	B-UGOO	Unspecified Goose	5	95
	B-UFAL	Unspecified Falcon	1	1
	B-UPTA	Unspecified Ptarmigan	2	26
	B-SACR	Sandhill Crane	1	3
7 November	B-UPTA	Unspecified Ptarmigan	2	17
Totals			104	1339

Incidental observations of birds are summarized in Table 6.4-2; details are given in Appendix 6.4-1.

Table 6.4-2
Summary of Incidental Observations of Birds, Summer 2001

Species Code	Common Name	No. of Sightings	No. of Individuals	No. of Individuals/Sighting
July Sightings				
B-RTLO	Red-throated Loon	1	2	2
B-CAGO	Canada Goose	8	165	20.6
B-GWFG	Greater White-fronted Goose	1	14	14
B-RBME	Red-breasted Merganser	1	3	3
B-TUSW	Tundra Swan	1	2	2
B-RLHA	Rough-legged Hawk	3	3	1
B-PEFA	Peregrine Falcon	2	2	1
B-UFAL	Unspecified Falcon	1	1	1
B-ROPT	Rock Ptarmigan	1	2	2
B-UPTA	Unspecified Ptarmigan	1	1	1
B-SACR	Sandhill Crane	1	3	3
B-LTJA	Long-tailed Jaeger	1	1	1
B-SPSA	Spotted Sandpiper	2	2	1
B-UJAE	Unspecified Jaeger	1	1	1
B-SEOW	Short-eared Owl	1	1	1
B-CORA	Common Raven	2	4	2
B-ATSP	American Tree Sparrow	1	2	2
B-LALO	Lapland Longspur	2	3	1.5
B-URED	Unspecified Redpoll	1	1	1
TOTALS		32	213	
August Sightings				
B-YBLO	Yellow-billed Loon	1	2	2
B-ULOO	Unspecified Loon	2	3	1.5
B-CAGO	Canada Goose	1	6	6
B-GOEA	Golden Eagle	2	2	1
B-PEFA	Peregrine Falcon	1	1	1
B-SACR	Sandhill Crane	2	6	3
B-HOLA	Horned Lark	1	1	1
B-LALO	Lapland Longspur	2	2	1
Totals		**12**	**23**	

Waterfowl

The following species of waterfowl were recorded incidentally in 2001:

- Red-throated Loon *Gavia stellata*
- Greater White-fronted Goose *Anser albifrons*
- Yellow-billed Loon *G. adamsii*
- Red-breasted Merganser *Mergus serrator*
- Canada Goose *Branta canadensis*
- Tundra Swan *Cygnus columbianus*

All of the above species presumably bred in the area. Canada geese were by far the most frequently reported species of waterfowl, followed by greater white-fronted geese.

Raptors

Observers reported four species of raptors in summer 2001:

- Rough Legged Hawk *Buteo lagopus*
- Peregrine Falcon *Falco peregrinus*
- Golden Eagle *Aquila chrysaetos*
- Short-eared Owl *Asio flammeus*

Songbirds and Other Birds

Nine species of songbirds and other birds were recorded during summer 2001:

- Rock Ptarmigan *Lagopus mutus*
- Sandhill Crane *Grus canadensis*
- Spotted Sandpiper *Actitis macularia*
- Long-tailed Jaegaer *Stercorarius longicaudus*
- Common Raven *Corvus corax*
- American Tree Sparrow *Spizella arborea*
- Horned Lark *Eremophila alpestris*
- Lapland Longspur *Calcarius lapponicus*
- Unspecified Redpoll *Carduelis ssp.*

The species recorded were seen incidental to other work, and the list is undoubtedly incomplete. This species list will be expanded considerably when specific breeding bird surveys are conducted.

During the winter ground survey in late April 2002, just three bird species were recorded. These were rock ptarmigan, common raven, and an unidentified hawk.

7. SUMMARY

7. Summary

Aerial surveys of the project area in 2001 and 2002 showed that the density of caribou varied seasonally, reflecting the northern migration of caribou through the area in spring and summer and their southern migration through the area in autumn. Densities began rising in August 2001 as caribou began their southward migration and reached a maximum of 0.60 animals/km^2 for 2001 in late September. The lowest densities (0.0 animals/10 km^2) occurred in November 2001 when most caribou had already reached their winter grounds at the tree-line well south of the project area. Significant numbers began to return to the project area in late March 2002 (0.86 animals/km^2), and high densities (0.80 animals/km^2) were also recorded during May 2002 when the pregnant cows were travelling towards the calving grounds northeast of Contwoyto Lake. Densities fell between the end of May and early July 2002 as the caribou moved through the project area. No cows with calves were observed in early June 2002, indicating that the migration to the calving grounds was nearly completed by early June. The relatively low densities observed in June and July 2002 indicated that most calving took place north of the project area.

The use of the project area by caribou in 2001 and 2002 was strongly influenced by Contwoyto Lake – the single largest topographic feature in the project area. The highest densities of caribou were observed in blocks 18E to 21E, which lie east of Contwoyto Lake. Relatively high use was observed during the southern migration in the summer of 2001 and the northern migration in March 2002.

Muskoxen were observed at low densities (an average of 0.3 animals/10 km^2) in the project area throughout the year, reflecting their lack of seasonal migration. An average of between 8 and 9 animals were observed at each sighting. Those data suggest that approximately six herds of muskoxen may use habitat within 5 km of the proposed road. Unlike caribou, the distribution of those herds within the project area was not obviously linked to Contwoyto Lake. Instead, muskoxen were scattered along the road route with relatively high densities in blocks close to Bathurst Inlet (4E), the eastern shore of Contwoyto Lake (19E), and in blocks 14E to 16E between Bathurst Inlet and Contwoyto Lake.

Low-level aerial surveys of the project area during July and August 2001 found 23 carnivore dens: 13 Arctic wolf, 2 fox (1 Arctic fox and 1 coloured fox), one wolverine, and two grizzly bear. None were found within the easternmost 70 km of the road. Wolf dens were located on elevated sites, mainly on eskers, with substrates consisting mainly of sandy or sandy loam soil stabilized by vegetation. Nearly all wolf dens were on slopes with about half situated on or near the top of the slope. There was no preferred direction. The remains of prey found at the den sites were dominated by caribou, followed by ground squirrel. Like wolves, the fox dens were built on eskers in soil containing sand and there was no preferred site direction. The prey remains of fox were similar to those of wolves. The single wolverine den was located in a jumble of rocks at the top of a hill near the proposed port on the southeastern shore of Contwoyto Lake and was surrounded by caribou remains. The two grizzly bear dens were located along the eastern section of the road, but neither appeared to have been used, at least not for overwintering.

Summary

Data from the radio-collar program of the West Kitikmeot/Slave Study (WKSS) indicates that there is little grizzly bear denning within the project area.

Arctic wolves were observed in the project area from July to November, 2001, and in March and early July, 2002, but not in May or early June, 2002. This pattern probably reflects their migration south in autumn and north in spring to follow the caribou, but it may also reflect the difficulty of observing wolves over snow and in close proximity to their dens. Coloured foxes were observed during aerial surveys of the project area in November 2001 and in March and May 2002, and were also incidentally observed by members of the project team during summer. There was only one incidental sighting of an Arctic fox. These patterns may reflect migratory behaviour in search of prey or the difficulty in observing these small animals from the air. Wolverines were observed during aerial surveys in September 2001 and March 2002, and incidental ground observations were made during the summer of 2001, but this pattern most likely reflects the difficulty of observing this rare and secretive animal from the air. Grizzly bears were observed by aerial surveys of the project area during late August and September, 2001, and in May, June and July 2002. They were also seen by ground observers in July and August 2001. That pattern reflects their hibernation schedule; they would have been underground from November to March and above ground the rest of the year.

Radio-collar data collected on grizzly bears by the WKSS indicated that 14 collared bears used areas in the vicinity of the proposed road route. Of those, eight males and three females used areas within 6 km of the road route.

A low-level helicopter survey of potential raptor nests was made in July 2002. A total of 59 raptors of five species were observed: rough-legged hawk (34), peregrine falcon (18), gyrfalcon (3), raven (3) and bald eagle (1). A total of 108 nest sites were observed. Twenty two of the 108 sites were in occupied territories, of which 18 nests with eggs and two nests with young were observed. In two sites, the likely presence of a nest was inferred from territorial behaviour of parents. Seven of the 108 sites were not occupied territories and did not have nests. The remaining seventy-nine were potential sites, some of which were used as perches. The highest concentration of raptor nesting sites was observed in blocks 1E to 4E near Bathurst Inlet.

A small-mammal trapping survey was conducted in August 2001. A total of 22 animals were caught in 900 trap nights of effort distributed over seven types of habitat. Red-backed voles were the only species caught. Catch per unit effort of red-backed voles was greatest in rocky habitat, followed by the riparian zones of streams. No species of lemming were caught, most likely because lemming populations were at the lowest ebb of their population cycle.

Eleven species of waterfowl and other non-raptor species of birds were observed during aerial surveys of the project area. Waterfowl were the most common type of non-raptor bird and Canada geese were the dominant species of waterfowl. Incidental observations in the summer of 2001 resulted in 44 sightings for a total of 236 birds, the most common of which was the Canada goose.

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APPENDIX 2.3-1
AERIAL SURVEYS, SURVEY BLOCK PARAMETERS

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Appendix 2.3-1
Aerial Surveys, Survey Block Parameters

Survey Block#	Chainage Km	Leg	Map Ref	Area (km^2)	Survey Type km^2 surveyed/block			Survey Intensity km^2 surveyed/km^2 in Block		
					Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
1	0-10	Bathurst	1E	65.6	15.0	13.5	8.3	0.23	0.21	0.13
2	10-20	Bathurst	2E	98.1	20.0	29.5	19.7	0.20	0.30	0.20
3	20-30	Bathurst	3E	89.9	20.0	29.5	19.7	0.22	0.33	0.22
4	30-40	Bathurst	4E	96.1	20.0	29.1	19.4	0.21	0.30	0.20
5	40-50	Bathurst	5E	85.8	18.8	26.2	17.5	0.22	0.30	0.20
6	50-60	Bathurst	6E	98.8	21.3	31.8	21.3	0.22	0.32	0.22
7	60-70	Bathurst	7E	94.1	20.0	30.1	20.1	0.21	0.32	0.21
8	70-80	Bathurst	8E	92.1	20.0	29.6	19.8	0.22	0.32	0.21
9	80-90	Bathurst	9E	99.3	20.0	29.7	19.8	0.20	0.30	0.20
10	90-100	Bathurst	10E	92.8	20.0	28.9	19.3	0.22	0.31	0.21
11	100-110	Bathurst	11E	90.8	20.0	27.7	18.7	0.22	0.31	0.21
12	110-120	Bathurst	12E	103.3	20.0	29.9	19.9	0.19	0.29	0.19
13	120-130	Bathurst	13E	90.0	20.0	29.1	19.5	0.22	0.32	0.22
14	130-140	Bathurst	14E	95.7	20.0	29.3	19.6	0.21	0.31	0.20
15	140-150	Bathurst	15E	95.3	20.0	29.0	19.4	0.21	0.30	0.20
16	150-160	Bathurst	16E	73.3	20.0	28.3	20.1	0.27	0.39	0.27
17	160-170	Bathurst	17E	81.4	18.7	28.5	18.4	0.23	0.35	0.23
18	170-180	Bathurst	18E	93.7	21.3	27.7	19.2	0.23	0.30	0.20
19	180-190	Bathurst	19E	91.7	20.0	29.5	19.7	0.22	0.32	0.21
20	190-200	Bathurst	20E	85.5	20.0	27.3	18.2	0.23	0.32	0.21
21	200-210	Bathurst	21E	106.2	20.0	28.8	18.5	0.19	0.27	0.17
31	0-10	Lupin	1W	100.1	26.3	33.1	22.0	0.26	0.33	0.22
32	10-20	Lupin	2W	91.6	21.6	28.2	18.9	0.24	0.31	0.21
33	20-30	Lupin	3W	95.6	19.5	29.3	19.6	0.20	0.31	0.21
34	30-40	Lupin	4W	96.4	22.7	29.2	19.5	0.24	0.30	0.20
35	40-50	Lupin	5W	95.5	20.0	29.8	20.2	0.21	0.31	0.21
36	50-60	Lupin	6W	96.5	20.0	28.9	19.3	0.21	0.30	0.20
37	60-70	Lupin	7W	83.9	17.3	17.1	16.2	0.21	0.20	0.19
38	70-78	Lupin	8W	93.0	22.7	25.4	25.4	0.24	0.27	0.27

Notes:

Survey Types	Explanation	Dates
Type 1	perpendicular flight lines	21-Jul-01, 29-Jul-01, 9-Aug-01, 21-Aug-01
Type 2	parallel flight lines - 3 lines	7-Sep-01, 20-Sep-01
Type 3	parallel flight lines - 2 lines	8-Nov-01, 22-Mar-02, 28-May-02, 7-Jun-02, 7-Jul-02

APPENDIX 2.4-1
AERIAL SURVEY RESULTS

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Appendix 2.4-1
Aerial Survey Results

Index For Data Set

Attribute	Explanation
Index	wildlife data index
Density	observation equivalent for # of animals/100km^2 in that aerial study block
Type	Survey Type (1, 2, or 3)
Chain	Chainage (kilometers from reference point along route): Bathurst Inlet =1 km; Start of Lupin leg = 282 km
Block#	Survey block #
Zone	UTM Zone
UTM East	UTM Easting
UTM North	UTM Northing
Date	Date Survey (when survey was conducted over several days, only the first date is indicated here).
Species	Species Code for species observed (see table of Species Codes for more details)
Total	Total number of animals in observation

Specie Code

Spp Code	Common Name
M-RATA	caribou
B-CAGO	canada goose
B-UGOO	unspecified goose
M-OVMO	muskox
B-UGUL	unspecified gull
B-UBIR	unspecified bird
M-CALU	Arctic wolf
B-UDUC	unspecified duck
B-TUSW	tundra swan
M-VUVU	coloured fox
M-LEAR	Arctic hare
B-GWFG	greater white-fronted goose
M-URAR	grizzly bear
B-UPTA	unspecified ptarmigan
B-RLHA	rough-legged hawk
B-UFAL	unspecified falcon
B-SACR	sandhill crane
M-GUGU	wolverine
B-UHAW	unspecified hawk
B-SNGO	snow goose
B-ARTE	Arctic tern
M-USEA	unspecified seal
M-UMUS	unspecified weasel
B-YBLO	yellow-billed loon
B-URAP	unspecified raptor
B-ULOO	unspecified loon
B-RTLO	red-throated loon
B-GOEA	golden eagle
B-CORA	common raven
B-COLO	common loon
B-BLGO	blue goose

Appendix 2.4-1
Aerial Survey Results

On-Transect Observations

Index	Density	Type	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
1	0.05	1	341	36	12	436,450	7,285,000	21-Jul-01	B-UGUL	1
2	0.05	1	294	32	12	482,350	7,285,500	21-Jul-01	B-UGUL	1
3	0.04	1	285	31	12	492,200	7,285,700	21-Jul-01	B-UGUL	1
6	0.05	1	179	18	12	569,500	7,264,000	21-Jul-01	B-UGUL	1
7	0.05	1	131	13	12	609,200	7,282,750	21-Jul-01	M-CALU	1
8	0.10	1	121	12	12	618,300	7,286,600	21-Jul-01	B-RLHA	2
9	0.05	1	23	3	13	387,000	7,366,000	21-Jul-01	B-UGUL	1
10	0.10	1	13	2	13	384,000	7,376,250	21-Jul-01	B-TUSW	2
11	0.40	1	206	21	12	545,300	7,263,500	21-Jul-01	B-UDUC	8
12	0.05	1	179	18	12	569,800	7,261,400	21-Jul-01	M-CALU	1
13	0.65	1	136	14	12	603,800	7,281,100	21-Jul-01	M-OVMO	13
14	0.10	1	131	13	12	613,500	7,279,000	21-Jul-01	B-UGUL	2
15	0.05	1	186	19	12	564,700	7,264,500	21-Jul-01	B-UGUL	1
16	1.25	1	150	15	12	598,200	7,267,700	21-Jul-01	B-UGOO	25
17	1.50	1	78	8	13	367,400	7,320,600	21-Jul-01	B-UGOO	30
18	0.05	1	20	2	13	387,600	7,371,500	21-Jul-01	M-OVMO	1
21	0.05	1	336	36	12	441,000	7,279,500	29-Jul-01	B-UGUL	1
22	0.04	1	351	38	12	427,000	7,283,000	29-Jul-01	M-RATA	1
23	0.04	1	286	31	12	487,300	7,286,000	29-Jul-01	B-UGUL	1
24	0.44	1	320	34	12	455,500	7,277,000	29-Jul-01	B-CAGO	10
26	1.34	1	168	17	12	579,200	7,268,000	29-Jul-01	B-ARTE	25
29	0.30	1	85	9	13	367,200	7,312,100	29-Jul-01	B-CAGO	6
30	0.80	1	156	16	12	595,000	7,263,800	29-Jul-01	M-OVMO	16
34	0.10	1	308	33	12	469,500	7,279,700	9-Aug-01	M-RATA	2
35	0.05	1	304	33	12	469,500	7,287,600	9-Aug-01	M-RATA	1
36	0.05	1	212	21	12	540,350	7,262,700	9-Aug-01	M-RATA	1
37	0.05	1	205	21	12	546,100	7,259,400	9-Aug-01	M-RATA	1
38	0.15	1	196	20	12	555,200	7,264,500	9-Aug-01	M-RATA	3
39	0.15	1	195	20	12	555,100	7,260,000	9-Aug-01	M-RATA	3
40	0.30	1	195	20	12	555,100	7,259,000	9-Aug-01	M-RATA	6
41	0.40	1	103	11	12	634,600	7,295,500	9-Aug-01	M-RATA	8
42	0.30	1	90	9	13	366,800	7,307,000	9-Aug-01	M-RATA	6
43	0.25	1	85	9	13	368,600	7,312,000	9-Aug-01	M-RATA	5
44	0.05	1	70	7	13	369,500	7,324,800	9-Aug-01	M-UMUS	1
45	0.05	1	45	5	13	374,500	7,349,700	9-Aug-01	M-OVMO	1
46	0.05	1	210	21	12	541,100	7,257,600	9-Aug-01	M-RATA	1
47	0.05	1	205	21	12	545,400	7,255,000	9-Aug-01	M-RATA	1
48	0.05	1	189	19	12	560,300	7,259,000	9-Aug-01	M-RATA	1
49	1.15	1	190	19	12	560,300	7,262,200	9-Aug-01	M-OVMO	23
50	0.09	1	181	18	12	569,800	7,255,100	9-Aug-01	M-RATA	2
51	1.25	1	160	16	12	588,000	7,264,000	9-Aug-01	B-UGOO	25
52	0.25	1	101	10	12	631,000	7,299,700	9-Aug-01	M-RATA	5
53	0.05	1	86	9	13	366,700	7,311,500	9-Aug-01	M-RATA	1
54	0.10	1	81	8	13	367,500	7,316,700	9-Aug-01	M-RATA	2
55	0.25	1	78	8	13	367,500	7,320,400	9-Aug-01	M-RATA	5
56	0.10	1	14	2	13	384,000	7,375,700	9-Aug-01	B-TUSW	2
57	0.20	1	210	21	12	541,000	7,259,500	9-Aug-01	M-RATA	4
58	0.05	1	211	21	12	541,000	7,261,300	9-Aug-01	M-RATA	1
59	0.05	1	212	21	12	541,000	7,262,700	9-Aug-01	M-RATA	1
60	0.15	1	206	21	12	545,300	7,261,000	9-Aug-01	M-RATA	3
61	0.15	1	205	21	12	545,300	7,258,000	9-Aug-01	M-RATA	3
62	0.05	1	205	21	12	545,150	7,255,500	9-Aug-01	M-RATA	1
63	0.15	1	201	20	12	550,900	7,256,000	9-Aug-01	M-RATA	3
64	0.05	1	201	20	12	550,900	7,256,000	9-Aug-01	M-RATA	1
65	0.05	1	199	20	12	551,000	7,262,850	9-Aug-01	M-RATA	1
66	0.05	1	196	20	12	554,400	7,264,500	9-Aug-01	M-RATA	1
67	0.05	1	195	20	12	554,400	7,260,200	9-Aug-01	M-RATA	1

(continued)

Appendix 2.4-1
Aerial Survey Results

On-Transect Observations

Index	Density	Type	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
68	0.10	1	195	20	12	554,400	7,260,200	9-Aug-01	M-RATA	2
69	0.05	1	195	20	12	554,400	7,259,000	9-Aug-01	M-RATA	1
70	0.05	1	199	20	12	554,400	7,256,600	9-Aug-01	M-RATA	1
71	0.05	1	188	19	12	560,300	7,257,100	9-Aug-01	M-RATA	1
72	0.05	1	189	19	12	560,300	7,258,600	9-Aug-01	M-RATA	1
73	0.05	1	189	19	12	560,300	7,259,000	9-Aug-01	M-RATA	1
74	0.10	1	189	19	12	560,300	7,259,000	9-Aug-01	M-RATA	2
75	0.05	1	186	19	12	564,300	7,259,800	9-Aug-01	M-RATA	1
76	0.05	1	181	18	12	569,700	7,254,500	9-Aug-01	M-RATA	1
78	0.11	1	170	17	12	578,800	7,263,900	9-Aug-01	M-RATA	2
79	0.05	1	110	11	12	629,000	7,291,000	9-Aug-01	M-RATA	1
80	0.30	1	95	10	13	364,000	7,302,800	9-Aug-01	M-RATA	6
81	0.15	1	89	9	13	368,000	7,307,300	9-Aug-01	M-RATA	3
82	0.15	1	90	9	13	365,000	7,307,300	9-Aug-01	M-RATA	3
83	0.30	1	86	9	13	367,000	7,311,800	9-Aug-01	M-RATA	6
84	0.10	1	80	8	13	369,000	7,316,400	9-Aug-01	M-RATA	2
85	0.10	1	79	8	13	371,000	7,316,800	9-Aug-01	M-RATA	2
86	1.40	1	74	8	13	375,000	7,320,600	9-Aug-01	B-UDUC	28
90	0.05	1	307	33	12	470,500	7,279,800	21-Aug-01	M-RATA	1
91	0.05	1	331	35	12	446,300	7,285,050	21-Aug-01	M-RATA	1
92	0.05	1	341	36	12	436,200	7,285,500	21-Aug-01	M-RATA	1
93	0.10	1	341	36	12	436,200	7,285,500	21-Aug-01	M-RATA	2
94	0.06	1	347	37	12	432,000	7,276,000	21-Aug-01	M-RATA	1
95	0.76	1	285	31	12	492,500	7,288,400	21-Aug-01	M-OVMO	20
97	0.05	1	331	35	12	446,500	7,282,000	21-Aug-01	M-RATA	1
98	0.05	1	210	21	12	541,300	7,256,000	21-Aug-01	M-RATA	1
99	0.15	1	210	21	12	541,300	7,257,000	21-Aug-01	M-RATA	3
100	0.05	1	210	21	12	541,300	7,259,500	21-Aug-01	M-RATA	1
101	0.05	1	210	21	12	541,300	7,260,000	21-Aug-01	M-RATA	1
103	0.20	1	196	20	12	554,300	7,266,000	21-Aug-01	M-RATA	4
104	0.05	1	196	20	12	554,300	7,261,500	21-Aug-01	M-OVMO	1
105	0.10	1	195	20	12	554,300	7,259,000	21-Aug-01	M-RATA	2
106	0.05	1	189	19	12	560,300	7,258,600	21-Aug-01	M-RATA	1
107	0.15	1	189	19	12	560,300	7,258,600	21-Aug-01	M-RATA	3
109	0.05	1	186	19	12	564,300	7,259,500	21-Aug-01	M-RATA	1
110	0.05	1	185	19	12	564,300	7,258,700	21-Aug-01	M-RATA	1
111	0.10	1	185	19	12	564,300	7,258,700	21-Aug-01	M-RATA	2
112	0.05	1	185	19	12	564,300	7,256,800	21-Aug-01	M-RATA	1
113	0.05	1	185	19	12	564,300	7,256,800	21-Aug-01	M-RATA	1
114	0.05	1	185	19	12	564,300	7,256,000	21-Aug-01	M-RATA	1
115	0.05	1	180	18	12	570,000	7,256,800	21-Aug-01	M-RATA	1
116	0.14	1	180	18	12	570,000	7,259,600	21-Aug-01	M-RATA	3
117	0.05	1	180	18	12	570,000	7,259,600	21-Aug-01	M-RATA	1
118	0.05	1	179	18	12	570,000	7,261,000	21-Aug-01	M-RATA	1
119	0.19	1	179	18	12	570,000	7,261,000	21-Aug-01	M-RATA	4
120	0.09	1	179	18	12	570,000	7,261,300	21-Aug-01	M-RATA	2
121	0.14	1	179	18	12	570,000	7,261,300	21-Aug-01	M-RATA	3
122	0.05	1	179	18	12	570,000	7,261,800	21-Aug-01	M-RATA	1
123	0.05	1	179	18	12	570,000	7,261,800	21-Aug-01	M-RATA	1
124	0.05	1	179	18	12	570,000	7,263,000	21-Aug-01	M-RATA	1
125	0.05	1	179	18	12	570,000	7,263,300	21-Aug-01	M-RATA	1
126	0.05	1	173	18	12	574,000	7,265,000	21-Aug-01	M-RATA	1
127	0.09	1	176	18	12	574,000	7,260,000	21-Aug-01	M-RATA	2
128	0.05	1	172	17	12	579,000	7,259,500	21-Aug-01	M-RATA	1
129	0.05	1	166	17	12	583,600	7,262,300	21-Aug-01	M-RATA	1
130	0.05	1	166	17	12	583,600	7,261,600	21-Aug-01	M-RATA	1
132	0.05	1	136	14	12	606,600	7,278,300	21-Aug-01	M-RATA	1
133	0.05	1	86	9	13	366,300	7,311,400	21-Aug-01	M-RATA	1
134	0.05	1	85	9	13	371,300	7,311,400	21-Aug-01	M-RATA	1
135	0.10	1	80	8	13	369,000	7,316,800	21-Aug-01	M-RATA	2
136	0.05	1	78	8	13	369,000	7,320,000	21-Aug-01	M-RATA	1

(continued)

Appendix 2.4-1
Aerial Survey Results

On-Transect Observations

Index	Density	Type	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
137	0.05	1	75	8	13	374,000	7,320,000	21-Aug-01	M-RATA	1
138	0.05	1	71	7	13	377,500	7,325,500	21-Aug-01	M-RATA	1
140	0.05	1	66	7	13	374,000	7,329,200	21-Aug-01	M-RATA	1
142	0.05	1	60	6	13	376,500	7,335,200	21-Aug-01	M-RATA	1
143	0.05	1	60	6	13	376,500	7,335,200	21-Aug-01	M-RATA	1
144	0.09	1	60	6	13	372,000	7,335,200	21-Aug-01	M-RATA	2
145	0.05	1	60	6	13	372,000	7,335,200	21-Aug-01	M-RATA	1
146	0.11	1	50	5	13	376,100	7,345,000	21-Aug-01	M-RATA	2
147	0.05	1	50	5	13	375,900	7,345,000	21-Aug-01	M-RATA	1
148	0.11	1	50	5	13	373,400	7,344,600	21-Aug-01	M-RATA	2
149	0.21	1	45	5	13	377,000	7,349,000	21-Aug-01	M-RATA	4
150	0.16	1	45	5	13	379,000	7,349,000	21-Aug-01	M-RATA	3
151	0.05	1	39	4	13	377,000	7,354,000	21-Aug-01	M-RATA	1
152	0.05	1	42	4	13	371,000	7,354,000	21-Aug-01	M-RATA	1
153	0.05	1	210	21	12	540,300	7,255,000	21-Aug-01	M-RATA	1
154	0.20	1	210	21	12	540,300	7,257,000	21-Aug-01	M-RATA	4
155	0.05	1	201	20	12	550,200	7,260,400	21-Aug-01	M-URAR	1
156	0.10	1	191	19	12	559,500	7,259,300	21-Aug-01	M-RATA	2
157	0.80	1	186	19	12	565,000	7,263,400	21-Aug-01	M-RATA	16
158	0.09	1	179	18	12	569,200	7,262,800	21-Aug-01	M-RATA	2
159	0.05	1	174	18	12	578,200	7,259,000	21-Aug-01	M-RATA	1
160	0.05	1	115	12	12	625,300	7,287,700	21-Aug-01	B-SACR	1
161	0.05	1	79	8	13	371,400	7,316,000	21-Aug-01	M-RATA	1
162	0.05	1	70	7	13	371,000	7,324,600	21-Aug-01	M-RATA	1
163	0.05	1	65	7	13	372,600	7,329,900	21-Aug-01	M-RATA	1
164	0.05	1	60	6	13	377,700	7,334,600	21-Aug-01	M-RATA	1
165	0.05	1	47	5	13	369,700	7,349,700	21-Aug-01	M-RATA	1
166	0.05	1	42	4	13	371,500	7,353,300	21-Aug-01	M-OVMO	1
173	0.04	2	302	32	12	473,987	7,284,572	7-Sep-01	B-UGOO	1
174	0.18	2	294	32	12	480,412	7,288,245	7-Sep-01	B-UGOO	5
175	0.03	2	281	31	12	491,288	7,294,012	7-Sep-01	B-URAP	1
176	0.24	2	281	31	12	491,746	7,294,258	7-Sep-01	B-UGOO	8
177	0.03	2	284	31	12	490,738	7,291,303	7-Sep-01	M-OVMO	1
178	0.10	2	316	34	12	460,503	7,282,371	7-Sep-01	B-UGOO	3
181	0.18	2	281	31	12	488,536	7,297,171	7-Sep-01	B-TUSW	6
182	0.91	2	281	31	12	491,471	7,294,742	7-Sep-01	B-CAGO	30
183	0.36	2	281	31	12	492,005	7,294,859	7-Sep-01	B-CAGO	12
261	0.25	2	162	16	12	586,948	7,260,956	7-Sep-01	B-GWFG	7
264	0.03	2	213	21	12	538,626	7,261,319	7-Sep-01	B-UGUL	1
271	0.29	2	196	20	12	555,038	7,263,185	7-Sep-01	M-RATA	8
272	0.18	2	195	20	12	555,882	7,263,288	7-Sep-01	M-RATA	5
273	0.40	2	194	20	12	556,965	7,263,002	7-Sep-01	M-RATA	11
274	0.14	2	191	19	12	558,638	7,263,018	7-Sep-01	M-RATA	4
275	0.24	2	191	19	12	559,459	7,262,996	7-Sep-01	M-RATA	7
276	0.24	2	189	19	12	560,295	7,259,909	7-Sep-01	M-RATA	7
277	0.04	2	200	20	12	553,400	7,256,643	7-Sep-01	B-UGUL	1
278	0.11	2	192	20	12	557,042	7,257,014	7-Sep-01	M-RATA	3
279	0.07	2	181	18	12	568,764	7,256,786	7-Sep-01	M-RATA	2
280	0.04	2	180	18	12	570,548	7,256,630	7-Sep-01	B-UGUL	1
282	0.07	2	177	18	12	572,617	7,260,014	7-Sep-01	M-RATA	2
283	0.04	2	178	18	12	571,573	7,259,948	7-Sep-01	M-RATA	1
284	0.22	2	179	18	12	571,098	7,259,898	7-Sep-01	M-RATA	6
285	0.04	2	182	18	12	567,888	7,259,837	7-Sep-01	M-RATA	1
286	0.07	2	182	18	12	567,589	7,259,846	7-Sep-01	M-RATA	2
287	0.14	2	186	19	12	564,010	7,260,088	7-Sep-01	M-RATA	4
288	0.22	2	194	20	12	557,146	7,264,829	7-Sep-01	M-RATA	6
289	0.31	2	191	19	12	558,840	7,262,895	7-Sep-01	M-RATA	9
290	0.34	2	190	19	12	561,362	7,262,638	7-Sep-01	M-RATA	10
291	0.07	2	189	19	12	561,723	7,262,662	7-Sep-01	B-SACR	2
292	0.27	2	186	19	12	564,678	7,262,828	7-Sep-01	M-RATA	8
293	0.04	2	182	18	12	567,889	7,263,172	7-Sep-01	M-RATA	1
294	0.14	2	179	18	12	569,208	7,263,243	7-Sep-01	M-RATA	4

(continued)

Appendix 2.4-1
Aerial Survey Results

On-Transect Observations

Index	Density	Type	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
295	0.22	2	179	18	12	569,346	7,263,216	7-Sep-01	M-RATA	6
296	0.07	2	178	18	12	570,797	7,262,815	7-Sep-01	M-RATA	2
297	0.07	2	178	18	12	571,603	7,262,678	7-Sep-01	M-RATA	2
298	0.21	2	167	17	12	581,964	7,261,038	7-Sep-01	B-GWFG	6
299	0.25	2	166	17	12	582,884	7,261,020	7-Sep-01	B-CAGO	7
300	0.21	2	166	17	12	582,934	7,261,017	7-Sep-01	B-UDUC	6
301	1.23	2	163	17	12	584,160	7,260,984	7-Sep-01	B-CAGO	35
302	0.04	2	167	17	12	581,369	7,263,933	7-Sep-01	M-OVMO	1
303	0.28	2	171	17	12	576,798	7,264,427	7-Sep-01	M-RATA	8
304	0.35	2	165	17	12	583,817	7,266,849	7-Sep-01	B-CAGO	10
305	0.07	2	152	15	12	592,646	7,271,808	7-Sep-01	M-OVMO	2
306	0.10	2	151	15	12	593,210	7,272,279	7-Sep-01	M-OVMO	3
307	0.07	2	151	15	12	593,620	7,272,697	7-Sep-01	M-OVMO	2
309	1.73	2	148	15	12	597,545	7,272,477	7-Sep-01	B-UGOO	50
310	0.14	2	157	16	12	593,425	7,263,743	7-Sep-01	M-RATA	4
311	0.04	2	156	16	12	594,396	7,264,590	7-Sep-01	M-RATA	1
312	0.17	2	151	15	12	596,923	7,267,376	7-Sep-01	M-RATA	5
313	0.27	2	142	14	12	603,343	7,273,480	7-Sep-01	B-UGOO	8
315	0.10	2	128	13	12	613,636	7,280,355	7-Sep-01	M-RATA	3
316	0.04	2	107	11	12	630,254	7,294,756	7-Sep-01	B-UBIR	1
317	0.03	2	99	10	12	632,574	7,302,120	7-Sep-01	M-CALU	1
319	0.47	2	76	8	13	374,253	7,317,743	7-Sep-01	B-CAGO	14
321	0.17	2	41	4	13	373,442	7,355,234	7-Sep-01	B-CAGO	5
328	0.27	2	46	5	13	377,392	7,347,815	7-Sep-01	B-TUSW	7
334	0.07	2	14	2	13	386,155	7,375,024	7-Sep-01	B-TUSW	2
336	0.07	2	2	1	13	390,127	7,379,424	7-Sep-01	B-UDUC	1
337	0.35	2	165	17	12	584,916	7,268,454	7-Sep-01	B-UGOO	10
340	0.90	2	181	18	12	568,930	7,263,091	7-Sep-01	M-RATA	25
341	0.29	2	181	18	12	568,830	7,263,423	7-Sep-01	M-RATA	8
342	0.07	2	179	18	12	569,038	7,264,124	7-Sep-01	M-RATA	2
343	0.22	2	178	18	12	570,045	7,264,636	7-Sep-01	M-RATA	6
344	0.11	2	177	18	12	571,615	7,264,726	7-Sep-01	M-RATA	3
346	0.07	2	173	18	12	573,632	7,265,019	7-Sep-01	M-RATA	2
347	0.18	2	177	18	12	571,661	7,265,607	7-Sep-01	B-CAGO	5
348	0.04	2	179	18	12	568,602	7,266,046	7-Sep-01	M-RATA	1
349	0.27	2	186	19	12	565,620	7,264,572	7-Sep-01	M-RATA	8
350	0.17	2	185	19	12	566,035	7,264,346	7-Sep-01	M-RATA	5
351	0.11	2	181	18	12	569,109	7,260,406	7-Sep-01	M-RATA	3
352	0.03	2	184	19	12	565,990	7,258,705	7-Sep-01	M-RATA	1
361	0.03	2	318	34	12	457,825	7,285,230	20-Sep-01	M-RATA	1
363	0.27	2	325	35	12	452,172	7,285,201	20-Sep-01	M-RATA	8
364	0.03	2	326	35	12	451,486	7,285,242	20-Sep-01	M-RATA	1
365	0.07	2	322	34	12	455,146	7,282,225	20-Sep-01	M-RATA	2
366	0.41	2	321	34	12	456,307	7,282,225	20-Sep-01	M-RATA	12
367	0.10	2	320	34	12	456,782	7,282,229	20-Sep-01	M-RATA	3
368	0.07	2	316	34	12	460,066	7,282,198	20-Sep-01	M-RATA	2
369	0.03	2	316	34	12	460,185	7,282,197	20-Sep-01	M-RATA	1
370	0.03	2	316	34	12	460,904	7,282,207	20-Sep-01	M-RATA	1
373	0.03	2	313	34	12	463,822	7,282,233	20-Sep-01	M-RATA	1
374	0.07	2	314	34	12	462,490	7,279,309	20-Sep-01	M-RATA	2
375	0.03	2	316	34	12	460,870	7,279,313	20-Sep-01	M-RATA	1
376	0.10	2	317	34	12	460,477	7,279,316	20-Sep-01	M-RATA	3
379	0.07	2	326	35	12	450,478	7,279,179	20-Sep-01	M-RATA	2
381	0.18	2	342	37	12	435,019	7,281,949	20-Sep-01	M-RATA	3
382	0.24	2	341	36	12	435,885	7,281,950	20-Sep-01	M-RATA	7
384	0.06	2	350	37	12	428,816	7,284,669	20-Sep-01	B-UFAL	1
386	0.06	2	350	37	12	427,727	7,281,580	20-Sep-01	M-OVMO	1
391	0.07	2	194	20	12	556,701	7,263,027	20-Sep-01	M-RATA	2
392	0.04	2	193	20	12	557,456	7,263,016	20-Sep-01	M-RATA	1
396	0.14	2	209	21	12	541,899	7,257,154	20-Sep-01	M-RATA	4
399	0.38	2	203	21	12	548,212	7,257,097	20-Sep-01	B-UGOO	11

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Aerial Survey Results

On-Transect Observations

Index	Density	Type	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
400	0.04	2	195	20	12	555,058	7,257,071	20-Sep-01	M-RATA	1
403	0.24	2	187	19	12	563,359	7,259,998	20-Sep-01	B-TUSW	7
404	0.68	2	189	19	12	560,921	7,259,990	20-Sep-01	M-RATA	20
405	0.03	2	189	19	12	560,921	7,259,990	20-Sep-01	M-GUGU	1
406	0.24	2	190	19	12	561,482	7,262,982	20-Sep-01	M-RATA	7
407	0.03	2	189	19	12	561,758	7,262,980	20-Sep-01	M-RATA	1
408	0.17	2	186	19	12	564,898	7,262,950	20-Sep-01	M-RATA	5
414	0.39	2	162	16	12	587,128	7,261,124	20-Sep-01	M-RATA	11
416	0.03	2	151	15	12	596,870	7,267,603	20-Sep-01	M-RATA	1
419	0.41	2	129	13	12	611,118	7,285,104	20-Sep-01	M-RATA	12
432	0.17	2	96	10	13	364,745	7,301,304	20-Sep-01	M-RATA	5
442	0.16	2	61	6	13	371,160	7,334,017	20-Sep-01	M-RATA	5
443	0.04	2	43	5	13	371,979	7,352,227	20-Sep-01	M-URAR	1
444	0.13	2	67	7	13	373,959	7,328,513	20-Sep-01	M-RATA	4
445	0.10	2	67	7	13	373,989	7,327,776	20-Sep-01	M-RATA	3
446	0.03	2	65	7	13	376,846	7,330,384	20-Sep-01	M-RATA	1
447	0.20	2	63	7	13	376,886	7,331,221	20-Sep-01	M-RATA	6
448	0.14	2	23	3	13	385,426	7,365,711	20-Sep-01	M-RATA	4
459	0.03	2	289	31	12	484,532	7,290,383	20-Sep-01	M-LEAR	1
460	0.03	2	285	31	12	489,480	7,290,222	20-Sep-01	M-LEAR	1
461	0.10	2	305	33	12	472,771	7,280,880	20-Sep-01	B-UPTA	3
462	0.03	2	307	33	12	467,163	7,285,112	20-Sep-01	B-COLO	1
465	0.03	2	326	35	12	451,428	7,285,242	20-Sep-01	M-RATA	1
467	0.17	2	326	35	12	450,715	7,282,251	20-Sep-01	M-RATA	5
468	0.54	2	324	35	12	452,845	7,282,253	20-Sep-01	M-RATA	16
469	0.50	2	322	35	12	454,487	7,282,227	20-Sep-01	M-RATA	15
470	0.10	2	321	34	12	455,714	7,282,224	20-Sep-01	M-RATA	3
471	0.27	2	318	34	12	458,433	7,282,201	20-Sep-01	M-RATA	8
472	0.51	2	318	34	12	459,054	7,282,197	20-Sep-01	M-RATA	15
473	1.03	2	316	34	12	460,935	7,282,209	20-Sep-01	M-RATA	30
475	0.27	2	313	34	12	464,282	7,279,262	20-Sep-01	M-RATA	8
476	0.51	2	320	34	12	456,198	7,279,182	20-Sep-01	M-RATA	15
477	0.27	2	325	35	12	451,989	7,279,219	20-Sep-01	M-RATA	8
478	0.27	2	329	35	12	448,179	7,279,282	20-Sep-01	M-RATA	8
479	0.47	2	342	37	12	433,772	7,285,192	20-Sep-01	M-RATA	8
482	0.52	2	334	36	12	443,613	7,279,135	20-Sep-01	M-RATA	15
483	0.06	2	343	37	12	435,222	7,279,244	20-Sep-01	M-LEAR	1
484	0.31	2	355	38	12	424,451	7,284,747	20-Sep-01	M-RATA	8
486	0.88	2	348	37	12	429,454	7,281,577	20-Sep-01	B-UPTA	15
488	0.52	2	208	21	12	542,699	7,262,946	20-Sep-01	M-RATA	15
490	0.24	2	203	21	12	547,956	7,263,026	20-Sep-01	M-CALU	7
494	0.52	2	208	21	12	542,804	7,259,869	20-Sep-01	M-RATA	15
495	0.28	2	209	21	12	542,054	7,259,916	20-Sep-01	M-RATA	8
499	0.42	2	203	21	12	547,711	7,257,111	20-Sep-01	M-RATA	12
507	0.04	2	176	18	12	573,919	7,259,945	20-Sep-01	M-URAR	1
509	0.25	2	181	18	12	569,311	7,260,042	20-Sep-01	M-RATA	7
511	0.27	2	190	19	12	561,272	7,262,981	20-Sep-01	M-RATA	8
516	0.03	2	149	15	12	598,087	7,268,837	20-Sep-01	M-LEAR	1
518	0.53	2	163	17	12	586,004	7,263,904	20-Sep-01	M-RATA	15
520	0.49	2	168	17	12	579,459	7,266,874	20-Sep-01	B-TUSW	14
522	0.45	2	152	15	12	592,554	7,271,762	20-Sep-01	B-UPTA	13
524	0.10	2	129	13	12	610,794	7,284,925	20-Sep-01	B-TUSW	3
525	0.52	2	127	13	12	611,831	7,285,552	20-Sep-01	M-RATA	15
528	0.18	2	112	11	12	626,328	7,291,447	20-Sep-01	B-TUSW	5
529	0.03	2	122	12	12	617,948	7,285,750	20-Sep-01	M-LEAR	1
530	0.44	2	136	14	12	606,375	7,279,475	20-Sep-01	B-UPTA	13
539	0.10	2	75	8	13	374,402	7,318,659	20-Sep-01	M-RATA	3
540	0.27	2	79	8	13	370,318	7,317,525	20-Sep-01	M-RATA	8
541	0.81	2	84	9	13	367,725	7,312,799	20-Sep-01	B-UGOO	24
544	0.03	2	83	9	13	365,497	7,314,889	20-Sep-01	B-UFAL	1
546	0.28	2	62	6	13	371,159	7,333,603	20-Sep-01	B-TUSW	9
547	0.47	2	60	6	13	371,132	7,334,984	20-Sep-01	M-RATA	15

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Appendix 2.4-1
Aerial Survey Results

On-Transect Observations

Index	Density	Type	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
548	0.47	2	56	6	13	371,052	7,339,234	20-Sep-01	M-RATA	15
550	0.03	2	18	2	13	380,262	7,372,045	20-Sep-01	M-CALU	1
551	0.51	2	17	2	13	380,257	7,373,991	20-Sep-01	M-RATA	15
553	0.81	2	15	2	13	383,206	7,375,662	20-Sep-01	B-UGOO	24
554	0.14	2	16	2	13	383,214	7,374,307	20-Sep-01	B-TUSW	4
557	0.41	2	36	4	13	377,573	7,356,830	20-Sep-01	M-RATA	12
558	0.24	2	33	4	13	379,193	7,360,323	20-Sep-01	B-TUSW	7
559	0.17	2	33	4	13	379,193	7,360,323	20-Sep-01	M-RATA	5
560	0.92	2	44	5	13	373,830	7,351,003	20-Sep-01	B-UGOO	24
561	0.46	2	44	5	13	373,830	7,351,003	20-Sep-01	M-RATA	12
564	0.40	2	62	7	13	376,891	7,332,092	20-Sep-01	B-UGOO	12
565	0.75	2	56	6	13	376,997	7,338,235	20-Sep-01	M-RATA	24
566	0.75	2	56	6	13	376,997	7,338,235	20-Sep-01	M-RATA	24
567	0.34	2	45	5	13	377,298	7,350,250	20-Sep-01	M-RATA	9
568	0.50	2	45	5	13	377,298	7,350,250	20-Sep-01	M-RATA	13
570	0.89	2	4	1	13	385,925	7,378,869	20-Sep-01	M-RATA	12
571	0.52	3	172	18	12	577,008	7,262,197	7-Nov-01	B-UPTA	10
572	0.05	3	166	17	12	583,162	7,264,337	7-Nov-01	M-LEAR	1
573	0.11	3	164	17	12	585,144	7,264,981	7-Nov-01	M-CALU	2
575	0.05	3	142	14	12	600,040	7,278,545	7-Nov-01	M-LEAR	1
576	0.05	3	130	13	12	609,189	7,283,722	7-Nov-01	M-LEAR	1
577	0.10	3	122	12	12	617,015	7,287,718	7-Nov-01	M-LEAR	2
579	0.11	3	110	11	12	625,905	7,294,463	7-Nov-01	M-OVMO	2
580	0.05	3	106	11	12	629,461	7,297,770	7-Nov-01	M-VUVU	1
581	0.05	3	101	10	12	631,787	7,299,936	7-Nov-01	M-CALU	1
582	0.05	3	83	9	13	365,899	7,315,065	7-Nov-01	M-VUVU	1
583	0.06	3	48	5	13	371,347	7,346,812	7-Nov-01	M-VUVU	1
584	0.05	3	17	2	13	380,232	7,374,174	7-Nov-01	M-VUVU	1
586	0.33	3	50	6	13	376,815	7,344,598	7-Nov-01	B-UPTA	7
590	0.26	3	144	15	12	600,939	7,270,890	7-Nov-01	M-OVMO	5
591	0.05	3	157	16	12	593,277	7,263,910	7-Nov-01	M-LEAR	1
592	0.06	3	201	20	12	550,482	7,256,674	7-Nov-01	M-VUVU	1
593	0.10	3	319	34	12	458,567	7,279,134	7-Nov-01	M-OVMO	2
594	1.19	3	33	4	13	381,990	7,358,653	7-Nov-01	M-OVMO	23
595	0.05	3	182	19	12	567,381	7,262,592	7-Nov-01	M-CALU	1
596	0.22	3	172	17	12	577,696	7,262,598	7-Nov-01	B-UBIR	4
597	0.52	3	150	15	12	594,429	7,272,012	7-Nov-01	B-UBIR	10
600	0.41	3	138	14	12	606,591	7,275,363	7-Nov-01	B-UBIR	8
1000	0.22	3	207	21	12	543,513	7,262,407	22-Mar-02	M-RATA	4
1001	0.43	3	207	21	12	544,356	7,262,488	22-Mar-02	M-RATA	8
1002	2.53	3	197	20	12	553,313	7,262,765	22-Mar-02	M-RATA	46
1003	0.44	3	196	20	12	554,318	7,262,789	22-Mar-02	M-RATA	8
1004	1.05	3	195	20	12	555,996	7,262,856	22-Mar-02	M-RATA	19
1005	0.66	3	193	19	12	558,398	7,262,874	22-Mar-02	M-RATA	13
1006	0.56	3	189	19	12	562,365	7,262,970	22-Mar-02	M-RATA	11
1007	0.61	3	187	19	12	563,118	7,262,971	22-Mar-02	M-RATA	12
1008	0.36	3	182	18	12	567,507	7,263,011	22-Mar-02	M-RATA	7
1009	0.10	3	179	18	12	570,180	7,262,897	22-Mar-02	M-CALU	2
1010	0.10	3	179	18	12	570,562	7,262,892	22-Mar-02	M-RATA	2
1011	0.31	3	178	18	12	571,324	7,262,905	22-Mar-02	M-RATA	6
1012	0.05	3	177	18	12	572,690	7,262,880	22-Mar-02	M-VUVU	1
1013	0.16	3	176	18	12	573,520	7,262,882	22-Mar-02	M-RATA	3
1014	0.05	3	168	17	12	581,379	7,267,096	22-Mar-02	M-VUVU	1
1015	0.16	3	150	15	12	593,389	7,273,112	22-Mar-02	M-RATA	3
1016	0.15	3	157	16	12	592,697	7,263,592	22-Mar-02	M-RATA	3
1017	0.55	3	161	16	12	589,691	7,260,720	22-Mar-02	M-RATA	11
1018	0.65	3	166	17	12	582,202	7,260,386	22-Mar-02	M-RATA	12
1019	0.10	3	174	18	12	576,412	7,261,028	22-Mar-02	M-RATA	2
1020	1.77	3	175	18	12	574,872	7,258,389	22-Mar-02	M-RATA	34
1021	0.21	3	180	18	12	571,784	7,256,896	22-Mar-02	M-RATA	4
1022	0.31	3	180	18	12	570,370	7,257,072	22-Mar-02	M-RATA	6
1024	0.30	3	184	19	12	565,154	7,257,233	22-Mar-02	M-RATA	6

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Appendix 2.4-1
Aerial Survey Results

On-Transect Observations

Index	Density	Type	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
1025	0.25	3	188	19	12	561,192	7,257,198	22-Mar-02	M-RATA	5
1026	0.66	3	188	19	12	560,371	7,257,178	22-Mar-02	M-RATA	13
1027	0.05	3	191	19	12	559,374	7,257,136	22-Mar-02	M-GUGU	1
1028	0.20	3	192	19	12	557,746	7,257,313	22-Mar-02	M-RATA	4
1029	0.11	3	192	20	12	557,060	7,257,347	22-Mar-02	M-RATA	2
1030	0.06	3	194	20	12	555,295	7,257,406	22-Mar-02	M-CALU	1
1031	0.06	3	202	20	12	548,902	7,257,273	22-Mar-02	M-RATA	1
1032	0.05	3	284	31	12	490,994	7,291,629	22-Mar-02	M-VUVU	1
1034	0.20	3	332	35	12	445,349	7,279,269	22-Mar-02	M-RATA	4
1035	0.21	3	338	36	12	438,480	7,279,312	22-Mar-02	M-RATA	4
1036	0.04	3	356	38	12	422,800	7,284,722	22-Mar-02	M-VUVU	1
1037	0.05	3	328	35	12	449,182	7,285,275	22-Mar-02	M-VUVU	1
1038	0.14	3	290	31	12	481,984	7,292,716	22-Mar-02	M-RATA	3
1039	0.05	3	280	31	12	487,368	7,295,044	22-Mar-02	M-VUVU	1
1070	0.10	3	85	9	13	364,322	7,312,895	22-Mar-02	M-RATA	2
1071	1.16	3	83	9	13	365,706	7,315,313	22-Mar-02	M-RATA	23
1072	0.63	3	48	5	13	371,258	7,346,600	22-Mar-02	M-OVMO	11
1073	0.05	3	38	4	13	379,426	7,354,574	22-Mar-02	M-VUVU	1
1074	0.20	3	75	8	13	374,648	7,319,530	22-Mar-02	M-RATA	4
1075	1.41	3	75	8	13	374,168	7,318,696	22-Mar-02	M-RATA	28
1076	1.52	3	90	9	13	366,879	7,305,764	22-Mar-02	M-RATA	30
1077	0.53	3	105	11	12	632,660	7,292,927	22-Mar-02	M-RATA	10
1078	0.20	3	137	14	12	607,153	7,276,328	22-Mar-02	M-RATA	4
1090	0.55	3	202	20	12	549,402	7,263,053	28-May-02	M-RATA	10
1093	0.50	3	70	7	13	370,760	7,324,705	28-May-02	M-RATA	10
1095	0.05	3	66	7	13	371,340	7,328,569	28-May-02	M-RATA	1
1097	0.85	3	57	6	13	371,273	7,337,955	28-May-02	M-RATA	18
1098	0.46	3	48	5	13	371,087	7,346,950	28-May-02	M-RATA	8
1099	0.29	3	48	5	13	371,050	7,347,867	28-May-02	M-RATA	5
1100	0.17	3	44	5	13	371,147	7,350,946	28-May-02	M-RATA	3
1101	0.17	3	44	5	13	370,487	7,350,212	28-May-02	M-URAR	3
1102	0.23	3	44	5	13	371,514	7,351,079	28-May-02	M-RATA	4
1103	0.72	3	36	4	13	375,264	7,358,855	28-May-02	M-RATA	14
1104	0.76	3	30	3	13	377,522	7,363,483	28-May-02	M-RATA	15
1105	1.52	3	30	3	13	377,908	7,364,195	28-May-02	M-RATA	30
1106	0.86	3	28	3	13	378,990	7,366,111	28-May-02	M-RATA	17
1108	1.53	3	21	2	13	386,028	7,370,765	28-May-02	M-RATA	30
1109	0.61	3	21	2	13	386,042	7,370,050	28-May-02	M-RATA	12
1110	0.51	3	26	3	13	384,804	7,364,226	28-May-02	M-RATA	10
1113	0.29	3	45	5	13	376,779	7,349,454	28-May-02	M-OVMO	5
1114	1.75	3	65	7	13	376,984	7,330,223	28-May-02	M-RATA	35
1115	0.30	3	68	7	13	377,012	7,327,551	28-May-02	M-RATA	6
1116	0.10	3	73	8	13	376,369	7,321,979	28-May-02	M-RATA	2
1117	1.26	3	75	8	13	374,988	7,319,451	28-May-02	M-RATA	25
1119	0.51	3	133	14	12	610,851	7,278,472	28-May-02	M-RATA	10
1120	2.07	3	149	15	12	598,428	7,269,271	28-May-02	M-RATA	40
1121	0.42	3	179	18	12	570,956	7,259,730	28-May-02	M-RATA	8
1122	0.86	3	205	21	12	546,815	7,257,008	28-May-02	M-RATA	16
1123	45.45	3	281	31	12	496,390	7,293,549	28-May-02	M-RATA	1000
1124	0.91	3	280	31	12	491,598	7,292,054	28-May-02	M-RATA	20
1125	1.36	3	284	31	12	490,832	7,291,600	28-May-02	M-RATA	30
1126	0.05	3	284	31	12	490,186	7,291,225	28-May-02	M-VUVU	1
1127	0.09	3	285	31	12	489,248	7,290,685	28-May-02	M-RATA	2
1128	0.59	3	286	31	12	487,861	7,289,857	28-May-02	B-GWFG	13
1129	0.91	3	287	31	12	485,719	7,288,596	28-May-02	B-GWFG	20
1130	0.37	3	293	32	12	482,726	7,286,858	28-May-02	M-RATA	7
1132	2.18	3	297	32	12	479,394	7,284,932	28-May-02	M-RATA	41
1134	0.48	3	299	32	12	477,001	7,283,561	28-May-02	M-RATA	9
1136	0.51	3	309	33	12	468,040	7,278,975	28-May-02	M-RATA	10
1142	1.29	3	324	35	12	452,779	7,279,147	28-May-02	M-OVMO	26
1150	0.25	3	350	37	12	428,598	7,282,023	28-May-02	M-RATA	4
1158	0.06	3	347	37	12	428,966	7,284,571	28-May-02	B-RLHA	1
1160	0.25	3	342	37	12	434,517	7,284,547	28-May-02	M-RATA	4

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Appendix 2.4-1
Aerial Survey Results

On-Transect Observations

Index	Density	Type	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
1163	0.47	3	336	36	12	441,202	7,284,682	28-May-02	M-RATA	9
1170	0.58	3	301	32	12	474,477	7,287,386	28-May-02	M-RATA	11
1171	1.33	3	296	32	12	476,798	7,288,755	28-May-02	M-RATA	25
1172	0.05	3	296	32	12	476,798	7,288,755	28-May-02	M-RATA	1
1173	0.53	3	294	32	12	478,922	7,290,066	28-May-02	M-RATA	10
1178	0.55	3	286	31	12	486,183	7,288,796	7-Jun-02	B-CAGO	12
1180	0.05	3	309	33	12	468,474	7,279,200	7-Jun-02	B-UGUL	1
1182	0.10	3	325	35	12	452,000	7,279,109	7-Jun-02	B-UGUL	2
1183	0.05	3	328	35	12	448,909	7,279,064	7-Jun-02	B-UGUL	1
1184	0.78	3	338	36	12	438,324	7,279,388	7-Jun-02	M-RATA	15
1185	1.56	3	339	36	12	437,104	7,279,495	7-Jun-02	M-OVMO	30
1186	0.47	3	340	36	12	436,204	7,279,529	7-Jun-02	M-RATA	9
1187	0.04	3	360	38	12	417,124	7,281,631	7-Jun-02	B-UGUL	1
1188	0.20	3	360	38	12	418,382	7,284,609	7-Jun-02	M-RATA	5
1190	0.12	3	357	38	12	421,614	7,284,605	7-Jun-02	B-UDUC	3
1191	0.37	3	347	37	12	429,645	7,284,658	7-Jun-02	B-UGOO	6
1192	0.16	3	336	36	12	440,584	7,284,654	7-Jun-02	M-RATA	3
1193	0.35	3	330	35	12	447,167	7,284,976	7-Jun-02	M-RATA	7
1194	0.35	3	329	35	12	448,709	7,285,057	7-Jun-02	M-RATA	7
1197	0.05	3	322	34	12	454,881	7,285,085	7-Jun-02	B-UBIR	1
1199	0.05	3	305	33	12	469,502	7,285,233	7-Jun-02	B-UFAL	1
1200	0.31	3	302	33	12	472,330	7,286,540	7-Jun-02	B-UDUC	6
1201	0.51	3	302	33	12	472,330	7,286,540	7-Jun-02	B-UGOO	10
1202	0.11	3	302	32	12	473,193	7,287,023	7-Jun-02	B-TUSW	2
1203	0.21	3	302	32	12	473,193	7,287,023	7-Jun-02	B-UGOO	4
1205	0.09	3	291	31	12	481,492	7,291,801	7-Jun-02	B-SNGO	2
1206	0.23	3	288	31	12	484,756	7,293,732	7-Jun-02	M-RATA	5
1207	0.05	3	280	31	12	487,303	7,295,209	7-Jun-02	M-RATA	1
1209	0.45	3	281	31	12	490,140	7,296,732	7-Jun-02	M-RATA	10
1211	0.05	3	203	21	12	548,307	7,257,227	7-Jun-02	B-UHAW	1
1214	0.25	3	184	19	12	565,103	7,257,029	7-Jun-02	M-RATA	5
1215	0.10	3	179	18	12	572,339	7,256,939	7-Jun-02	B-UGOO	2
1217	1.09	3	174	18	12	579,168	7,257,852	7-Jun-02	M-RATA	21
1220	0.20	3	162	16	12	585,625	7,260,085	7-Jun-02	B-UGOO	4
1222	0.25	3	159	16	12	591,048	7,262,838	7-Jun-02	B-UGOO	5
1223	0.54	3	167	17	12	581,830	7,263,692	7-Jun-02	B-UBIR	10
1225	0.16	3	151	15	12	596,523	7,268,022	7-Jun-02	M-RATA	3
1227	0.10	3	135	14	12	608,358	7,277,192	7-Jun-02	B-UGOO	2
1228	0.15	3	123	13	12	617,385	7,281,959	7-Jun-02	B-UDUC	3
1230	0.05	3	118	12	12	623,668	7,285,428	7-Jun-02	B-UBIR	1
1233	0.05	3	105	11	12	632,652	7,293,173	7-Jun-02	B-ARTE	1
1234	0.10	3	93	10	13	366,104	7,304,295	7-Jun-02	B-UGOO	2
1236	0.05	3	83	8	13	371,258	7,313,258	7-Jun-02	M-RATA	1
1237	0.05	3	81	8	13	371,946	7,314,275	7-Jun-02	M-RATA	1
1243	0.10	3	68	7	13	377,099	7,326,553	7-Jun-02	B-UGOO	2
1259	0.21	3	38	4	13	378,999	7,353,855	7-Jun-02	B-UGOO	4
1274	0.05	3	17	2	13	379,982	7,376,010	7-Jun-02	B-UGUL	1
1277	0.15	3	22	2	13	379,647	7,369,214	7-Jun-02	M-URAR	3
1279	0.15	3	27	3	13	379,011	7,366,638	7-Jun-02	M-RATA	3
1280	0.10	3	27	3	13	379,011	7,366,638	7-Jun-02	B-UGOO	2
1283	0.21	3	40	4	13	374,239	7,357,379	7-Jun-02	M-RATA	4
1287	0.57	3	44	5	13	371,650	7,351,606	7-Jun-02	M-RATA	10
1288	0.23	3	44	5	13	371,022	7,350,145	7-Jun-02	B-UGOO	4
1292	0.06	3	51	5	13	371,108	7,344,334	7-Jun-02	B-UFAL	1
1294	0.14	3	58	6	13	370,856	7,337,054	7-Jun-02	M-RATA	3
1296	0.09	3	60	6	13	370,853	7,335,356	7-Jun-02	M-RATA	2
1298	0.10	3	64	7	13	371,010	7,331,336	7-Jun-02	M-RATA	2
1299	0.20	3	66	7	13	370,990	7,328,578	7-Jun-02	M-RATA	4
1300	0.15	3	70	7	13	371,005	7,325,509	7-Jun-02	B-UGOO	3
1301	0.10	3	70	7	13	370,845	7,324,416	7-Jun-02	B-UGOO	2
1303	0.10	3	78	8	13	368,633	7,320,510	7-Jun-02	B-UDUC	2
1305	0.10	3	78	8	13	368,255	7,319,811	7-Jun-02	M-RATA	2
1306	0.15	3	82	8	13	366,309	7,316,369	7-Jun-02	B-UGOO	3
1307	0.25	3	91	9	12	636,102	7,309,682	7-Jun-02	M-RATA	5

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Aerial Survey Results

On-Transect Observations

Index	Density	Type	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
1308	0.15	3	91	9	12	635,879	7,309,216	7-Jun-02	M-RATA	3
1309	0.05	3	98	10	12	633,691	7,304,152	7-Jun-02	M-RATA	1
1310	0.16	3	101	10	12	631,828	7,300,305	7-Jun-02	M-RATA	3
1312	0.16	3	102	10	12	630,230	7,298,972	7-Jun-02	M-RATA	3
1314	0.11	3	111	11	12	625,049	7,294,520	7-Jun-02	B-UBIR	2
1315	0.16	3	112	11	12	624,172	7,293,846	7-Jun-02	M-RATA	3
1317	0.35	3	115	12	12	621,999	7,291,784	7-Jun-02	M-RATA	7
1318	0.15	3	117	12	12	620,158	7,290,143	7-Jun-02	B-UGOO	3
1320	0.05	3	127	13	12	611,688	7,285,576	7-Jun-02	B-UGUL	1
1321	0.05	3	135	14	12	605,004	7,281,884	7-Jun-02	B-UBIR	1
1322	0.10	3	141	14	12	601,218	7,279,815	7-Jun-02	B-UBIR	2
1323	0.36	3	144	15	12	598,952	7,278,363	7-Jun-02	B-UGOO	7
1324	0.26	3	149	15	12	594,516	7,273,505	7-Jun-02	M-RATA	5
1325	0.16	3	152	15	12	592,819	7,271,525	7-Jun-02	B-UDUC	3
1326	0.21	3	152	15	12	592,232	7,270,901	7-Jun-02	M-RATA	4
1327	0.11	3	167	17	12	582,715	7,267,101	7-Jun-02	B-UBIR	2
1331	0.21	3	177	18	12	572,053	7,262,937	7-Jun-02	B-UGOO	4
1332	0.47	3	179	18	12	570,512	7,263,000	7-Jun-02	M-RATA	9
1333	0.25	3	185	19	12	565,378	7,263,019	7-Jun-02	B-UDUC	5
1334	0.10	3	188	19	12	562,725	7,262,944	7-Jun-02	M-RATA	2
1335	0.05	3	188	19	12	562,725	7,262,944	7-Jun-02	B-ULOO	1
1336	0.20	3	191	19	12	559,463	7,263,056	7-Jun-02	B-UBIR	4
1337	0.22	3	195	20	12	556,026	7,263,004	7-Jun-02	M-RATA	4
1338	0.06	3	197	20	12	553,910	7,263,023	7-Jun-02	B-UPTA	1
1339	0.11	3	204	21	12	547,030	7,263,140	7-Jun-02	B-UGOO	2
1340	0.05	3	206	21	12	545,119	7,263,094	7-Jun-02	B-UHAW	1
1341	1.08	3	207	21	12	544,470	7,263,065	7-Jun-02	M-RATA	20
1500	0.73	3	285	31	12	489,004	7,290,342	7-Jul-02	M-OVMO	16
1502	0.35	3	351	38	12	426,856	7,281,684	7-Jul-02	B-UDUC	9
1503	0.05	3	296	32	12	476,767	7,289,316	7-Jul-02	B-RLHA	1
1504	0.06	3	202	20	12	549,700	7,262,932	7-Jul-02	B-GWFG	1
1505	0.05	3	129	13	12	611,002	7,285,102	7-Jul-02	M-RATA	1
1506	0.83	3	93	10	12	634,406	7,305,897	7-Jul-02	B-GWFG	16
1507	0.15	3	79	8	13	367,619	7,318,970	7-Jul-02	M-RATA	3
1508	0.05	3	69	7	13	370,915	7,326,628	7-Jul-02	M-RATA	1
1509	0.15	3	69	7	13	370,921	7,326,716	7-Jul-02	M-RATA	3
1510	0.05	3	66	7	13	371,040	7,329,158	7-Jul-02	M-RATA	1
1511	0.14	3	62	6	13	371,184	7,332,922	7-Jul-02	M-RATA	3
1512	0.09	3	58	6	13	371,125	7,336,747	7-Jul-02	M-RATA	2
1513	0.36	3	41	4	13	373,272	7,355,240	7-Jul-02	B-GWFG	7
1514	0.67	3	40	4	13	373,825	7,356,648	7-Jul-02	M-OVMO	13
1515	0.12	3	6	1	13	385,749	7,381,959	7-Jul-02	M-CALU	1
1516	0.05	3	19	2	13	385,979	7,372,187	7-Jul-02	M-RATA	1
1517	0.05	3	65	7	13	377,095	7,330,440	7-Jul-02	M-RATA	1
1518	0.05	3	68	7	13	377,117	7,327,647	7-Jul-02	M-URAR	1
1519	3.79	3	74	8	13	375,516	7,320,632	7-Jul-02	M-RATA	75
1520	0.61	3	78	8	13	373,265	7,316,684	7-Jul-02	M-RATA	12
1521	1.00	3	159	16	12	591,337	7,262,133	7-Jul-02	B-UGOO	20
355		2	288	31	12	485,228	7,294,075	20-Sep-01	M-RATA trks	
356		2	300	32	12	475,736	7,288,545	20-Sep-01	M-RATA trks	
357		2	304	33	12	471,881	7,282,976	20-Sep-01	M-RATA trks	
358		2	297	32	12	477,892	7,286,439	20-Sep-01	M-RATA trks	
359		2	298	32	12	478,882	7,284,305	20-Sep-01	M-RATA trks	
362		2	322	35	12	454,347	7,285,186	20-Sep-01	M-RATA trks	
371		2	316	34	12	460,904	7,282,207	20-Sep-01	M-RATA trks	
372		2	313	34	12	463,407	7,282,226	20-Sep-01	M-RATA trks	
377		2	319	34	12	458,134	7,279,259	20-Sep-01	M-RATA trks	
378		2	321	34	12	455,107	7,279,162	20-Sep-01	M-RATA trks	
385		2	353	38	12	425,667	7,284,688	20-Sep-01	M-RATA trks	
387		2	343	37	12	434,453	7,281,647	20-Sep-01	M-RATA trks	
389		2	206	21	12	544,684	7,263,014	20-Sep-01	M-RATA trks	
390		2	198	20	12	551,127	7,263,007	20-Sep-01	M-RATA trks	
393		2	192	19	12	558,302	7,260,013	20-Sep-01	M-RATA trks	
394		2	210	21	12	541,045	7,259,978	20-Sep-01	M-RATA trks	
395		2	211	21	12	538,960	7,257,090	20-Sep-01	M-RATA trks	

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Aerial Survey Results

On-Transect Observations

Index	Density	Type	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
398		2	205	21	12	545,506	7,257,112	20-Sep-01	M-RATA trks	
401		2	188	19	12	562,065	7,257,020	20-Sep-01	M-RATA trks	
402		2	180	18	12	570,414	7,260,019	20-Sep-01	M-RATA trks	
410		2	176	18	12	573,455	7,262,839	20-Sep-01	M-RATA trks	
411		2	170	17	12	580,174	7,260,968	20-Sep-01	M-RATA trks	
412		2	167	17	12	581,667	7,261,039	20-Sep-01	M-RATA trks	
413		2	166	17	12	582,845	7,261,049	20-Sep-01	M-RATA trks	
415		2	157	16	12	592,827	7,263,792	20-Sep-01	M-RATA trks	
417		2	153	15	12	593,981	7,269,056	20-Sep-01	M-RATA trks	
418		2	137	14	12	603,455	7,280,987	20-Sep-01	M-RATA trks	
420		2	109	11	12	628,244	7,293,174	20-Sep-01	M-RATA trks	
422		2	117	12	12	622,603	7,288,321	20-Sep-01	M-RATA trks	
423		2	129	13	12	612,273	7,282,676	20-Sep-01	M-RATA trks	
424		2	137	14	12	605,271	7,278,859	20-Sep-01	M-RATA trks	
426		2	128	13	12	614,819	7,280,512	20-Sep-01	M-RATA trks	
427		2	105	11	12	633,763	7,293,861	20-Sep-01	M-RATA trks	
428		2	96	10	13	364,745	7,301,304	20-Sep-01	M-RATA trks	
429		2	96	10	13	364,745	7,301,304	20-Sep-01	M-RATA trks	
450		2	296	32	12	476,877	7,289,165	20-Sep-01	M-RATA trks	
451		2	297	32	12	476,114	7,288,745	20-Sep-01	M-RATA trks	
452		2	300	32	12	475,587	7,288,464	20-Sep-01	M-RATA trks	
453		2	304	33	12	470,406	7,285,547	20-Sep-01	M-RATA trks	
454		2	305	33	12	470,099	7,285,351	20-Sep-01	M-RATA trks	
455		2	305	33	12	469,895	7,285,222	20-Sep-01	M-RATA trks	
456		2	305	33	12	469,639	7,285,063	20-Sep-01	M-RATA trks	
457		2	304	33	12	471,760	7,282,914	20-Sep-01	M-RATA trks	
458		2	297	32	12	477,807	7,286,389	20-Sep-01	M-RATA trks	
463		2	321	34	12	456,571	7,285,229	20-Sep-01	M-RATA trks	
464		2	322	35	12	454,236	7,285,175	20-Sep-01	M-RATA trks	
466		2	327	35	12	450,006	7,282,246	20-Sep-01	M-RATA trks	
474		2	307	33	12	469,289	7,282,260	20-Sep-01	M-RATA trks	
480		2	340	36	12	437,378	7,281,952	20-Sep-01	M-RATA trks	
481		2	339	36	12	438,569	7,282,016	20-Sep-01	M-RATA trks	
485		2	360	38	12	415,982	7,284,716	20-Sep-01	M-RATA trks	
489		2	204	21	12	546,000	7,263,056	20-Sep-01	M-RATA trks	
491		2	199	20	12	550,902	7,263,005	20-Sep-01	M-RATA trks	
492		2	198	20	12	553,987	7,260,034	20-Sep-01	M-RATA trks	
493		2	204	21	12	547,088	7,259,950	20-Sep-01	M-RATA trks	
496		2	210	21	12	541,408	7,259,967	20-Sep-01	M-RATA trks	
497		2	209	21	12	541,691	7,257,162	20-Sep-01	M-RATA trks	
498		2	209	21	12	542,217	7,257,145	20-Sep-01	M-RATA trks	
501		2	200	20	12	551,755	7,257,092	20-Sep-01	M-RATA trks	
502		2	192	19	12	558,617	7,257,094	20-Sep-01	M-RATA trks	
503		2	191	19	12	559,385	7,257,078	20-Sep-01	M-RATA trks	
504		2	179	18	12	572,290	7,256,978	20-Sep-01	M-RATA trks	
505		2	175	18	12	576,302	7,256,878	20-Sep-01	M-RATA trks	
506		2	175	18	12	575,921	7,259,896	20-Sep-01	M-RATA trks	
513		2	162	16	12	587,554	7,261,150	20-Sep-01	M-RATA trks	
514		2	152	15	12	596,252	7,267,026	20-Sep-01	M-RATA trks	
515		2	150	15	12	597,611	7,268,387	20-Sep-01	M-RATA trks	
517		2	154	16	12	592,929	7,267,995	20-Sep-01	M-RATA trks	
519		2	164	17	12	584,899	7,263,918	20-Sep-01	M-RATA trks	
521		2	156	16	12	589,340	7,268,516	20-Sep-01	M-RATA trks	
523		2	137	14	12	603,145	7,280,786	20-Sep-01	M-RATA trks	
526		2	118	12	12	619,674	7,289,705	20-Sep-01	M-RATA trks	
527		2	106	11	12	629,426	7,298,291	20-Sep-01	M-RATA trks	
531		2	140	14	12	603,891	7,278,181	20-Sep-01	M-RATA trks	
532		2	131	13	12	613,221	7,279,674	20-Sep-01	M-RATA trks	
533		2	128	13	12	614,755	7,280,479	20-Sep-01	M-RATA trks	
534		2	119	12	12	622,272	7,284,626	20-Sep-01	M-RATA trks	
535		2	104	11	12	634,543	7,294,501	20-Sep-01	M-RATA trks	
536		2	96	10	13	364,052	7,300,109	20-Sep-01	M-RATA trks	
537		2	96	10	13	364,796	7,301,399	20-Sep-01	M-RATA trks	
542		2	97	10	12	635,801	7,301,648	20-Sep-01	M-RATA trks	
543		2	85	9	13	364,723	7,313,402	20-Sep-01	M-RATA trks	

(continued)

Appendix 2.4-1
Aerial Survey Results

On-Transect Observations

Index	Density	Type	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
545		2	78	8	13	368,389	7,320,010	20-Sep-01	M-RATA trks	
552		2	10	1	13	383,197	7,379,259	20-Sep-01	M-RATA trks	
556		2	281	31	12	490,034	7,294,758	20-Sep-01	M-RATA trks	
562		2	62	6	13	372,801	7,332,766	20-Sep-01	M-RATA trks	
563		2	63	7	13	376,869	7,330,767	20-Sep-01	M-RATA trks	
1096		3	59	6	13	371,193	7,335,817	28-May-02	M-RATA trks	
1107		3	21	2	13	380,446	7,369,399	28-May-02	M-RATA trks	
1111		3	32	3	13	382,806	7,360,497	28-May-02	M-RATA trks	
1135		3	306	33	12	471,264	7,280,442	28-May-02	M-RATA trks	
1137		3	309	33	12	467,283	7,279,000	28-May-02	M-RATA trks	
1138		3	314	34	12	462,330	7,279,014	28-May-02	M-RATA trks	
1139		3	317	34	12	459,738	7,279,010	28-May-02	M-RATA trks	
1140		3	319	34	12	458,385	7,279,084	28-May-02	M-RATA trks	
1141		3	320	34	12	456,562	7,279,120	28-May-02	M-RATA trks	
1143		3	326	35	12	450,660	7,279,137	28-May-02	M-RATA trks	
1145		3	334	36	12	443,620	7,279,198	28-May-02	M-RATA trks	
1147		3	344	37	12	434,099	7,280,249	28-May-02	M-RATA trks	
1148		3	344	37	12	432,558	7,282,147	28-May-02	M-RATA trks	
1149		3	348	37	12	429,327	7,282,067	28-May-02	M-RATA trks	
1151		3	351	37	12	427,079	7,282,001	28-May-02	M-RATA trks	
1152		3	353	38	12	424,992	7,281,920	28-May-02	M-RATA trks	
1153		3	360	38	12	415,685	7,281,676	28-May-02	M-RATA trks	
1154		3	359	38	12	419,193	7,284,851	28-May-02	M-RATA trks	
1156		3	355	38	12	424,879	7,284,713	28-May-02	M-RATA trks	
1157		3	347	37	12	428,966	7,284,571	28-May-02	M-RATA trks	
1159		3	344	37	12	431,499	7,284,519	28-May-02	M-RATA trks	
1161		3	341	36	12	436,430	7,284,585	28-May-02	M-RATA trks	
1162		3	337	36	12	439,724	7,284,675	28-May-02	M-RATA trks	
1164		3	334	36	12	442,951	7,284,713	28-May-02	M-RATA trks	
1165		3	327	35	12	449,921	7,285,247	28-May-02	M-RATA trks	
1166		3	324	35	12	452,644	7,285,249	28-May-02	M-RATA trks	
1167		3	318	34	12	457,537	7,285,263	28-May-02	M-RATA trks	
1168		3	314	34	12	462,001	7,285,099	28-May-02	M-RATA trks	
1169		3	307	33	12	468,134	7,285,060	28-May-02	M-RATA trks	
1179		3	308	33	12	469,739	7,279,362	7-Jun-02	M-RATA trks	
1181		3	323	34	12	454,912	7,279,122	7-Jun-02	M-RATA trks	
1198		3	305	33	12	469,502	7,285,233	7-Jun-02	M-RATA trks	
1204		3	296	32	12	476,271	7,288,832	7-Jun-02	M-RATA trks	
1208		3	281	31	12	488,112	7,295,731	7-Jun-02	M-RATA trks	
1212		3	192	20	12	556,410	7,257,017	7-Jun-02	M-RATA trks	
1213		3	187	19	12	562,524	7,257,003	7-Jun-02	M-RATA trks	
1216		3	175	18	12	578,090	7,257,514	7-Jun-02	M-RATA trks	
1218		3	166	17	12	582,888	7,259,177	7-Jun-02	M-RATA trks	
1219		3	162	16	12	584,681	7,259,771	7-Jun-02	M-RATA trks	
1221		3	162	16	12	587,200	7,260,550	7-Jun-02	M-RATA trks	
1224		3	152	15	12	595,825	7,267,385	7-Jun-02	M-RATA trks	
1226		3	151	15	12	596,523	7,268,022	7-Jun-02	M-RATA trks	
1229		3	120	12	12	621,692	7,284,272	7-Jun-02	M-RATA trks	
1231		3	107	11	12	631,314	7,291,981	7-Jun-02	M-RATA trks	
1232		3	106	11	12	632,087	7,292,649	7-Jun-02	M-RATA trks	
1235		3	84	9	13	370,648	7,312,233	7-Jun-02	M-RATA trks	
1238		3	78	8	13	373,158	7,316,538	7-Jun-02	M-RATA trks	
1239		3	76	8	13	374,120	7,318,268	7-Jun-02	M-RATA trks	
1240		3	73	8	13	376,280	7,322,254	7-Jun-02	M-RATA trks	
1241		3	71	7	13	377,126	7,325,078	7-Jun-02	M-RATA trks	
1242		3	68	7	13	377,099	7,326,553	7-Jun-02	M-RATA trks	
1244		3	67	7	13	377,132	7,328,076	7-Jun-02	M-RATA trks	
1245		3	65	7	13	377,162	7,330,470	7-Jun-02	M-RATA trks	
1246		3	63	7	13	377,145	7,331,404	7-Jun-02	M-RATA trks	
1247		3	62	7	13	377,123	7,332,281	7-Jun-02	M-RATA trks	
1248		3	62	7	13	377,177	7,333,172	7-Jun-02	M-RATA trks	
1249		3	60	6	13	377,126	7,335,068	7-Jun-02	M-RATA trks	
1250		3	57	6	13	377,091	7,337,502	7-Jun-02	M-RATA trks	
1251		3	56	6	13	377,046	7,338,513	7-Jun-02	M-RATA trks	
1252		3	54	6	13	377,029	7,341,889	7-Jun-02	M-RATA trks	

(continued)

Appendix 2.4-1
Aerial Survey Results

On-Transect Observations

Index	Density	Type	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
1253		3	50	6	13	376,966	7,343,894	7-Jun-02	M-RATA trks	
1254		3	50	5	13	376,964	7,345,218	7-Jun-02	M-RATA trks	
1255		3	47	5	13	376,975	7,346,171	7-Jun-02	M-RATA trks	
1256		3	46	5	13	376,943	7,347,691	7-Jun-02	M-RATA trks	
1257		3	45	5	13	376,950	7,349,657	7-Jun-02	M-RATA trks	
1258		3	39	4	13	377,979	7,351,851	7-Jun-02	M-RATA trks	
1260		3	38	4	13	379,373	7,354,628	7-Jun-02	M-RATA trks	
1261		3	33	4	13	381,856	7,359,291	7-Jun-02	M-RATA trks	
1262		3	29	3	13	382,699	7,360,978	7-Jun-02	M-RATA trks	
1263		3	26	3	13	384,024	7,363,423	7-Jun-02	M-RATA trks	
1264		3	23	3	13	385,806	7,366,685	7-Jun-02	M-RATA trks	
1265		3	21	2	13	385,897	7,370,318	7-Jun-02	M-RATA trks	
1266		3	20	2	13	385,873	7,371,518	7-Jun-02	M-RATA trks	
1267		3	15	2	13	385,874	7,373,222	7-Jun-02	M-RATA trks	
1268		3	13	2	13	385,900	7,376,410	7-Jun-02	M-RATA trks	
1269		3	4	1	13	385,870	7,378,864	7-Jun-02	M-RATA trks	
1271		3	9	1	13	379,811	7,382,145	7-Jun-02	M-RATA trks	
1272		3	11	2	13	379,956	7,378,285	7-Jun-02	M-RATA trks	
1273		3	17	2	13	379,982	7,376,010	7-Jun-02	M-RATA trks	
1275		3	17	2	13	379,998	7,373,773	7-Jun-02	M-RATA trks	
1276		3	19	2	13	379,927	7,370,944	7-Jun-02	M-RATA trks	
1278		3	22	2	13	379,647	7,369,214	7-Jun-02	M-RATA trks	
1281		3	30	3	13	377,911	7,364,759	7-Jun-02	M-RATA trks	
1282		3	31	3	13	376,961	7,363,041	7-Jun-02	M-RATA trks	
1284		3	40	4	13	373,961	7,356,708	7-Jun-02	M-RATA trks	
1285		3	41	4	13	373,373	7,355,475	7-Jun-02	M-RATA trks	
1286		3	43	5	13	372,074	7,352,530	7-Jun-02	M-RATA trks	
1289		3	44	5	13	371,022	7,350,145	7-Jun-02	M-RATA trks	
1290		3	49	5	13	371,089	7,346,079	7-Jun-02	M-RATA trks	
1291		3	51	5	13	371,108	7,344,334	7-Jun-02	M-RATA trks	
1293		3	55	6	13	370,957	7,339,827	7-Jun-02	M-RATA trks	
1295		3	59	6	13	370,827	7,336,066	7-Jun-02	M-RATA trks	
1297		3	63	7	13	371,004	7,332,162	7-Jun-02	M-RATA trks	
1302		3	76	8	13	369,428	7,322,181	7-Jun-02	M-RATA trks	
1304		3	78	8	13	368,633	7,320,510	7-Jun-02	M-RATA trks	
1311		3	101	10	12	630,781	7,299,447	7-Jun-02	M-RATA trks	
1313		3	106	11	12	629,346	7,298,217	7-Jun-02	M-RATA trks	
1316		3	114	12	12	622,430	7,292,174	7-Jun-02	M-RATA trks	
1319		3	118	12	12	619,324	7,289,698	7-Jun-02	M-RATA trks	
1328		3	168	17	12	581,303	7,267,119	7-Jun-02	M-RATA trks	

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Appendix 2.4-1
Aerial Survey Results

Off-Transect Observations

Index	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
4	358	38	12	420,000.0	7,288,000.0	21-Jul-01	B-RLHA	1
5	323	35	12	454,000.0	7,281,000.0	21-Jul-01	B-UGUL	1
19	115	12	12	620,300.0	7,292,400.0	21-Jul-01	M-URAR	3
20	139	14	12	604,000.0	7,277,000.0	21-Jul-01	M-OVMO	4
25	284	31	12	488,300.0	7,292,500.0	29-Jul-01	M-RATA	1
27	56	6	13	380,000.0	7,338,000.0	29-Jul-01	B-UGOO	10
28	83	8	12	635,000.0	7,316,000.0	29-Jul-01	B-UGOO	5
31	26	3	13	385,500.0	7,362,500.0	29-Jul-01	B-TUSW	2
32	3	1	13	392,000.0	7,376,500.0	29-Jul-01	M-OVMO	8
33	116	12	12	627,000.0	7,283,000.0	29-Jul-01	B-UGOO	20
87	108	11	12	627,000.0	7,298,000.0	9-Aug-01	M-RATA	4
88	192	19	12	557,000.0	7,255,000.0	9-Aug-01	M-RATA	1
89	113	12	12	621,000.0	7,295,500.0	9-Aug-01	M-CALU	1
167	173	18	12	574,000.0	7,266,000.0	21-Aug-01	M-RATA	1
169	175	18	12	577,000.0	7,256,000.0	21-Aug-01	M-RATA	3
170	156	16	12	593,000.0	7,265,000.0	21-Aug-01	M-OVMO	5
171	73	8	13	378,500.0	7,321,700.0	21-Aug-01	M-RATA	1
172	62	7	13	379,500.0	7,333,000.0	21-Aug-01	M-RATA	1
184	281	31	12	498,039.1	7,290,058.7	7-Sep-01	B-CAGO	50
185	284	31	12	498,504.1	7,289,172.3	7-Sep-01	B-SACR	10
186	284	31	12	499,054.2	7,288,950.9	7-Sep-01	B-CAGO	20
187	284	31	12	500,484.5	7,287,390.2	7-Sep-01	B-CAGO	4
188	284	31	12	500,474.8	7,286,411.4	7-Sep-01	B-CAGO	4
189	285	31	12	497,797.0	7,285,954.9	7-Sep-01	B-UBIR	3
190	285	31	12	500,572.0	7,285,540.9	7-Sep-01	B-CAGO	10
191	285	31	12	501,170.2	7,285,084.8	7-Sep-01	B-CAGO	60
192			12	508,376.7	7,277,210.8	7-Sep-01	B-UGUL	1
193			12	509,376.2	7,278,521.4	7-Sep-01	B-CAGO	3
194			12	510,593.3	7,280,510.1	7-Sep-01	B-UDUC	10
195			12	514,021.3	7,279,049.5	7-Sep-01	B-CAGO	30
196			12	516,036.8	7,277,136.4	7-Sep-01	B-CAGO	50
197			12	516,436.1	7,273,608.0	7-Sep-01	B-CAGO	20
198			12	517,726.5	7,273,258.0	7-Sep-01	B-CAGO	15
199			12	518,812.1	7,272,369.8	7-Sep-01	B-CAGO	15
200			12	516,137.2	7,270,426.1	7-Sep-01	M-OVMO	23
201			12	516,481.0	7,269,813.9	7-Sep-01	M-OVMO	1
202			12	521,337.2	7,267,513.0	7-Sep-01	M-RATA	1
203			12	522,989.9	7,261,504.5	7-Sep-01	B-CAGO	7
204			12	521,389.0	7,259,301.0	7-Sep-01	B-GWFG	16
205			12	520,599.2	7,258,794.9	7-Sep-01	B-GWFG	9
206			12	518,823.4	7,259,373.1	7-Sep-01	B-UDUC	1
207			12	519,824.7	7,257,927.4	7-Sep-01	B-UDUC	1
208			12	520,268.2	7,257,498.8	7-Sep-01	M-OVMO	1
209			12	521,631.9	7,256,101.0	7-Sep-01	M-RATA	5
212	213	21	12	530,394.4	7,253,657.4	7-Sep-01	B-CAGO	36
213	213	21	12	531,988.3	7,253,135.0	7-Sep-01	M-RATA	2
214	213	21	12	533,063.3	7,252,784.0	7-Sep-01	B-CAGO	30
215	210	21	12	536,581.3	7,249,739.2	7-Sep-01	B-CAGO	8
216	210	21	12	537,263.3	7,249,449.4	7-Sep-01	B-CAGO	12
217	201	20	12	551,641.6	7,250,783.6	7-Sep-01	M-RATA	1
218	201	20	12	553,205.2	7,250,851.0	7-Sep-01	M-RATA	1
219	200	20	12	554,497.5	7,250,862.2	7-Sep-01	B-UGUL	16
220	192	19	12	558,240.4	7,250,580.1	7-Sep-01	B-TUSW	12
221	192	19	12	558,124.1	7,250,657.9	7-Sep-01	B-UDUC	3
222	184	19	12	564,553.0	7,251,734.3	7-Sep-01	B-UGUL	1
223	180	18	12	571,025.6	7,253,712.4	7-Sep-01	M-RATA	1
224	162	16	12	587,549.4	7,254,202.9	7-Sep-01	M-RATA	1
225	162	16	12	586,984.0	7,250,494.5	7-Sep-01	B-UGUL	30

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Aerial Survey Results

Off-Transect Observations

Index	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
226	162	16	12	587,336.8	7,250,232.2	7-Sep-01	B-CAGO	50
227	162	16	12	588,528.4	7,250,140.5	7-Sep-01	B-CAGO	4
228	162	16	12	589,863.5	7,250,175.8	7-Sep-01	B-CAGO	150
229	161	16	12	592,058.4	7,249,990.8	7-Sep-01	M-RATA	1
230			12	594,385.8	7,249,666.9	7-Sep-01	M-RATA	1
231	161	16	12	594,765.9	7,250,486.2	7-Sep-01	M-RATA	2
232	161	16	12	593,281.2	7,251,504.1	7-Sep-01	M-RATA	1
233	161	16	12	594,609.4	7,253,167.4	7-Sep-01	M-RATA	1
234	161	16	12	595,039.7	7,253,260.9	7-Sep-01	B-UDUC	1
235	161	16	12	595,090.0	7,253,271.5	7-Sep-01	M-RATA	1
236	161	16	12	597,366.9	7,254,978.4	7-Sep-01	B-CAGO	30
237	159	16	12	598,475.6	7,254,540.4	7-Sep-01	B-CAGO	25
238			12	598,651.9	7,253,052.4	7-Sep-01	B-UGUL	1
239			12	598,913.2	7,252,901.5	7-Sep-01	M-RATA	2
240			12	599,302.8	7,252,684.4	7-Sep-01	M-RATA	1
241			12	599,759.5	7,252,109.9	7-Sep-01	B-UDUC	2
242			12	600,632.0	7,249,846.5	7-Sep-01	M-RATA	1
243			12	601,042.6	7,250,856.8	7-Sep-01	B-UGUL	1
244			12	600,679.6	7,251,146.4	7-Sep-01	B-UDUC	3
245			12	601,860.3	7,250,703.2	7-Sep-01	B-GOEA	1
246			12	602,066.7	7,250,564.4	7-Sep-01	B-UGUL	1
247			12	603,013.2	7,249,067.0	7-Sep-01	B-CAGO	6
248			12	603,194.8	7,250,426.2	7-Sep-01	B-CAGO	10
249			12	603,061.5	7,251,475.1	7-Sep-01	M-RATA	1
250			12	607,836.0	7,252,488.2	7-Sep-01	M-OVMO	12
251			12	608,494.0	7,252,878.1	7-Sep-01	B-CAGO	25
252			12	608,594.2	7,253,715.4	7-Sep-01	M-RATA	1
253			12	608,602.8	7,253,948.5	7-Sep-01	M-RATA	2
254			12	608,882.6	7,254,237.7	7-Sep-01	M-RATA	1
255			12	609,709.8	7,254,577.4	7-Sep-01	M-RATA	9
256			12	610,480.7	7,254,657.2	7-Sep-01	M-RATA	100
257			12	609,458.8	7,253,590.8	7-Sep-01	B-CAGO	50
258			12	604,801.4	7,256,153.7	7-Sep-01	B-CAGO	8
259	156	16	12	598,968.6	7,260,412.0	7-Sep-01	B-CAGO	6
260	157	16	12	596,134.3	7,261,726.3	7-Sep-01	M-RATA	1
262	162	16	12	587,104.7	7,257,905.7	7-Sep-01	B-CAGO	6
263	211	21	12	537,714.7	7,254,376.2	7-Sep-01	B-CORA	6
265	213	21	12	530,795.6	7,261,285.7	7-Sep-01	B-RTLO	1
266			12	527,475.6	7,274,310.1	7-Sep-01	B-CAGO	20
267			12	522,766.7	7,282,189.0	7-Sep-01	B-YBLO	1
268			12	513,188.4	7,285,668.1	7-Sep-01	B-UGUL	1
269			12	513,271.7	7,297,504.9	7-Sep-01	M-RATA	1
270	281	31	12	500,500.4	7,293,167.2	7-Sep-01	B-RLHA	1
281	174	18	12	577,118.2	7,259,078.1	7-Sep-01	M-RATA	2
353	213	21	12	528,108.0	7,266,704.0	7-Sep-01	B-SNGO	9
354	213	21	12	528,108.0	7,266,704.0	7-Sep-01	B-BLGO	30
425	131	13	12	613,175.4	7,279,642.0	20-Sep-01	B-SACR	3
431	96	10	13	364,745.3	7,301,303.9	20-Sep-01	M-RATA	1
441	74	8	13	384,111.5	7,316,299.9	20-Sep-01	M-URAR	1
1091	191	19	12	558,701.0	7,263,041.0	28-May-02	M-RATA	14
1092	187	19	12	562,850.0	7,262,256.0	28-May-02	M-RATA	16
1094	70	7	13	370,760.0	7,324,705.0	28-May-02	M-RATA	30
1112	39	4	13	378,768.0	7,353,171.0	28-May-02	M-RATA	50
1118	77	8	13	373,659.0	7,317,171.0	28-May-02	M-RATA	24
1131	295	32	12	481,312.0	7,286,040.0	28-May-02	M-RATA	8
1133	298	32	12	477,581.0	7,283,886.0	28-May-02	M-RATA	15
1144	334	36	12	443,620.0	7,279,198.0	28-May-02	M-RATA	17
1155	356	38	12	422,072.0	7,284,793.0	28-May-02	M-RATA	10
1175	293	32	12	479,566.0	7,290,441.0	28-May-02	M-RATA	28

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Appendix 2.4-1
Aerial Survey Results

Off-Transect Observations

Index	Chain	Block#	Zone	UTM East	UTM North	Date	Species	Total
1176	280	31	12	486,813.0	7,294,928.0	28-May-02	M-RATA	30
1189	357	38	12	420,831.0	7,284,611.0	7-Jun-02	M-OVMO	2
1195	327	35	12	450,497.0	7,285,053.0	7-Jun-02	M-RATA	13
1196	322	34	12	453,837.0	7,285,090.0	7-Jun-02	M-RATA	11
1210	283	31	12	487,763.0	7,293,839.0	7-Jun-02	M-RATA	1
1270	1	1	13	386,894.0	7,384,357.0	7-Jun-02	M-USEA	5
1329	172	18	12	576,493.0	7,263,538.0	7-Jun-02	B-UGUL	2
1330	173	18	12	576,074.0	7,263,039.0	7-Jun-02	M-RATA	3
1501	340	36	12	435,909.0	7,278,355.0	7-Jul-02	M-CALU	4

(completed)

APPENDIX 2.4-2
NUMBER OF CARIBOU OBSERVED ALONG THE BATHURST INLET ROAD ROUTE DURING 11 AERIAL SURVEYS GROUPED INTO SURVEYS BLOCKS

Appendix 2.4-2
Number of Caribou Observed along the Bathurst Inlet Road Route during 11 Aerial Surveys Grouped into Survey Blocks

Block	21-Jul-01	29-Jul-01	9-Aug-01	21-Aug-01	7-Sep-01	20-Sep-01	7-Nov-01	22-Mar-02	28-May-02	7-Jun-02	7-Jul-02	Total
1E	0	0	0	0	0	12	0	0	0	0	0	**12**
2E	0	0	0	0	0	15	0	0	42	0	1	**58**
3E	0	0	0	0	0	4	0	0	72	3	0	**79**
4E	0	0	0	2	0	17	0	0	14	4	0	**37**
5E	0	0	0	13	0	34	0	0	20	10	0	**77**
6E	0	0	0	6	0	83	0	0	18	5	5	**117**
7E	0	0	0	4	0	14	0	0	52	6	6	**82**
8E	0	0	11	5	0	11	0	32	27	4	90	**180**
9E	0	0	24	2	0	0	0	55	0	8	0	**89**
10E	0	0	11	0	0	5	0	0	0	7	0	**23**
11E	0	0	9	0	0	0	0	10	0	3	0	**22**
12E	0	0	0	0	0	0	0	0	0	7	0	**7**
13E	0	0	0	0	3	27	0	0	0	0	1	**31**
14E	0	0	0	1	0	0	0	4	10	0	0	**15**
15E	0	0	0	0	5	1	0	3	40	12	0	**61**
16E	0	0	0	0	5	11	0	14	0	0	0	**30**
17E	0	0	2	3	8	15	0	12	0	0	0	**40**
18E	0	0	3	25	79	7	0	64	8	30	0	**216**
19E	0	0	7	29	63	41	0	64	0	7	0	**211**
20E	0	0	23	6	33	4	0	76	10	4	0	**156**
21E	0	0	17	11	0	54	0	12	16	20	0	**130**
1W	0	0	0	0	0	0	0	3	1,052	16	0	**1,071**
2W	0	0	0	0	0	0	0	0	104	0	0	**104**
3W	0	0	3	1	0	0	0	0	10	0	0	**14**
4W	0	0	0	0	0	108	0	0	0	0	0	**108**
5W	0	0	0	2	0	64	0	4	0	14	0	**84**
6W	0	0	0	3	0	22	0	4	9	27	0	**65**
7W	0	0	0	1	0	11	0	0	8	0	0	**20**
8W	0	1	0	0	0	8	0	0	0	5	0	**14**
Total	**0**	**1**	**110**	**114**	**196**	**568**	**0**	**357**	**1,512**	**192**	**103**	**3,153**

APPENDIX 2.4-3
DENSITIES OF CARIBOU (#/KM^2) PER SURVEY BLOCK OBSERVED ALONG THE BATHURST INLET ROAD ROUTE DURING 11 AERIAL SURVEYS

Appendix 2.4-3

Densities of Caribou (#/km^2) per Survey Block Observed along the Bathurst Inlet Road Route during 11 Aerial Surveys

Block	21-Jul-01	29-Jul-01	9-Aug-01	21-Aug-01	7-Sep-01	20-Sep-01	7-Nov-01	22-Mar-02	28-May-02	7-Jun-02	7-Jul-02	Average
1E	0.00	0.00	0.00	0.00	0.00	0.89	0.00	0.00	0.00	0.00	0.00	**0.1**
2E	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	2.14	0.00	0.05	**0.2**
3E	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	3.65	0.15	0.00	**0.4**
4E	0.00	0.00	0.00	0.10	0.00	0.58	0.00	0.00	0.72	0.21	0.00	**0.1**
5E	0.00	0.00	0.00	0.69	0.00	1.30	0.00	0.00	1.15	0.57	0.00	**0.3**
6E	0.00	0.00	0.00	0.28	0.00	2.61	0.00	0.00	0.85	0.24	0.24	**0.4**
7E	0.00	0.00	0.00	0.20	0.00	0.47	0.00	0.00	2.59	0.30	0.30	**0.4**
8E	0.00	0.00	0.55	0.25	0.00	0.37	0.00	1.62	1.36	0.20	4.55	**0.8**
9E	0.00	0.00	1.20	0.10	0.00	0.00	0.00	2.78	0.00	0.41	0.00	**0.4**
10E	0.00	0.00	0.55	0.00	0.00	0.17	0.00	0.00	0.00	0.36	0.00	**0.1**
11E	0.00	0.00	0.45	0.00	0.00	0.00	0.00	0.53	0.00	0.16	0.00	**0.1**
12E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	**0.0**
13E	0.00	0.00	0.00	0.00	0.10	0.93	0.00	0.00	0.00	0.00	0.05	**0.1**
14E	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.20	0.51	0.00	0.00	**0.1**
15E	0.00	0.00	0.00	0.00	0.17	0.03	0.00	0.16	2.07	0.62	0.00	**0.3**
16E	0.00	0.00	0.00	0.00	0.18	0.39	0.00	0.70	0.00	0.00	0.00	**0.1**
17E	0.00	0.00	0.11	0.16	0.28	0.53	0.00	0.65	0.00	0.00	0.00	**0.2**
18E	0.00	0.00	0.14	1.17	2.85	0.25	0.00	3.33	0.42	1.56	0.00	**0.9**
19E	0.00	0.00	0.35	1.45	2.14	1.39	0.00	3.25	0.00	0.36	0.00	**0.8**
20E	0.00	0.00	1.15	0.30	1.21	0.15	0.00	4.19	0.55	0.22	0.00	**0.7**
21E	0.00	0.00	0.85	0.55	0.00	1.87	0.00	0.65	0.86	1.08	0.00	**0.5**
1W	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	47.82	0.73	0.00	**4.4**
2W	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.52	0.00	0.00	**0.5**
3W	0.00	0.00	0.15	0.05	0.00	0.00	0.00	0.00	0.51	0.00	0.00	**0.1**
4W	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00	0.00	0.00	0.00	**0.3**
5W	0.00	0.00	0.00	0.10	0.00	2.15	0.00	0.20	0.00	0.69	0.00	**0.3**
6W	0.00	0.00	0.00	0.15	0.00	0.76	0.00	0.21	0.47	1.40	0.00	**0.3**
7W	0.00	0.00	0.00	0.06	0.00	0.65	0.00	0.00	0.50	0.00	0.00	**0.1**
8W	0.00	0.04	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.20	0.00	**0.1**
Average	**0.00**	**0.002**	**0.19**	**0.20**	**0.24**	**0.70**	**0.00**	**0.64**	**2.47**	**0.34**	**0.18**	**0.45**

APPENDIX 2.4-4
WINTER GROUND OBSERVATIONS BY SNOWMOBILE TRANSECT ALONG ROUTE (BATHURST LEG ONLY), APRIL 2002

Appendix 2.4-4
Winter Ground Observations by Snowmobile Transect Along Route (Bathurst Leg Only), April 2002

Index	Leg	Block	Chain	UTM zone	Northing	Easting	Waypoint	Date	Time (GMT)	Species	Obs Type	# animals	Activity	Habitat	Other notes	End
5096	Bath	6	53	13	7,342,086	372,991	234	25-Apr-02	19:37	B-CORA	sighting	1	flying			x
5121	Bath	21	205	12	7,260,181	546,562	263	27-Apr-02	21:48	B-CORA	sighting	2	flying			x
5133	Bath	1	8	13	7,381,139	383,385	8			B-ROPT	sighting	2			flushed	x
5016	Bath	2	13	13	7,376,520	384,264	12			B-ROPT	sighting	3			flushed	x
5129	Bath	7	72	13	7,323,356	373,297	70			B-ROPT	sighting	2				x
5056	Bath	18	173	12	7,262,162	575,795	171			B-ROPT	sighting	1	flying			x
5128	Bath	1	8	13	7,381,935	383,805	7			B-UIHA	sighting	1	flying			x
5050	Bath	17	167	12	7,264,574	581,085	165			B-UIHA	sighting	1	flying			x
5114	Bath	17	168	12	7,264,248	580,253	256	27-Apr-02	18:13	B-UIHA	sighting	1	flying			x
5097	Bath	5	49	13	7,346,255	373,030	235	25-Apr-02	20:04	M-CALU	tracks				approx km46	x
5094	Bath	6	55	13	7,340,449	373,399	233	25-Apr-02	19:33	M-CALU	sighting	1	heard howling		fresh tracks	x
5127	Bath	7	70	13	7,325,097	372,589	68			M-CALU	tracks					x
5134	Bath	9	89	13	7,308,182	365,616	87			M-CALU	tracks					x
5136	Bath	9	90	13	7,307,616	365,239	88			M-CALU	tracks					x
5138	Bath	9	91	13	7,306,875	364,461	89			M-CALU	tracks					x
5142	Bath	10	98	12	7,301,375	635,711	95			M-CALU	tracks					x
5143	Bath	10	98	12	7,300,807	635,052	96			M-CALU	tracks				lots	x
5145	Bath	10	100	12	7,299,633	634,034	97			M-CALU	tracks				lots	x
5146	Bath	10	100	12	7,299,471	633,905	98			M-CALU	tracks					x
5002	Bath	11	103	12	7,297,182	633,184	100			M-CALU	tracks					x
5005	Bath	11	107	12	7,294,437	629,860	104			M-CALU	tracks					x
5007	Bath	11	107	12	7,294,281	629,542	105			M-CALU	tracks				fresh	x
5086	Bath	12	115	12	7,289,382	623,621	222	24-Apr-02	20:30	M-CALU	sighting	4			running	x
5020	Bath	13	126	12	7,284,469	614,562	123			M-CALU	tracks					x
5027	Bath	13	130	12	7,282,033	610,695	128			M-CALU	tracks					x
5031	Bath	14	142	12	7,275,622	601,276	140			M-CALU	tracks					x
5111	Bath	15	149	12	7,272,474	595,550	254	27-Apr-02	2:15	M-CALU	sighting	1	howling			x
5048	Bath	17	167	12	7,264,185	581,905	164			M-CALU	tracks					x
5118	Bath	20	195	12	7,261,592	554,965	260	27-Apr-02	20:36	M-CALU	sighting	4	howling			x
5119	Bath	20	195	12	7,261,592	554,965	261	27-Apr-02	20:36	M-CALU	tracks				fresh	x
5080	Bath	21	213	12	7,261,332	538,239	211			M-CALU	sighting	1	howling			x
5000	Bath	1	1	13	7,382,562	388,236	0			M-GUGU	tracks				near km 0 -by shack	x
5098	Bath	5	47	13	7,347,341	373,245	236	25-Apr-02	20:07	M-GUGU	tracks				approx km45	x
5090	Bath	10	98	12	7,301,400	635,797	226	24-Apr-02	22:37	M-GUGU	tracks					x
5112	Bath	15	153	12	7,269,397	593,162	255	27-Apr-02	17:17	M-GUGU	tracks				fresh	x
5047	Bath	17	167	12	7,264,185	581,905	164			M-GUGU	tracks					x
5011	Bath	21	204	12	7,260,400	547,600	116	23-Apr-02	20:06	M-GUGU	tracks					x
5070	Bath	1	3	13	7,380,534	387,735	2			M-LEAR	tracks					x
5124	Bath	4	42	13	7,352,708	374,577	39B			M-LEAR	sighting	1	running			x
5034	Bath	20	194	12	7,261,420	556,017	147	23-Apr-02	20:55	M-LEAR	sighting	2	running, resting	2 hares, tracks and 1 den in snow		x
5117	Bath	20	195	12	7,261,593	554,963	259	27-Apr-02	20:23	M-LEAR	sighting	2	sitting	on rocks		x
5068	Bath	20	197	12	7,261,769	553,250	195			M-LEAR	tracks					x
5123	Bath	4	34	13	7,359,338	379,034	31			M-OVMO	tracks					x
5101	Bath	5	43	13	7,351,927	374,334	239	25-Apr-02	20:23	M-OVMO	tracks					x

Note: CALU = Arctic Wolf, CORA = common raven, GUGU = wolverine, LEAR = Arctic hare, OVMO = muskox, ROPT = Rock Ptarmigan, RATA = caribou, VUVU = coloured fox, UHAW = Unspecified Hawk

(continued)

Appendix 2.4-4
Winter Ground Observations by Snowmobile Transect Along Route (Bathurst Leg Only), April 2002

Index	Leg	Block	Chain	UTM zone	Northing	Easting	Waypoint	Date	Time (GMT)	Species	Obs Type	# animals	Activity	Habitat	Other notes	End
5099	Bath	5	45	13	7,349,627	374,098	237	25-Apr-02	20:14	M-OVMO	tracks					x
5130	Bath	8	73	13	7,322,243	373,145	71			M-OVMO	tracks					x
5032	Bath	14	142	12	7,275,622	601,276	140			M-OVMO	sign					x
5033	Bath	15	146	12	7,274,296	598,030	143			M-OVMO	tracks					x
5035	Bath	15	153	12	7,269,400	593,158	150			M-OVMO	tracks					x
5053	Bath	17	170	12	7,263,718	578,371	168			M-OVMO	tracks					x
5074	Bath	19	187	12	7,260,089	563,257	205	23-Apr-02	21:48	M-OVMO	tracks					x
5028	Bath	20	199	12	7,261,134	552,282	129	23-Apr-02	20:35	M-OVMO	tracks					x
5103	Bath	4	33	13	7,360,051	379,131	241	25-Apr-02	21:07	M-RATA	tracks					x
5102	Bath	4	42	13	7,352,498	374,468	240	25-Apr-02	20:25	M-RATA	sighting	4	walking	hilltop		x
5106	Bath	5	44	13	7,351,035	374,439	249	26-Apr-02	16:32	M-RATA	sighting	30		hilltop		x
5100	Bath	5	45	13	7,349,627	374,097	238	25-Apr-02	20:16	M-RATA	tracks					x
5107	Bath	6	53	13	7,341,801	372,042	250	26-Apr-02	17:11	M-RATA	sighting	4	running			x
5095	Bath	6	53	13	7,342,086	372,991	234	25-Apr-02	19:37	M-RATA	tracks					x
5125	Bath	7	69	13	7,326,054	372,737	67			M-RATA	tracks					x
5126	Bath	7	70	13	7,325,097	372,589	68			M-RATA	tracks					x
5093	Bath	7	71	13	7,324,520	373,001	229	25-Apr-02	0:13	M-RATA	sighting	21			running	x
5131	Bath	8	74	13	7,321,208	372,804	72			M-RATA	sign					x
5132	Bath	8	75	13	7,320,754	372,499	72B			M-RATA	tracks					x
5108	Bath	8	76	13	7,319,940	371,423	251	26-Apr-02	18:34	M-RATA	tracks					x
5092	Bath	8	81	13	7,316,324	368,886	228	24-Apr-02	23:49	M-RATA	tracks					x
5109	Bath	8	81	13	7,316,370	368,957	252	26-Apr-02	19:05	M-RATA	tracks				fresh	x
5091	Bath	8	83	13	7,314,522	368,083	227	24-Apr-02	23:29	M-RATA	tracks					x
5135	Bath	9	89	13	7,308,182	365,616	87			M-RATA	tracks					x
5137	Bath	9	90	13	7,307,616	365,239	88			M-RATA	tracks					x
5139	Bath	9	91	13	7,306,875	364,461	89			M-RATA	tracks					x
5140	Bath	10	95	13	7,303,015	363,063	93			M-RATA	tracks					x
5141	Bath	10	96	12	7,302,249	636,863	94			M-RATA	tracks					x
5144	Bath	10	98	12	7,300,807	635,052	96			M-RATA	sign				lots	x
5089	Bath	10	100	12	7,299,771	634,115	225	24-Apr-02	22:26	M-RATA	tracks					x
5147	Bath	10	100	12	7,299,471	633,905	98			M-RATA	tracks					x
5001	Bath	11	103	12	7,297,182	633,184	100			M-RATA	tracks					x
5003	Bath	11	105	12	7,295,564	632,185	102			M-RATA	tracks					x
5004	Bath	11	105	12	7,295,326	631,893	102B			M-RATA	tracks					x
5088	Bath	11	105	12	7,295,175	631,751	224	24-Apr-02	21:17	M-RATA	tracks					x
5087	Bath	11	106	12	7,294,737	630,742	223	24-Apr-02	21:13	M-RATA	tracks					x
5006	Bath	11	107	12	7,294,437	629,860	104			M-RATA	tracks					x
5008	Bath	11	107	12	7,294,281	629,542	105			M-RATA	tracks					x
5009	Bath	11	108	12	7,293,888	628,953	106			M-RATA	tracks					x
5110	Bath	11	112	12	7,292,437	625,633	253	26-Apr-02	22:50	M-RATA	tracks		grazing		tracks of ~ 100 animal	x
5085	Bath	12	116	12	7,288,988	623,196	221	24-Apr-02	20:27	M-RATA	tracks					x
5084	Bath	12	119	12	7,287,310	620,982	220	24-Apr-02	20:03	M-RATA	tracks					x
5082	Bath	12	120	12	7,286,389	619,706	218	24-Apr-02	19:59	M-RATA	tracks					x
5083	Bath	12	120	12	7,286,684	620,124	219	24-Apr-02	20:00	M-RATA	tracks					x
5015	Bath	12	122	12	7,285,405	618,372	119			M-RATA	tracks					x
5017	Bath	12	122	12	7,285,072	617,761	120			M-RATA	tracks					x
5021	Bath	13	126	12	7,284,469	614,562	123			M-RATA	tracks					x

Note: CALU = Arctic Wolf, CORA = common raven, GUGU = wolverine, LEAR = Arctic hare, OVMO = muskox, ROPT = Rock Ptarmigan, RATA = caribou, VUVU = coloured fox, UHAW = Unspecified Hawk

(continued)

Appendix 2.4-4
Winter Ground Observations by Snowmobile Transect Along Route (Bathurst Leg Only), April 2002

Index	Leg	Block	Chain	UTM zone	Northing	Easting	Waypoint	Date	Time (GMT)	Species	Obs Type	# animals	Activity	Habitat	Other notes	End
5022	Bath	13	126	12	7,284,300	613,916	124			M-RATA	tracks					x
5081	Bath	13	127	12	7,283,871	613,028	217	24-Apr-02	19:28	M-RATA	sighting	6	walking			x
5023	Bath	13	127	12	7,283,851	613,023	125			M-RATA	tracks					x
5024	Bath	13	128	12	7,283,248	612,246	126			M-RATA	tracks					x
5025	Bath	13	130	12	7,282,196	610,823	127			M-RATA	tracks				by Mara River	x
5026	Bath	13	130	12	7,282,033	610,695	128			M-RATA	tracks					x
5029	Bath	14	141	12	7,276,142	602,063	139			M-RATA	tracks				fresh	x
5113	Bath	15	153	12	7,269,397	593,162	255	27-Apr-02	17:17	M-RATA	sighting	5	grazing			x
5040	Bath	16	160	12	7,264,345	588,310	157			M-RATA	sign					x
5043	Bath	17	164	12	7,264,213	584,564	161			M-RATA	tracks					x
5044	Bath	17	165	12	7,264,339	583,897	162			M-RATA	tracks					x
5045	Bath	17	166	12	7,264,077	582,897	163			M-RATA	tracks					x
5046	Bath	17	167	12	7,264,185	581,905	164			M-RATA	tracks					x
5049	Bath	17	167	12	7,264,574	581,085	165			M-RATA	tracks					x
5051	Bath	17	168	12	7,264,629	579,951	166			M-RATA	tracks					x
5115	Bath	17	170	12	7,265,086	577,810	257	27-Apr-02	19:03	M-RATA	sighting	13	grazing	hilltop		x
5052	Bath	17	170	12	7,263,718	578,371	168			M-RATA	tracks					x
5055	Bath	18	173	12	7,262,469	576,200	170			M-RATA	tracks					x
5116	Bath	18	175	12	7,261,151	575,010	258	27-Apr-02	19:17	M-RATA	sighting	3	running			x
5057	Bath	19	184	12	7,259,549	566,194	181			M-RATA	tracks					x
5058	Bath	19	184	12	7,259,577	565,619	182			M-RATA	tracks					x
5078	Bath	19	186	12	7,260,033	563,947	209	23-Apr-02	21:50	M-RATA	sign				droppings	x
5079	Bath	19	186	12	7,259,957	564,354	210	23-Apr-02	21:52	M-RATA	sign				droppings	x
5059	Bath	19	186	12	7,259,971	564,264	183			M-RATA	tracks					x
5069	Bath	19	188	12	7,260,156	562,384	196	23-Apr-02	21:46	M-RATA	sign				droppings	x
5060	Bath	19	188	12	7,260,251	561,899	184	23-Apr-02	21:44	M-RATA	tracks					x
5061	Bath	19	188	12	7,260,147	562,459	185			M-RATA	tracks					x
5062	Bath	19	188	12	7,260,324	561,767	186			M-RATA	tracks					x
5054	Bath	19	189	12	7,260,824	560,820	169	23-Apr-02	21:41	M-RATA	tracks					x
5042	Bath	19	190	12	7,260,972	560,510	160	23-Apr-02	21:40	M-RATA	tracks					x
5063	Bath	19	190	12	7,261,024	560,241	187			M-RATA	tracks					x
5037	Bath	19	191	12	7,260,630	558,970	152	23-Apr-02	21:11	M-RATA	tracks					x
5038	Bath	19	191	12	7,260,521	559,185	153	23-Apr-02	21:11	M-RATA	tracks					x
5039	Bath	19	191	12	7,260,327	559,639	154	23-Apr-02	21:13	M-RATA	tracks					x
5036	Bath	20	192	12	7,260,818	558,511	151	23-Apr-02	21:09	M-RATA	sign					x
5064	Bath	20	193	12	7,261,449	556,941	191			M-RATA	tracks					x
5065	Bath	20	196	12	7,261,964	554,911	193			M-RATA	tracks					x
5066	Bath	20	197	12	7,262,115	553,721	194			M-RATA	tracks				lots!	x
5067	Bath	20	197	12	7,261,769	553,250	195			M-RATA	tracks					x
5120	Bath	20	200	12	7,260,611	551,097	262	27-Apr-02	20:51	M-RATA	sighting	13	grazing			x
5019	Bath	20	200	12	7,260,530	551,291	122	23-Apr-02	20:30	M-RATA	tracks					x
5018	Bath	20	201	12	7,260,261	550,602	121	23-Apr-02	20:23	M-RATA	tracks					x
5014	Bath	20	202	12	7,260,295	548,925	118	23-Apr-02	20:10	M-RATA	tracks					x
5013	Bath	21	203	12	7,260,402	548,142	117	23-Apr-02	20:08	M-RATA	tracks					x
5012	Bath	21	204	12	7,260,400	547,600	116	23-Apr-02	20:06	M-RATA	tracks					x
5071	Bath	21	204	12	7,260,345	547,134	201B			M-RATA	tracks					x
5122	Bath	21	205	12	7,260,181	546,562	264	27-Apr-02	21:58	M-RATA	sighting	5	grazing/walking			x

Note: CALU = Arctic Wolf, CORA = common raven, GUGU = wolverine, LEAR = Arctic hare, OVMO = muskox, ROPT = Rock Ptarmigan, RATA = caribou, VUVU = coloured fox, UHAW = Unspecified Hawk

(continued)

Appendix 2.4-4
Winter Ground Observations by Snowmobile Transect Along Route (Bathurst Leg Only), April 2002

Index	Leg	Block	Chain	UTM zone	Northing	Easting	Waypoint	Date	Time (GMT)	Species	Obs Type	# animals	Activity	Habitat	Other notes	End
5072	Bath	21	205	12	7,260,101	546,370	202			M-RATA	tracks					x
5010	Bath	21	207	12	7,260,248	544,713	115	23-Apr-02	19:47	M-RATA	sighting	4				x
5073	Bath	21	207	12	7,260,262	544,594	204			M-RATA	tracks					x
5075	Bath	21	209	12	7,259,695	542,380	206			M-RATA	sign				droppings	x
5076	Bath	21	209	12	7,259,632	541,887	207			M-RATA	sign				droppings	x
5077	Bath	21	210	12	7,259,873	540,931	208			M-RATA	sign				droppings	x
5030	Bath	2	14	13	7,375,484	384,087	14			M-VUVU	tracks					x
5105	Bath	2	16	13	7,374,055	382,777	243	25-Apr-02	23:16	M-VUVU	tracks					x
5041	Bath	2	17	13	7,373,144	382,186	16			M-VUVU	tracks					x
5104	Bath	3	25	13	7,366,583	382,647	242	25-Apr-02	22:05	M-VUVU	tracks					x

Note: CALU = Arctic Wolf, CORA = common raven, GUGU = wolverine, LEAR = Arctic hare, OVMO = muskox, ROPT = Rock Ptarmigan, RATA = caribou, VUVU = coloured fox, UHAW = Unspecified Hawk

(completed)

APPENDIX 2.4-5
NUMBER OF MUSKOXEN OBSERVED ALONG THE BATHURST INLET ROAD ROUTE DURING 11 AERIAL SURVEYS GROUPED INTO SURVEYS BLOCKS

Appendix 2.4-5
Number of Muskoxen Observed along the Bathurst Inlet Road Route during 11 Aerial Surveys Grouped into Surveys Blocks

Block	21-Jul-01	29-Jul-01	9-Aug-01	21-Aug-01	7-Sep-01	20-Sep-01	7-Nov-01	22-Mar-02	28-May-02	7-Jun-02	7-Jul-02	Total
1E	0	0	0	0	0	0	0	0	0	0	0	**0**
2E	1	0	0	0	0	0	0	0	0	0	0	**1**
3E	0	0	0	0	0	0	0	0	0	0	0	**0**
4E	0	0	0	1	0	0	23	0	0	0	13	**37**
5E	0	0	1	0	0	0	0	11	5	0	0	**17**
6E	0	0	0	0	0	0	0	0	0	0	0	**0**
7E	0	0	0	0	0	0	0	0	0	0	0	**0**
8E	0	0	0	0	0	0	0	0	0	0	0	**0**
9E	0	0	0	0	0	0	0	0	0	0	0	**0**
10E	0	0	0	0	0	0	0	0	0	0	0	**0**
11E	0	0	0	0	0	0	2	0	0	0	0	**2**
12E	0	0	0	0	0	0	0	0	0	0	0	**0**
13E	0	0	0	0	0	0	0	0	0	0	0	**0**
14E	13	0	0	0	0	0	0	0	0	0	0	**13**
15E	0	0	0	0	7	0	5	0	0	0	0	**12**
16E	0	16	0	0	0	0	0	0	0	0	0	**16**
17E	0	0	0	0	1	0	0	0	0	0	0	**1**
18E	0	0	0	0	0	0	0	0	0	0	0	**0**
19E	0	0	23	0	0	0	0	0	0	0	0	**23**
20E	0	0	0	1	0	0	0	0	0	0	0	**1**
21E	0	0	0	0	0	0	0	0	0	0	0	**0**
1W	0	0	0	20	1	0	0	0	0	0	16	**37**
2W	0	0	0	0	0	0	0	0	0	0	0	**0**
3W	0	0	0	0	0	0	0	0	0	0	0	**0**
4W	0	0	0	0	0	0	2	0	0	0	0	**2**
5W	0	0	0	0	0	0	0	0	26	0	0	**26**
6W	0	0	0	0	0	0	0	0	0	30	0	**30**
7W	0	0	0	0	0	1	0	0	0	0	0	**1**
8W	0	0	0	0	0	0	0	0	0	0	0	**0**
Total	**14**	**16**	**24**	**22**	**9**	**1**	**32**	**11**	**31**	**30**	**29**	**219**

APPENDIX 2.4-6
INCIDENTAL MAMMAL OBSERVATIONS, 2001

Appendix 2.4-6
Incidental Mammal Observations, 2001

		UTM Coordinates				Animal									Site
Rec. No.	Date	Zone	East	North	Species	Male Adults	Female Adults	Uncl Adults	Uncl Uncl	Uncl Young	Total Animals Observed	Activity	Sign	No. of Sign	Age of Sign	Landform
S004-701	20-Jul-01	12	493197	7285383	M-CALU						0		Scat / Tracks	2	<yr / <mo.	Side of esker
S006-701	20-Jul-01	12	489735	7288623	M-LEAR			1			1	Living				Rocky Mound
S007-701	22-Jul-01	12	489487	7292870	M-VUVU			1			1	Living				Flat wet area
S009-701	23-Jul-01	12	489487	7292870	M-OVMO			13			13	Resting				Gentle Slope
S010-701	24-Jul-01	12	634621	7299246	M-URAR			1			1	Swimming				
S011-701	24-Jul-01	13	384232	7366900	M-CALU						0		Vomit	1	<month	Esker
S012-701	24-Jul-01	13	370611	7356003	M-CALU			1			1	Insect Relief				
S013-701	24-Jul-01	13	386038	7375229	M-URAR			1			1	Living				
S015-701	24-Jul-01	13	369860	7346723	M-RATA		1				1	Living				
S018-701	24-Jul-01	13	383619	7368941	M-UWEA					1	1	Living				Rocky Esker
S021-701	24-Jul-01	13	382048	7370896	M-RATA		1				1	Feeding				Flat area between eskers
S022-701	24-Jul-01	13	378233	7322741	M-CALU			1			1	Insect Relief				
S023-701	24-Jul-01	13	366745	7314476	M-OVMO	1					1	Dead				Base of esker
S025-701	24-Jul-01	13	368766	7312855	M-CALU			1			1	Sighting and den				
S026-701	24-Jul-01	13	366801	7314631	M-VUVU			1			1	Sighting and den				Esker
S028-701	24-Jul-01	13	387500	7312250	M-GUGU			1			1	Insect Relief				
S029-701	24-Jul-01	13	388205	7313020	M-LEAR	1	1			1	3	Feeding				
S033-701	25-Jul-01	12	624077	7290727	M-CALU						0		Scat	1	<yr	Side of esker
S035-701	25-Jul-01	12	580515	7264885	M-RATA					1	1	Insect Relief				Snow patch
S037-701	25-Jul-01	12	620698	7293303	M-RATA			1		1	2	Dead / Living				Bank beside lake
S041-701	25-Jul-01	12	611384	7282255	M-RATA					1	1	Dead				Esker
S042-701	25-Jul-01	13	371500	7303830	M-RATA	1					1	Dead				Esker
S045-701	25-Jul-01	12	614675	7302915	M-URAR			1			1	Living				Flat
S046-701	25-Jul-01	12	583169	7263290	M-RATA				150		150	Living				
S047-701	25-Jul-01	13	383270	7371711	M-URAR			1			1	Living				
S048-701	25-Jul-01	12	538841	7261129	M-URAR			1			1	Swimming				
S049-701	25-Jul-01	12	555829	7261842	M-CALU			1			1	Living				
S050-701	25-Jul-01	12	599513	7281078	M-URAR		1			2	3	Living				Flat
S054-701	25-Jul-01	12	580190	7262200	M-RATA					1	1	Dead				
S055-701	25-Jul-01	12	580190	7262200	M-RATA	1					1	Dead				
S057-701	25-Jul-01	12	590791	7265895	M-OVMO			11		1	12	Feeding				
S058-701	26-Jul-01	12	624490	7290200	M-CALU	1	1			5	7	Living				Sandy mound
S059-701	26-Jul-01	12	553350	7261980	M-CALU			1		1	2	Living				Esker
S066-701	27-Jul-01	12	601035	7273950	M-OVMO			13		1	14	Resting				Flat area near rocky bank
S068-701	27-Jul-01	12	630656	7293998	M-CALU			5			5	Living				Moraine?
S069-701	27-Jul-01	12	590568	7265019	M-OVMO	2	5			5	12	Feeding				Moraine?
S072-701	27-Jul-01	12	625880	7287540	M-CALU			1			1	Resting				Esker
S073-701	27-Jul-01	12	581998	7264260	M-CALU			2			2	Living				Flat area near esker
S074-701	27-Jul-01	12	582704	7264359	M-CALU			1			1	Living				Esker
S078-701	26-Jul-01	12	624390	7290182	M-CALU	1	1			4	6	Denning				
S080-701	29-Jul-01	12	595000	7270000	M-RATA			300			300	Travelling				
S081-701	27-Jul-01	12	630656	7293998	M-CALU			5			5	Living				
S082-701	29-Jul-01	12	601000	7275000	M-OVMO				20		20	Living				
S083-701	27-Jul-01	12	592000	7267000	M-RATA			300			300	Insect Relief				
S084-701	29-Jul-01	12	606000	7277000	M-CALU			1			1	Insect Relief				
S085-701	24-Jul-01	13	383814	7368387	M-UMUS			1			1	Living				Rocky
S086-701	24-Jul-01	13	383582	7369077	M-SPPA			1			1	Living				Rocky
S087-701	24-Jul-01	13	383045	7370505	M-DITO			1			1	Living				Rocky
S090-701	26-Jul-01	12	557145	7259020	M-CALU						0		Tracks	1	UNKN	Beside esker and lake
S091-701	26-Jul-01	12	557145	7259020	M-LEAR			1			1	Living				Sandy esker beside lake
S094-701	22-Jul-01	12	620300	7292400	M-URAR		1			2	3	Living				
S095-701	22-Jul-01	12	604000	7277000	M-OVMO			4			4					
S097-701	29-Jul-01	12	488300	7292500	M-RATA			1			1					
S099-701	29-Jul-01	13	658369	7378952	M-OVMO			8			8	Living				
S001-801	4-Aug-01	12	541000	7261000	M-RATA				500		500	Moving S				
S002-801	4-Aug-01	12	545000	7246000	M-GUGU			1			1	Living				
S003-801	6-Aug-01	12	481921	7293666	M-OVMO			3			3	Feeding				
S004-801	6-Aug-01	12	487161	7282758	M-RATA				100		100	Moving S				
S005-801	6-Aug-01	12	489232	7282310	M-RATA				150		150	Moving S				
S006-801	6-Aug-01	12	471907	7283566	M-RATA				15		15	Feeding				
S007-801	6-Aug-01	12	464716	7275856	M-RATA				75		75	Feeding				
S008-801	6-Aug-01	12	465144	7284668	M-RATA				50		50	Moving S				
S010-801	7-Aug-01	12	451443	7285288	M-RATA				10		10	Resting				
S011-801	7-Aug-01	12	442141	7286830	M-OVMO			1			1	Feeding				
S012-801	7-Aug-01	12	438852	7283806	M-OVMO				15		15	Feeding				
S013-801	7-Aug-01	12	423774	7283906	M-OVMO			1			1	Feeding				

Notes: ALLA = Arctic fox, CALU = Arctic wolf, CLRU, Red Backed Vole, DITO = Collared lemming, GUGU = wolverine, LEAR = Arctic hare, LESI = brown lemming,
OVMO = muskox, RATA = caribou, SPPA = Arctic ground squirrel, UMUS - unspecified weasel, URAR = grizzly bear, UWEA = uspecified weasel, VUVU = coloured fox.

(continued)

Appendix 2.4-6
Incidental Mammal Observations, 2001

		UTM Coordinates				Animal									Site
Rec. No.	Date	Zone	East	North	Species	Male Adults	Female Adults	Uncl Adults	Uncl Uncl	Uncl Young	Total Animals Observed	Activity	Sign	No. of Sign	Age of Sign	Landform
S014-801	7-Aug-01	12	452634	7288304	M-OVMO			3			3	Feeding				
S016-801	11-Aug-01	12			M-URAR			1			1	Living				
S017-801	10-Aug-01	12	490000	7292000	M-VUVU	1	1			3	5	Living				Around boulder and in road fill
S021-801	12-Aug-01	12	554607	7262492	M-LESI						0		winter nest	1		
S022-801	13-Aug-01				M-RATA				100		100	grazing; warble, bot avoidance				
S023-801	13-Aug-01				M-OVMO			10			10					
S024-801	13-Aug-01				M-UMUS						0		scat	1	old	esker
S025-801	16-Aug-01				M-OVMO	1					1	Living				Flat
S026-801	16-Aug-01				M-DITO						0		Nest, winter	1		
S027-801	19-Aug-01	12	473154	7284971	M-URAR			1			1	Living				
S028-801	19-Aug-01	12			M-RATA				200		200	Feeding, insect avoidance				
S029-801	19-Aug-01	12	541288	7260864	M-RATA				100		100	Feeding, insect avoidance				
S031-801	13-Aug-01				M-CLRU						0	Running				Esker, rocky
S032-801	14-Aug-01	13	388000	7383000	M-GUGU			1			1					Beach
S033-801	14-Aug-01	13	388000	7383000	M-GUGU				1		1					Beach
S034-801	14-Aug-01	13	387500	7383000	M-URAR		1			2	3					Beach
S035-801	15-Aug-01	13	378000	7365000	M-URAR				1		1		diggings	3	Fresh	Swamp and muskeg
S036-801	15-Aug-01				M-RATA		1				1	Feeding				Esker
S040-801	17-Aug-01				M-URAR			1			1	Running from helicopter				Flat
S042-801	15-Aug-01	13	383402	7376164	M-URAR				1		1	Feeding				
S043-801	16-Aug-01	13	374156	7328642	M-RATA			1			1	Living				Gental undulating moraine
S044-801	16-Aug-01	13	374519	7327777	M-RATA	1					1	Living				Boulder field
S045-801	16-Aug-01	13	372539	7324688	M-RATA					1	1	Feeding, resting				Lower slope valley floor
S046-801	16-Aug-01	13	372746	7323427	M-RATA		1				1	Walking				Creek
S048-801	17-Aug-01	13	629759	7293860	M-RATA		9			1	10	Walking				Till plain
S049-801	18-Aug-01	12	624363	7290236	M-CALU				2		2					Esker
S050-801	20-Aug-01	12	427239	7279692	M-RATA			4			4	Feeding				Esker/rock complex
S052-801	21-Aug-01	12	539399	7261182	M-RATA				25		25					Soliflucted till
S053-801	21-Aug-01	12	554383	7261736	M-CALU			2			2	Moving				Esker/rock complex
S055-801	10-Aug-01	12	538560	7270220	M-URAR		1			2	3	Feeding				Lakeshore
S056-801	10-Aug-01				M-CALU			1			1	Walking				Bedrock hill th small lake
S059-801	10-Aug-01	12	554656	7260054	M-CALU		1			5	6	Living				Esker
S061-801	12-Aug-01	12	560208	7263374	M-OVMO	2		17			19	Feeding, playing				
S062-801	13-Aug-01	12	560208	7263366	M-LESI						0		Nest	1		Esker
S063-801	13-Aug-01	12	582748	7264233	M-DITO			1			1	Dead				Esker
S065-801	14-Aug-01				M-DITO						0		Nest	1		Side of esker
S067-801	14-Aug-01				M-LESI						0		Nest	1		Side esker
S068-801	14-Aug-01				M-DITO						0		Nest	1		
S070-801	14-Aug-01	12	622549	7292006	M-RATA			18			18					
S071-801	15-Aug-01	13	373516	7325111	M-RATA			4			4					
S072-801	15-Aug-01	13	373516	7325111	M-SPPA			1			1					
S073-801	15-Aug-01	13	373434	7333688	M-DITO						0		Nest	1		
S075-801	16-Aug-01	13	387351	7383616	M-RATA			1			1	Walking				
S077-801	16-Aug-01	13	387351	7383616	M-SPPA			2			2					
S079-801	18-Aug-01	13	374611	7349077	M-OVMO	2	9				11	Feeding, resting, and moving				
S081-801	23-Aug-01	12	539750	7262900	M-RATA			200			200	Migrating. Crossing channel.				
S082-801	19-Aug-01	12	459357	7280494	M-RATA			100			100	Feeding, walking, and insect avoidance				
S083-801	17-Aug-01	12	542711	7259665	M-ALLA			1			1	Living				Edge of drained lake.
S084-801	10-Aug-01	12	627000	7298000	M-RATA			4			4	Walking				
S085-801	10-Aug-01	12	557000	7255000	M-RATA			1			1					
S086-801	10-Aug-01	12	621000	7295500	M-CALU			1			1					
S087-801	22-Aug-01	12	574000	7266000	M-RATA			1			1					
S088-801	22-Aug-01	12	577000	7256000	M-RATA			3			3					
S089-801	22-Aug-01	13	379500	7333000	M-RATA			1			1					
S090-801	22-Aug-01	12	593000	7265000	M-OVMO			5			5	Running				
S091-801	22-Aug-01	13	378500	7321700	M-RATA			1			1	Running				
S001-901	7-Sep-01	12	516625	7269749	M-OVMO			1			1	Resting				
S002-901	7-Sep-01	12	521390	7267457	M-RATA			3			3	Feeding				
S003-901	7-Sep-01	12	537871	7254343	M-URAR		1			1	2	Running				

Notes: ALLA = Arctic fox, CALU = Arctic wolf, CLRU, Red Backed Vole, DITO = Collared lemming, GUGU = wolverine, LEAR = Arctic hare, LESI = brown lemming, OVMO = muskox, RATA = caribou, SPPA = Arctic ground squirrel, UMUS - unspecified weasel, URAR = grizzly bear, UWEA = uspecified weasel, VUVU = coloured fox.

(completed)

APPENDIX 2.4-7
DENSITIES OF MUSKOXEN (#/10 KM^2) PER SURVEY BLOCK OBSERVED ALONG THE BATHURST INLET ROAD ROUTE DURING 11 AERIAL SURVEYS

Appendix 2.4-7

Densities of Muskoxen (#/km^2) per Survey Block Observed along the Bathurst Inlet Road Route during 11 Aerial Surveys

Block	21-Jul-01	29-Jul-01	9-Aug-01	21-Aug-01	7-Sep-01	20-Sep-01	7-Nov-01	22-Mar-02	28-May-02	7-Jun-02	7-Jul-02	Average
1E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
2E	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
3E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
4E	0.0	0.0	0.0	0.5	0.0	0.0	11.9	0.0	0.0	0.0	6.7	**1.7**
5E	0.0	0.0	0.5	0.0	0.0	0.0	0.0	6.3	2.9	0.0	0.0	**0.9**
6E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
7E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
8E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
9E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
10E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
11E	0.0	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	**0.1**
12E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
13E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
14E	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.6**
15E	0.0	0.0	0.0	0.0	2.4	0.0	2.6	0.0	0.0	0.0	0.0	**0.5**
16E	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.7**
17E	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
18E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
19E	0.0	0.0	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1.0**
20E	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
21E	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
1W	0.0	0.0	0.0	7.6	0.3	0.0	0.0	0.0	0.0	0.0	7.3	**1.4**
2W	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
3W	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
4W	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	**0.1**
5W	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.9	0.0	0.0	**1.2**
6W	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.6	0.0	**1.4**
7W	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	**0.1**
8W	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Average	**0.2**	**0.3**	**0.4**	**0.3**	**0.1**	**0.02**	**0.6**	**0.2**	**0.5**	**0.5**	**0.5**	**0.3**

APPENDIX 3.4-1
DEN SITE INFORMATION, SUMMER 2001

Appendix 3.4-1
Den Site Information, Summer 2001

				UTM Coordinates					Den Information						
Rec. No.	Date	Surveyors	Datum	Zone	North	East	Latitude	Longitude	Species	Status	Opening Width (in.)	Opening Height (in.)	Opening Depth (in.)	Photo roll / frame	Habitat Type
D001-701	20-Jul-01	Kerr, Fraker, Sateana	NAD 27		7285332	493120			M-SPPA	Not Active				1 / 1+2	Dry Heath
D002-701	24-Jul-01	Fraker	NAD 27	13	7312855	368766			M-CALU	Active	20	29			
D003-701	24-Jul-01	Fraker	NAD 27	13	7314631	366801			M-VUVU	Active	8 / 10	12 / 13			
D004-701	24-Jul-01	Kerr	NAD 27	13	7370257	383361			M-SPPA	Active					Dry Heath
D005-701	24-Jul-01	Kerr	NAD 27	13	7366900	384232			M-SPPA	Active					Dry Heath
D006-701	24-Jul-01	Kerr	NAD 27	13	7370917	381925			M-SPPA	Active					Dry Heath
D007-701	24-Jul-01	Kerr	NAD 27	13	7371611	381929			M-SPPA	Not Active					Dry Heath
D008-701	25-Jul-01	Kerr	NAD 27	12	7285850	627031			M-CALU	UNKN	12.5 / 12 / 12	14.5 / 13 / 9	43 / 30 / 48	xx2 / 24	
D009-701	25-Jul-01	Kerr, Sateana	NAD 27	12	7264359	582704			M-CALU	Active	17	20	96	xx2 / 01	Dry snady
D010-701	26-Jul-01	Fraker, Sateana	NAD 27	12	7290200	624490			M-CALU	Active	10 / 12 / 12 / 9.5 / 12 / 14 / 9 / 14 / 8 / 14	19 / 16 / 16 / 18 / 16 / 17 / 16 / 16 / 12 / 16		xx2 / 20+21	Dry Heath
D011-701	26-Jul-01	Kerr	NAD 27	12	7256400	572115			M-CALU	Not Active	29	15	142	xx2 / 6-9	Dry sandy mound
D012-701	26-Jul-01	Kerr, Shannon	NAD 27	12	7261980	553350			M-CALU	Active	17 / 16 / 12 / 12 / 16 / 10 / 12 / 13	19 / 18 / 20 / 19 / 14 / 16 / 16 / 13	96 / 34 / 20 / 26	xx2 / 12+13	Dry sandy
D013-701	27-Jul-01	Kerr, Sateana	NAD 27	12	7264385	581675			M-CALU	Active	16	24	60	xx3 / 14	Dry Heath
D014-701	27-Jul-01	Kerr	NAD 27	12	7264375	581565			M-CALU	Active	12	24			Dry side of esker
D015-701	27-Jul-01	Kerr, Sateana	NAD 27	12	7287540	625880			M-CALU	Active	20	20	84		Dry Heath
D016-701	27-Jul-01	Fraker	NAD 27	12	7293998	630656			M-CALU	Active	40 / 28 / 26 / 26 / 40	46 / 50 / 50 / 40 / 37		xx2 / 19	Dry Heath
D017-701	27-Jul-01	Kerr, Fraker, Sateana	NAD 27	12	7281750	612433			M-CALU	Active	12 / 8 / 12	25 / 9 / 7	13 / 48 / >5m		Dry Heath
D018-701	24-Jul-01	D. Sateana	NAD 27		7371651	381830			M-SPPA	Not Active	9	7			Dry Heath

				UTM Coordinates					Den Information						
Rec. No.	Date	Surveyors	Datum	Zone	North	East	Latitude	Longitude	Species	Status	Opening Width (in.)	Opening Height (in.)	Opening Depth (in.)	Photo roll / frame	Habitat Type
D001-801	6-Aug-01	Fraker, Danks, J.F.	NAD 27	12	7292013	480171			UFOX	Active	10	15	1m		
D002-801	6-Aug-01	Fraker, Danks, J.F.	NAD 27	12	7287483	481190			M-CALU	Inactive	12 / 14 / 14 / 12 / 15	11 / 14 / 11 / 12 / 11			
D003-801	7-Aug-01	Fraker, Danks, J.F.	NAD 27	12	7280687	440645			M-VUVU	Active	6 / 8 / 15 / 7 / 6	6 / 7 / 12 / 8 / 6		1 / 13-15	
D004-801	7-Aug-01	Fraker, Danks, J.F.	NAD 27	12	7280655	440653			M-VUVU	Active	12 / 7	9 / 7		8/1/2012	
D005-801	7-Aug-01	Fraker, Danks, J.F.	NAD 27	12	7278420	435764			M-CALU	Active	16 / 18 / 12 / 13 / 15 / 16 / 10 / 7 / 10 / 8 / 9 / 6	17 / 18 / 18 / 20 / 14 / 16 / 10 / 8 / 9 / 10 / 9 / 7		1 / 16-19	
D006-801	7-Aug-01	Fraker, Danks, Sateana	NAD 27	12	7289773	467598			M-CALU	Inactive	Collapsed	Collapsed	36	2 / 18-20	
D007-801	10-Aug-01		NAD 27	12	7289761	467560			M-CALU	Active	12 / 11 / 11	16 / 11 / 16	48	2 / 20-22	
D008-801	10-Aug-01	Fraker, Danks, Sateana	NAD 27	12	7279954	426542			Fox or wolf	Inactive	10 / 15 / 6 / 7 / 6 / 10 / 6 / 9 / 10	15 / 6.5 / 6 / 5 / 7 / 6.5 / 5.5 / 10 / 6.5		2 / 23	
D009-801	10-Aug-01	Fraker, Danks, Sateana	NAD 27	12	7290557	484478			UFOX	Inactive	12 / 7	8 / 8.5			
D010-801	13-Aug-01	Fraker	NAD 27	12	7283206	611854			M-URAR		83cm	66cm	90cm		
D011-801	13-Aug-01	Danks, Sateana	NAD 27	12	7264190	584568			M-CALU	Active	7	14	36		
D012-801	15-Aug-01	Fraker, GT	NAD 27	13	7325459	373260			M-CALU	Active					Dry Heath esker
D013-801	19-Aug-01	Fraker	NAD 27	12	7260637	541347			M-URAR	Inactive?	80cm	36cm	160cm		Dry heath / boulder
D014-801	19-Aug-01	Fraker	NAD 27	12	7260283	541884			M-GUGU	Active	15/20	25/30			Dry Heath
D015-801	19-Aug-01	Fraker	NAD 27	12	7259665	542711			M-ALLA	Active	25/15/16/15/16/23/20/18/20/15/17	25/25/20/17/21/22/20/20/24/25/28			Dry heath
D016-801	10-Aug-01	Fraker	NAD 27	12	7290335	487879			M-VUVU	Active					

Notes: ALLA = Arctic fox, CALU = Artic wolf, GUGU = Wolverine, SPPA = Arctic Ground Squirrel, UFOX = Unspecified fox, URAR - Grizzly Bear, VUVU = Coloured fox.

(continued)

Appendix 3.4-1
Den Site Information, Summer 2001

Site Information								
Rec. No.	**Date**	**Prey Remains**	**Slope Position**	**Slope %**	**Aspect**	**Soil Text.**	**Coarse Fragments**	**Landform**
D001-701	20-Jul-01	N/A	Top	10	148	Sandy		Edge of esker
D002-701	24-Jul-01	None	Lower 1/2	40	ESE	Sandy	Few	Esker base
D003-701	24-Jul-01	None	Lower 1/3	20	NE	Sandy	Few	Esker
D004-701	24-Jul-01	N/A		0	999	Sandy		Flat area between 2 rocky mounds
D005-701	24-Jul-01	N/A	Top	20	0	Sandy loom		Esker
D006-701	24-Jul-01	N/A	Bottom	30	190	Sandy		Esker
D007-701	24-Jul-01	N/A	Bottom 1/3	30	115	Sandy loom		Esker
D008-701	25-Jul-01	bone unidentified	Top	10	330	Sandy loom		Sandy mound
D009-701	25-Jul-01	None	Bottom 1/3	8	240	Sandy loom		Esker
D010-701	26-Jul-01	Caribou	top 1/2 of mound	10	SSE	Sandy	<5%	Sandy mound
D011-701	26-Jul-01	None	upper 1/3	35	196	Sandy clay loom		Esker / sandy mound
D012-701	26-Jul-01	Caribou and ground squirrel	Middle 1/3	15	220	Sandy loom		Esker
D013-701	27-Jul-01	Caribou	Bottom 1/3	22	253	Sandy loom		Bottom of esker
D014-701	27-Jul-01	None	Bottom 1/3	85	52	Sandy loom		Side of esker
D015-701	27-Jul-01	Caribou	upper 1/3	40	45	Sandy loom		Side of esker
D016-701	27-Jul-01	Caribou and ground squirrel	upper 1/3	22	NNW	Sandy	<5%	Moraine
D017-701	27-Jul-01	Caribou	N/A	0	999	Sandy loom		
D018-701	24-Jul-01	N/A	Upper 1/3	28	210	Dry, sandy loom	Gravel / coarse	Side of esker

Site Information								
Rec. No.	**Date**	**Prey Remains**	**Slope Position**	**Slope %**	**Aspect**	**Soil Text.**	**Coarse Fragments**	**Landform**
D001-801	6-Aug-01	None	Middle 1/3	40	SSW	Sandy	<5%	Esker
D002-801	6-Aug-01	caribou bones	Mid. And upper 1/3	15	SW	Loamy sand	<5%	Esker
D003-801	7-Aug-01	Caribou, ptarmigan, hare, B-WFGO	Upper	10	WSW	Sandy	<5%	Esker
D004-801	7-Aug-01	Caribou, ptarmigan	Upper	15	WSW	Sandy	<5%	Esker
D005-801	7-Aug-01	Ptarmigan, caribou, hare	Middle	5	SE	Fine sand	None	Esker
D006-801	7-Aug-01	None	Upper	30	ENE	Sandy	5%	Esker
D007-801	10-Aug-01	Caribou	Upper	5	WNW	Sandy	5%	Esker
D008-801	10-Aug-01	Gr. Sq. and caribou	Upper	10	NE	Loamy sand	5%	Esker
D009-801	10-Aug-01		Upper	15	SSW	Sandy loam	<5%	glacial fluvial
D010-801	13-Aug-01			25	250	Sandy loam		River Bank
D011-801	13-Aug-01	Ground squirrel	Mid	15	WNW/NW	Sandy	<5%	Esker
D012-801	15-Aug-01	Ground squirrel	Upper	15	S	Sandy loam	<5%	Esker
D013-801	19-Aug-01		lower	N/A	60			Rock
D014-801	19-Aug-01	Caribou	upper	5	40	Stones / boulders	5%	
D015-801	19-Aug-01	Ptarmigan, caribou, ground squirrel	upper 1/2	10	290	Sandy loam	0	Edge of drained lake
D016-801	10-Aug-01	M-LEAR						

(continued)

Appendix 3.4-1
Den Site Information, Summer 2001

Rec. No.	Date	Dom. Veg. (15m rad.)
D001-701	20-Jul-01	Dwarf Birch, labrador tea, bear berry, crowberry
D002-701	24-Jul-01	Large leaf Dwarf birch, Enipetmun migram, Dryas, Sax. Triaspidata, Vacc. Uliginosum, Arcto. Rubra, Vacc. Vitis-idea
D003-701	24-Jul-01	Large leaf betuala, Emp. nigran?, Vacc. Uliginosum, Arcto. Subra, Vacc. Vitis-idea
D004-701	24-Jul-01	Small leaf dwarf birch, heather, dryas, prickly saxifrage
D005-701	24-Jul-01	Heather, dwarf birch (small), bear berry
D006-701	24-Jul-01	Dryas, vetch, willow, drawf birch (small)
D007-701	24-Jul-01	Big and small leaf dwarf birch, red bear berry, heather, willow
D008-701	25-Jul-01	Grasses, dwarf birch (small leaf), crowberry, alpine azylea
D009-701	25-Jul-01	Dwarf birch, willow, blueberry, grasses
D010-701	26-Jul-01	Grasses, potentilla, stellaria, salix
D011-701	26-Jul-01	Dwarf birch, alpine bearberry, crowberry, heather, prickly saxifrage, blueberry, grasses
D012-701	26-Jul-01	Dwarf birch, crowberry, grasses, willow, chickweed, prickly saxifrage, alpine bearberry
D013-701	27-Jul-01	Crowberry, willow, blueberry, dwarf birch, chickweed
D014-701	27-Jul-01	Crowberry, willow, grasses, alpine bearberry, large leaf dwarf birch
D015-701	27-Jul-01	Small leaf dwarf birch, heather, alpine bearberry, crowberry, alpine azylea, grasses
D016-701	27-Jul-01	Grasses, luxurious, potentilla, salix
D017-701	27-Jul-01	Grasses, small leaf dwarf birch, prickily saxifrage, cinquefoil, stellaria
D018-701	24-Jul-01	Dwarf birch, dryas, prickly saxifrage

Rec. No.	Date	Dom. Veg. (15m rad.)
D001-801	6-Aug-01	Betula, potentilla cinq., salix sp., vacc. vit., grasses. / grasses
D002-801	6-Aug-01	Grasses, sedges / salix, stellaria, sax., epi. ang
D003-801	7-Aug-01	Betula, vacc. uli., vacc. vit., emp. nig., arc. / grasses, sedge, lichen
D004-801	7-Aug-01	Betula, Vacc. uli., vacc. vit., emp. nig., grasses / sedge, ipilobium, antennais, linnea
D005-801	7-Aug-01	Betula, salix, stellaria, arcto, epi ang. / grasses
D006-801	7-Aug-01	Betula, arcto., vacc. vit., vacc. uli., emp. nig / Betula, arcto., vacc. vit., vacc. uli., emp. nig
D007-801	10-Aug-01	Betula, grass, sedge, arcto,emp. nig, ledum / salix,
D008-801	10-Aug-01	Betula, grass, arcto, emp. nig / vac. Vit, vac. Uli, sedge, salix
D009-801	10-Aug-01	grasses, betula /
D010-801	13-Aug-01	Betula, grasses, vacc. uli., emp nig, voic uli, stell / ledum, salix spp, shrub, ground cover
D011-801	13-Aug-01	Betula, grasses, salix spp, sedges, emp nig, sax sp, ledum
D012-801	15-Aug-01	grasses, fireweed, stellaria / potentilla
D013-801	19-Aug-01	Citetrogona
D014-801	19-Aug-01	Grasses, stellaria
D015-801	19-Aug-01	Grasses, stellaria / betula, UNKN
D016-801	10-Aug-01	

(continued)

Appendix 3.4-1
Den Site Information, Summer 2001

Rec. No.	Date	Comments
D001-701	20-Jul-01	Many of the openings dug up
D002-701	24-Jul-01	Modified from SPUN burrow which URAR had also worked. Tracks of URAC and CALU both present.
D003-701	24-Jul-01	Modified from SRUN burrows. No evidence of pups.
D004-701	24-Jul-01	Some of the openings were dug out by Grizzly or wolf.
D005-701	24-Jul-01	Some of the openings dug out by grizzly
D006-701	24-Jul-01	Some of the openings dug out by grizzly
D007-701	24-Jul-01	Some of the openings were dug out by Grizzly or wolf.
D008-701	25-Jul-01	
D009-701	25-Jul-01	Found along side lake. Caribou and wolf tracks in sand besid lake. Black wolf seen coming out of den on 27July. 13 Aug 01 past by densite, nothing seen.
D010-701	26-Jul-01	Densite measurement = 14m x 12m. Two adults, 1 juv., and 4 pups in den.
D011-701	26-Jul-01	Den collapsed. Mostly grasses around den site. Difficult to determine height due to collapse. Wolf scat found nearby.
D012-701	26-Jul-01	Den area = 18m x 9m. Caribou bones found throughout area. One pup and one adult observed. SPUN colony next to CALU den.
D013-701	27-Jul-01	Two wolves seen running from area. B-SPPL with chick and B-ROTP seen in area.
D014-701	27-Jul-01	Wolf tracks and scat around den. Just west of den # D013-701.
D015-701	27-Jul-01	One adult wolf seen in den. Four other diggings in area. Possible abandonned denning attempts. Very close to den # D010-701.
D016-701	27-Jul-01	Five wolves seen, 1 with radio collar. Two were light gray colour and 1 with reddish ears. On 3 occasions a helicopter flew over. Each time 1 or 2 wolves would come out to investigate. Revisited, 14Aug01, and observed many prey remains (Caribou).
D017-701	27-Jul-01	Site located 1-3 m above surrounding dry heath habitat. This appears to be an old wolf den site that is being renovated. Only 1 opening showed active digging and use.Three of the other openings were grown over.
D018-701	24-Jul-01	12 different openings.

Rec. No.	Date	Comments	
D001-801	6-Aug-01	Vac. vit., salix, grasses, sedge, stel., sel. sp., vac. uli., emp. nig.	In process of digging den.
D002-801	6-Aug-01	betula, emp. nig., sax. / vacc. Ulig., Kilence	Abandonned. Some collapsed areas.
D003-801	7-Aug-01	Betula, vacc. uli., vacc. vit., emp. nig., arc. / grasses, sedge, lichen	
D004-801	7-Aug-01	betula, grasses, vac. uli., vac. vit., emp. nig. / epilobium, sedge, lichen	
D005-801	7-Aug-01	Betula, salix, emp. nig., grasses / stell (little)	
D006-801	7-Aug-01	Betula, arcto., vacc. vit., vacc. uli., emp. nig, grasses / Betula, arcto., vacc. vit., vacc. uli., emp. nig, grasses	
D007-801	10-Aug-01	emp. nig, betula, arcto. / ledum, sedge, grass	Wolf scat in area.
D008-801	10-Aug-01	Arcto, vac uli / betula, salix, led., sax tri	
D009-801	10-Aug-01	Grasses, betula / salix	
D010-801	13-Aug-01	Sedges, vacc vit, grasses, emp nig, voic uli. /	
D011-801	13-Aug-01	betula, arcto., ledum, sedges, vacc ut. grasses /	Wolf tracks nearby den but few prey remains. Ground squirrel tracks near den as well.
D012-801	15-Aug-01	Emp nig, arcto, dryas / sax tri, salix, vacc uli, vacc vila	Site measurements 11X12m. Partially collapsed. 3 active entrances.
D013-801	19-Aug-01		
D014-801	19-Aug-01	Ledurn, betula, arcto, emp /	Numerous GUGU scat.
D015-801	19-Aug-01	Betula, Empit. / salix, vacc vit, ledurm, vacc ulig, grasses, sedge	30 openings in total. Site measurements 14x8m. Arctic fox seen at site.
D016-801	10-Aug-01		Near Lupin Mine site.

(completed)

APPENDIX 4.3-1
RAPTORS OBSERVATIONS DURING SURVEYS OF THE BATHURST INLET PORT AND ROAD ROUTE, JULY 2002

Appendix 4.3-1
Raptor Observations During Surveys of the Bathurst Inlet Port and Road Route, July 2002

Index	Type	UTM Zone	Easting	Northing	Waypoint	Date	Time (GMT)	Species	Nest Status	No. Eggs for Young	Comments	Site Eval..	Site Comments
1	N	12W	485613	7294307	001	1-Jul-02	20:00	PEFA	OE	4		1	
2	N	12W	481285	7293182	003	1-Jul-02	20:16	PEFA	OE	4	with adult above (#002)	1	
3	N	12W	419685	7282495	020	1-Jul-02	21:45	PEFA	OE	4		1	
4	N	12W	417061	7284018	023	1-Jul-02	22:06	PEFA	OE	4		1	
5	N	12W	453134	7278309	028	1-Jul-02	22:52	PEFA	OE	can't see		1	
6	N	12W	585691	7262173	041	2-Jul-02	15:47	PEFA	OE	4		1	
7	N	13W	374358	7324137	055	2-Jul-02	20:07	PEFA	OE	4		1	
8	N	13W	379363	7357716	065	2-Jul-02	20:44	PEFA	OE	1+		1	
9	N	13W	385748	7367702	101	3-Jul-02	16:43	PEFA	OE	can't see		1	
10	N	13W	382960	7370680	105	3-Jul-02	16:55	PEFA	OE	can't see		1	
11	N	13W	378073	7365141	119	4-Jul-02	16:09	PEFA	OE	4		1	
12	N	13W	380456	7370964	122	4-Jul-02	16:31	PEFA	OE	1+		1	
13	N	13W	378808	7374186	131	4-Jul-02	17:01	PEFA	OE	4		1	
14	N	12W	421855	7282626	019	1-Jul-02	21:38	RLHA	OE	4		1	
15	N	12W	451989	7278135	027	1-Jul-02	22:50	RLHA	OE	3+		1	
16	N	12W	584572	7266362	044	2-Jul-02	16:16	RLHA	OE	4		1	
17	N	13W	379282	7357896	066	2-Jul-02	20:45	RLHA	OE	5		1	
18	N	13W	377280	7358221	067	2-Jul-02	20:52	RLHA	OE	4		1	
19	N	12W	626514	7292448	082	2-Jul-02	22:58	RLHA	OE	4	with adult above (#81)	1	
20	N	13W	381043	7362269	092	3-Jul-02	16:11	RLHA	OE	5		1	
21	N	13W	385154	7368351	100	3-Jul-02	16:41	RLHA	OE	can't see		1	
22	N	13W	383657	7370038	104	3-Jul-02	16:52	RLHA	OE	can't see		1	
23	N	13W	381143	7369178	120	4-Jul-02	16:17	RLHA	OE	4		1	
24	N	13W	381856	7376364	135	4-Jul-02	17:20	RLHA	OE	4		1	
25	N	13W	381521	7375900	137	4-Jul-02	17:24	RLHA	OE	4		1	
26	N	12W	419942	7282033	022	1-Jul-02	21:57	CORA	OY	1+		1	
27	N	12W	453134	7278309	028	1-Jul-02	22:52	CORA	OY	1+		1	
28	N	13W	383716	7385108	140	4-Jul-02	19:30	CORA	OY	2+		1	
29	N	12W	419421	7279465	025	1-Jul-02	22:26	GYRF	OY	2+		1	
30	N	13W	370667	7327792	071	2-Jul-02	21:25	GYRF	OY	2		1	
31	OBS	13W	380599	7360270	086	3-Jul-02	15:47	BAEA	NS		immature flying		
32	OBS	12W	481092	7293404	002	1-Jul-02	20:11	PEFA	NS		1 adult perched; with nest below (#003)		
33	OBS	12W	465350	7282791	004	1-Jul-02	20:30	RLHA	NS		adult flying		
34	OBS	12W	425012	7279146	016	1-Jul-02	21:26	RLHA	NS		adult flying		
35	OBS	12W	547952	7259189	030	2-Jul-02	15:00	RLHA	NS		adult flying		
36	OBS	12W	585289	7262816	042	2-Jul-02	15:52	RLHA	NS		adult flying; several old stick nests		
37	OBS	12W	567729	7260851	047	2-Jul-02	16:35	RLHA	NS		adult feeding on caribou carcass		
38	OBS	12W	627155	7293056	081	2-Jul-02	22:55	RLHA	NS		adult; with nest below (#82)		
39	OBS	12W	614788	7285433	084	2-Jul-02	23:08	RLHA	NS		adult flying		
40	OBS	13W	381947	7376574	134	4-Jul-02	17:17	RLHA	NS		adult flying; probably with nest below (#135)		
41	ON	13W	380852	7362526	091	3-Jul-02	16:06	GYRF	OT		adult flushed; empty nest seen	1	
42	ON	12W	631532	7294556	053	2-Jul-02	19:48	PEFA	UU		old site	2	
43	ON	13W	373739	7324651	056	2-Jul-02	20:09	PEFA	UU		old site	2	
44	ON	13W	364017	7308931	077	2-Jul-02	22:38	PEFA	UU		old site	2	
45	ON	13W	380559	7351706	085	3-Jul-02	15:42	PEFA	UU		old site	2	
46	ON	13W	380134	7362731	089	3-Jul-02	15:55	PEFA	UU		old site	2	
47	ON	13W	386006	7367492	103	3-Jul-02	16:48	PEFA	UU		old site	1	
48	ON	12W	555188	7261071	035	2-Jul-02	15:19	RLHA	UU		old site	2	
49	ON	12W	555640	7260933	036	2-Jul-02	15:21	RLHA	UU		old site	3	
50	ON	12W	585863	7261951	040	2-Jul-02	15:46	RLHA	UU		old site	2	
51	ON	13W	378564	7358604	062	2-Jul-02	20:40	RLHA	UU		old site	2	
52	ON	13W	379043	7358003	063	2-Jul-02	20:42	RLHA	UU		old site	2	
53	ON	12W	627684	7293557	080	2-Jul-02	22:54	RLHA	UU		old site	2	
54	ON	13W	382305	7365337	096	3-Jul-02	16:28	RLHA	UU		old site	2	
55	ON	13W	384607	7367116	098	3-Jul-02	16:35	RLHA	UU		old site	2	
56	ON	13W	384694	7368381	099	3-Jul-02	16:38	RLHA	UU		old site	2	
57	ON	13W	383701	7379445	106	3-Jul-02	17:53	RLHA	UU		old site	2	
58	ON	13W	383136	7381756	111	3-Jul-02	18:20	RLHA	UU		old site	1	2 old stick nests here
59	ON	13W	385708	7380165	113	3-Jul-02	18:27	RLHA	UU		old site	2	

(continued)

Appendix 4.3-1
Raptor Observations During Surveys of the Bathurst Inlet Port and Road Route, July 2002

Index	Type	UTM Zone	Easting	Northing	Waypoint	Date	Time (GMT)	Species	Nest Status	No. Eggs for Young	Comments	Site Eval..	Site Comments
60	ON	13W	380135	7371833	121	4-Jul-02	16:27	RLHA	UU		old site	2	
61	PNS	13W	381602	7375987	136	4-Jul-02	17:24	PEFA	OT		nest not seen	1	
62	PNS	12W	464333	7282776	005	1-Jul-02	20:32		UU			3	
63	PNS	12W	460178	7284200	006	1-Jul-02	20:37		UU			4	
64	PNS	12W	453214	7282244	007	1-Jul-02	20:41		UU			4	
65	PNS	12W	443405	7281135	008	1-Jul-02	20:53		UU			2	short cliff
66	PNS	12W	438643	7280870	009	1-Jul-02	20:58		UU			4	short cliff
67	PNS	12W	439150	7284449	010	1-Jul-02	21:03		UU			2	
68	PNS	12W	438625	7281293	011	1-Jul-02	21:08		UU			3	
69	PNS	12W	434255	7281877	012	1-Jul-02	21:13		UU			4	
70	PNS	12W	429167	7280499	013	1-Jul-02	21:17		UU			4	short cliff
71	PNS	12W	428742	7280727	014	1-Jul-02	21:19		UU			3	short cliff
72	PNS	12W	429031	7281462	015	1-Jul-02	21:21		UU			3	
73	PNS	12W	422849	7280464	018	1-Jul-02	21:31		UU			4	
74	PNS	12W	419517	7282253	021	1-Jul-02	21:55		UU			2	
75	PNS	12W	415949	7283360	024	1-Jul-02	22:22		UU			4	
76	PNS	12W	452031	7278548	026	1-Jul-02	22:49		UU			3	
77	PNS	12W	541238	7260929	029	2-Jul-02	14:57		UU			5	
78	PNS	12W	547840	7260152	031	2-Jul-02	15:04		UU			4	short cliff
79	PNS	12W	555756	7259726	032	2-Jul-02	15:12		UU			4	short cliff
80	PNS	12W	554407	7261625	033	2-Jul-02	15:15		UU			3	short cliff
81	PNS	12W	555138	7261251	034	2-Jul-02	15:17		UU			2	short cliff
82	PNS	12W	579936	7264485	037	2-Jul-02	15:38		UU			5	
83	PNS	12W	586081	7261628	039	2-Jul-02	15:44		UU			2	
84	PNS	12W	587367	7266673	043	2-Jul-02	16:09		UU			5	
85	PNS	12W	574613	7262096	045	2-Jul-02	16:27		UU			5	short cliff
86	PNS	12W	573634	7261419	046	2-Jul-02	16:30		UU			5	short cliff
87	PNS	12W	559191	7261096	048	2-Jul-02	16:41		UU			6	
88	PNS	12W	543695	7262655	049	2-Jul-02	16:52		UU			5	
89	PNS	12W	600991	7274183	050	2-Jul-02	19:26		UU			3	
90	PNS	12W	602334	7275292	051	2-Jul-02	19:29		UU			4	
91	PNS	12W	630978	7294366	052	2-Jul-02	19:44		UU			4	
92	PNS	13W	365875	7306636	054	2-Jul-02	19:58		UU			2	
93	PNS	13W	374685	7325565	057	2-Jul-02	20:12		UU			4	
94	PNS	13W	374958	7325975	058	2-Jul-02	20:14		UU			3	
95	PNS	13W	373500	7337382	059	2-Jul-02	20:21		UU			4	
96	PNS	13W	374257	7338094	060	2-Jul-02	20:23		UU			4	
97	PNS	13W	375657	7351292	061	2-Jul-02	20:29		UU			5	
98	PNS	13W	377801	7357311	068	2-Jul-02	20:54		UU			2	
99	PNS	13W	380906	7355784	069	2-Jul-02	21:02		UU			2	
100	PNS	13W	371405	7326980	070	2-Jul-02	21:23		UU			3	
101	PNS	13W	370380	7320964	072	2-Jul-02	21:34		UU			5	
102	PNS	13W	369718	7318661	073	2-Jul-02	22:25		UU			5	
103	PNS	13W	369425	7318186	074	2-Jul-02	22:28		UU			5	
104	PNS	13W	363843	7310459	075	2-Jul-02	22:35		UU			3	
105	PNS	13W	363589	7309521	076	2-Jul-02	22:36		UU			5	short cliff
106	PNS	12W	634550	7300993	078	2-Jul-02	22:45		UU			5	
107	PNS	12W	629416	7297469	079	2-Jul-02	22:50		UU			4	
108	PNS	12W	619225	7288013	083	2-Jul-02	23:04		UU			3	short cliff
109	PNS	13W	381539	7361519	087	3-Jul-02	15:50		UU			3	
110	PNS	13W	379921	7363047	088	3-Jul-02	15:53		UU			3	
111	PNS	13W	380847	7362570	090	3-Jul-02	16:03		UU			2	
112	PNS	13W	381138	7362212	093	3-Jul-02	16:14		UU			2	
113	PNS	13W	382559	7364122	094	3-Jul-02	16:20		UU			3	
114	PNS	13W	383544	7365273	095	3-Jul-02	16:25		UU			5	
115	PNS	13W	384920	7366267	097	3-Jul-02	16:33		UU			4	
116	PNS	13W	386269	7367169	102	3-Jul-02	16:45		UU			3	
117	PNS	13W	384094	7379831	107	3-Jul-02	17:58		UU			4	
118	PNS	13W	383631	7380528	108	3-Jul-02	18:02		UU			3	
119	PNS	13W	383574	7381053	109	3-Jul-02	18:05		UU			2	
120	PNS	13W	384043	7380545	110	3-Jul-02	18:08		UU			4	
121	PNS	13W	383380	7382076	112	3-Jul-02	18:23		UU			2	
122	PNS	13W	388226	7383379	114	3-Jul-02	18:34		UU			5	
123	PNS	13W	390087	7386042	115	3-Jul-02	18:40		UU			4	

(continued)

Appendix 4.3-1
Raptor Observations During Surveys of the Bathurst Inlet Port and Road Route, July 2002

Index	Type	UTM Zone	Easting	Northing	Waypoint	Date	Time (GMT)	Species	Nest Status	No. Eggs for Young	Comments	Site Eval..	Site Comments
124	PNS	12W	425012	7279146	016	1-Jul-02	21:26		NS		adult flying	4	
125	PNS	13W	379198	7363690	117	4-Jul-02	16:03		UU			3	short cliff
126	PNS	13W	378959	7364089	118	4-Jul-02	16:05		UU			3	
127	PNS	13W	380901	7369918	123	4-Jul-02	16:34		UU			3	
128	PNS	13W	380421	7371839	124	4-Jul-02	16:37		UU			3	
129	PNS	13W	380830	7370879	125	4-Jul-02	16:39		UU			5	
130	PNS	13W	381083	7370038	126	4-Jul-02	16:41		UU			3	
131	PNS	13W	381536	7370656	128	4-Jul-02	16:47		UU			5	
132	PNS	13W	379898	7373276	129	4-Jul-02	16:51		UU			4	
133	PNS	13W	381679	7371797	130	4-Jul-02	16:55		UU			4	
134	PNS	13W	381050	7376297	132	4-Jul-02	17:06		UU			2	several heavily-used perches
135	PNS	13W	381282	7376169	133	4-Jul-02	17:14		UU			2	very tight canyon
136	PNS	13W	382192	7377367	138	4-Jul-02	17:31		UU			2	heavily-used perch
137	PNS	13W	381635	7384508	139	4-Jul-02	19:28		UU			2	

(completed)

APPENDIX 5.4-1
SMALL MAMMAL TRAPPING RESULTS, SUMMER 2001

Appendix 5.4-1
Small Mammal Trapping Results, Summer 2001

Rec. #	Trappers	Date	Zone	Northing	Easting	# of Traps	Habitat Type	Total Caught	RBV	Col. Lem.	Br. Lem.	Other	Notes
1	MF, CN	9-Aug-01	12W	7284099	492507	50	sedge fen	0					
2	FD, DS, GT	9-Aug-01	12W	7284528	492687	50	dry heath	9	9				2 traps set but empty, 1 lost trap
3	FD, DS	12-Aug-01	12W	7291357	623023	50	rocky birch heath	0					
4	FD, DS	12-Aug-01	12W	7291357	623023	50	birch heath	0					
5	MF	12-Aug-01	12W	7291357	623023	50	fen	0					
6	FD, DS	13-Aug-01	12W	7275582	601786	50	soliflucted heath	1	1				
7	MF	13-Aug-01	12W	7275582	601786	50	soliflucted heath	0					
8	CN	13-Aug-01	12W	7275582	601786	50	soliflucted heath	0					
9	MF	15-Aug-01	12W	7293750	630800	50	flat rocky area	4	4				
10	GT	15-Aug-01	12W	7293700	630650	50	esker side	0					
11	FD, DS	15-Aug-01	12W	7293700	630600	50	esker top	1	1				2 traps set but empty
12	MF	16-Aug-01	13W	7314250	367275	50	rocky heath	6	6				
13	FD, DS	16-Aug-01	13W	7314100	367100	100	rocky esker top	4	4				
14	MF	17-Aug-01	13W	7332414	373805	50	rocky area	2	2				
15	FD, DS	17-Aug-01	13W	7332414	373805	50	carex soliflucted slope	0					
16	FD, DS	17-Aug-01	13W	7332414	373805	50	carex soliflucted slope	0					
17	DS	18-Aug-01	13W	7344726	372995	50	lakeshore	2	2				
18	FD, DS	18-Aug-01	13W	7344726	372995	50	streamshore	2	2				
19	FD	18-Aug-01	13W	7344726	372995	50	streamshore	0					
20	MF, DS	20-Aug-01	12W	7273983	469828	100	lake riparian	1				1 tundra vole	
21	MF, DS	20-Aug-01	12W	7273983	469828	50	esker side/heath	1	1				
							Totals	**33**	**32**	**0**	**0**	**1**	

Note: Trappers: MF = Mark Fraker, CN = Colin Niptanatiak, FD - Fiona Danks, DS = David Sateana, GT = George Taptuna

RBV = Red-backed vole, Col. Lem. = collared lemming, Br.Lem = Brown lemming

APPENDIX 6.4-1
INCIDENTAL BIRD OBSERVATIONS, SUMMER 2001

Appendix 6.4-1
Incidental Bird Observations, Summer 2001

		UTM Coordinates			Animal										Site
Rec. No.	Date	Zone	East	North	Species	Male Adults	Female Adults	Uncl Adults	Uncl Uncl	Uncl Young	Total Animals Observed	Activity	Sign	No. of Sign	Age of Sign	Landform
S001-701	20-Jul-01	12	492444	7285946	B-SEPL	1	1				2	Living				Esker edge
S002-701	20-Jul-01	12	491516	7286129	B-LESA			1			1	Living				Wetland
S003-701	20-Jul-01	12	490098	7287942	B-RNPL	1	1				2	Living				
S005-701	20-Jul-01	12	490098	7287942	B-SASP			1			1	Living				Flat wet hummock
S008-701	22-Jul-01	12	489000	7293500	B-HOLA			1			1	Living				
S014-701	24-Jul-01	13	384177	7367527	B-ATSP			2			2	Living				Top of esker
S016-701	24-Jul-01	13	370449	7327788	B-UFAL			1			1	Flying				Rocky cliff
S017-701	24-Jul-01	13	372224	7326549	B-RLHA			1			1	Hunting				
S019-701	24-Jul-01	13	383859	7369496	B-RLHA			1			1	Hunting				Rocky Mound
S020-701	24-Jul-01	13	383640	7369856	B-UPTA						0		Scat	1	<yr	Rocky Mound
S024-701	24-Jul-01	13			B-RLHA			1			1	Hunting				
S027-701	24-Jul-01	13	388205	7313020	B-LALO	1	1				2	Living				
S030-701	25-Jul-01	13			B-PEFA			2			2	Social Interact				
S031-701	25-Jul-01	13			B-CORA			2			2	Hunting				
S032-701	25-Jul-01	13			B-GYRF			2			2					
S034-701	25-Jul-01	12	581500	7264555	B-UPTA			1			1	Living				Esker
S036-701	25-Jul-01	13	365714	7307899	B-CAGO			4			4	Living				Lake
S038-701	25-Jul-01	12	626670	7287175	B-CAGO				25		25	Living				Lake
S039-701	25-Jul-01	12	627892	7285990	B-UJAE				1		1	Flying				Esker
S040-701	25-Jul-01	12	613900	7286165	B-RLHA			1			1	Flying				Esker
S043-701	25-Jul-01	12	591300	7271820	B-LTJA					1	1	Flying				Esker
S044-701	25-Jul-01	12	573600	7263570	B-PEFA			1			1	Flying				Esker
S051-701	25-Jul-01	13	371000	7303830	B-CAGO				15		15	Living				Lake
S052-701	25-Jul-01	12	606560	7280900	B-CORA			2			2	Flying				Esker
S053-701	25-Jul-01	12	596145	7268830	B-CAGO				27		27	Living				Lake
S056-701	25-Jul-01	13	384835	7315942	B-CAGO				30		30	Living				Lake
S060-701	26-Jul-01	12	573840	7262815	B-CAGO				12		12	Living				Lake
S061-701	26-Jul-01	12	572700	7256800	B-CORA			2			2	Flying				
S062-701	26-Jul-01	12	570970	7257335	B-GWFG			14			14	Living				Lake
S063-701	26-Jul-01	12	566600	7262115	B-RBME			3			3	Living				Lake
S064-701	26-Jul-01	12	564355	7264195	B-PEFA			1			1	Perched				Esker
S065-701	27-Jul-01	12	581998	7264260	B-SACR			3			3	Perched				Esker
S067-701	27-Jul-01	12	597332	7268930	B-CAGO				22		22	Living				Lake
S070-701	27-Jul-01	12	590568	7265019	B-URED		1				1	Living				Moraine
S071-701	27-Jul-01	12	590568	7265019	B-SASP			1			1	Living				Moraine
S075-701	28-Jul-01				B-HOLA			1			1	Living				
S076-701	26-Jul-01	12	624433	7290007	B-LALO	1					1	Living				
S077-701	26-Jul-01	12	624433	7290007	B-SASP			1			1	Living				
S079-701	26-Jul-01				B-CAGO			30			30	Moulting				Lake
S088-701	26-Jul-01	12	563455	7266080	B-RTLO			2			2	Living				Lake
S089-701	26-Jul-01	12	563630	7265630	B-SEOW			1			1	Perched				Esker
S092-701	26-Jul-01	12	554040	7262260	B-ROPT			2			2	Living				
S093-701	26-Jul-01	12	606380	7279270	B-CAGO			30			30	Living				Lake
S096-701	21-Jul-01	12	420000	7288000	B-RLHA			1			1	Flying				
S098-701	29-Jul-01	13	385500	7362500	B-TUSW			2			2					
S009-801	6-Aug-01	12	454184	7278961	B-UGOO				5		5	Swimming				
S015-801	10-Aug-01	12	427886	7279622	B-RTLO			2			2	Swimming				
S018-801	11-Aug-01	12	622870	7291315	B-PEFA			1			1	Flying				

Notes: ATSP = Americana Tree Sparrow, CAGO = Canada Goose, CORA = Common Raven, GOEA = Golden Eagle, GWFG = Greater White Fronted Goose, GYRF = Gyrfalcon, HOLA = Horned Lark **(continued)**

LALO = Lapland Longspur, LESA = Least Sandpiper, LTJA = Long-tailed Jaeger, PEFA = Peregrine Falcon, RBME = Red-breasted Merganser, RLHA = Rough-legged Hawk, RNPL = Red-necked Phalarope,

ROPT = Rock Ptarmingan, RTLO = Red-throated Loon, SACR = Sandhill Crane, SASP = Savannah Sparrow, SEOW = Short-eared Owl, SEPL = Semipalmated Plover, TUSW = Tundra Swan, UFAL = Unspecified falcon, UGOO = Unspecified goose,

UJAE = unspecified jaeger, ULOO = Unspecified loon, UPTA = Unspecified ptarmigan, URED = Unspecified redpoll, YBLO = Yellow-billed Loon

Appendix 6.4-1
Incidental Bird Observations, Summer 2001

		UTM Coordinates				Animal									Site
Rec. No.	Date	Zone	East	North	Species	Male Adults	Female Adults	Uncl Adults	Uncl Uncl	Uncl Young	Total Animals Observed	Activity	Sign	No. of Sign	Age of Sign	Landform
S019-801	12-Aug-01	12	623136	7291491	B-HOLA		1				1	Living				
S020-801	12-Aug-01	12	623069	7291562	B-LALO		1				1	Living				
S030-801	9-Aug-01				B-CAGO			4		9	13					Pond
S037-801	15-Aug-01	13	388000	7383000	B-GOEA			1			1	Flying				
S038-801	15-Aug-01	13	387000	7384000	B-YBLO			2			2	Swimming				
S039-801	17-Aug-01				B-CAGO						0	Feeding				
S041-801	18-Aug-01	12	609387	7281509	B-SACR	2	2				4	Walking				Marsh
S047-801	17-Aug-01	13	635302	7299966	B-RTLO						0		Call	1		Lake
S051-801	20-Aug-01	12	421686	7282174	B-GYRF						0		Call	1		Rocky area
S054-801	23-Aug-01	12	475359	7284987	B-SACR	1	1			1	3	Feeding, walking				Till plain
S057-801	10-Aug-01	12	489000	7292000	B-GOEA			1			1	Flying				
S058-801	15-Aug-01	12	562830	7265720	B-GOEA			1			1	Flying				Esker
S060-801	12-Aug-01				B-LALO			1			1					
S064-801	13-Aug-01	12	582748	7264233	B-ULOO			2			2	Swimming				Lake
S066-801	14-Aug-01				B-LALO			2			2					
S069-801	14-Aug-01	12	622549	7292006	B-LALO			1			1					
S074-801	15-Aug-01	13	366867	7314415	B-SACR			2			2					
S076-801	16-Aug-01	13	387351	7383616	B-CAGO			6			6	Swimming				Lake
S078-801	17-Aug-01	13	372995	7344726	B-ULOO			1			1	Flying				
S080-801	19-Aug-01	12	469828	7273983	B-SACR			2			2					Lake

Notes: ATSP = Americana Tree Sparrow, CAGO = Canada Goose, CORA = Common Raven, GOEA = Golden Eagle, GWFG = Greater White Fronted Goose, GYRF = Gyrfalcon, HOLA = Horned Lark **(completed)**
LALO = Lapland Longspur, LESA = Least Sandpiper, LTJA = Long-tailed Jaeger, PEFA = Peregrine Falcon, RBME = Red-breasted Merganser, RLHA = Rough-legged Hawk, RNPL = Red-necked Phalarope,
ROPT = Rock Ptarmingan, RTLO = Red-throated Loon, SACR = Sandhill Crane, SASP = Savannah Sparrow, SEOW = Short-eared Owl, SEPL = Semipalmated Plover, TUSW = Tundra Swan, UFAL = Unspecified falcon, UGOO = Unspecified goose,
UJAE = unspecified jaeger, ULOO = Unspecified loon, UPTA = Unspecified ptarmigan, URED = Unspecified redpoll, YBLO = Yellow-billed Loon

Appendix D-8
Habitat Suitability Baseline

Author: **Rescan Environmental Services Ltd.**
Date: **November 2007**

the BATHURST INLET PORT AND ROAD PROJECT

Bathurst Inlet Port and Road Project

Nunavut, Canada

Bathurst Inlet Port and Road Habitat Suitability Baseline

Prepared by:

Rescan™ Environmental Services Ltd.
Vancouver, British Columbia, Canada

November 2007

EXECUTIVE SUMMARY

Executive Summary

This report summarizes the results of habitat suitability mapping carried out in conjunction with ecosystem mapping completed for the Bathurst Inlet Port and Road (BIPR Joint Venture Ltd.) Project (the Project).

Wildlife surveys in 2001, 2002, and 2007 identified terrestrial wildlife species within the Project area that have the potential to be influenced by the proposed Project. Wildlife habitat suitability mapping was carried out in order to identify suitable habitat of nine wildlife species designated to be valued ecosystem components (VECs) in the study area: caribou (*Rangifer tarandus*), muskox (*Ovibos moschatus*), grizzly bear (*Ursus arctos horribilis*), wolf (*Canis lupis*), wolverine (*Gulo gulo*), migratory birds, cliff-nesting raptors (Peregrine falcon (*Falco peregrinus*)), ground-nesting raptors (short-eared owl (*Asio flammeus*)) and waterfowl (long-tailed duck (*Clangula hyemalis*)). VECs were selected based on ecological importance, conservation status and significance to Inuit lifestyle and culture.

Wildlife habitat suitability mapping was completed following a simplified version of the procedures outlined in *British Columbia Wildlife Habitat Rating Standards* (RIC, 1999), as a similar document does not exist for Nunavut. Species accounts were developed for each focal species and wildlife habitat ratings were completed for each mapped ecosystem unit. Rating interpretations were based on ecosystem mapping.

In developing the habitat suitability rating system, an intensive literature review was conducted on each VEC and map unit using university library catalogues, government reports, computer on-line searches and references supplied by species experts. The information collected was supplemented by empirical data from baseline surveys and personal experience and knowledge of Project biologists.

Habitat suitability ratings were assigned to each of the map units for each VEC. For some VECs, habitat use differs substantially among seasons; therefore, the assessment included seasonal differences, where appropriate. The seasons included for each VEC were selected based on when the VECs were in the study area as well as on critical life stages for each VEC (*i.e., Reproducing*). Ratings were based on knowledge of habitat preferences (*i.e.,* through scientific literature, professional experience and empirical evidence) for each VEC. In general, the following patterns were observed:

- Caribou and muskox habitat was distributed throughout the study area.
- Grizzly bear spring, summer and fall habitat occurred in nutrient rich, moist ecosystems, where shrubby and herbaceous plants are abundant.
- Wolverine denning and kit rearing habitat does not appear to be limiting.
- Wolf denning and pup rearing habitat occurs mainly in esker complexes, which is limited habitat throughout the local and regional study areas.
- Avian species were found throughout the study area. Habitat for cliff-nesting raptors and species requiring riparian and wetland areas appears to be limiting within the study area.

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This report was prepared for Bathurst Inlet Port and Road Joint Venture Ltd. (the proponent) by Rescan Environmental Services Ltd. (Rescan). Fieldwork was conducted by Geowest Environmental Consultants Ltd. (Geowest). The report was written by Christine Kent (B.A., Dipl. Tech.). ArcView GIS mapping was conducted by Rose Spicker (B.Sc.) with direction from Tania Perzoff.

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GLOSSARY, ACRONYMS AND ABBREVIATIONS

Glossary, Acronyms and Abbreviations

Glossary

adjustments	A process in which observations are corrected to reduce or remove errors or internal inconsistencies in the results. A series of underlying logic rules which correct ratings given to an ecosystem unit based on additional attributes, which are not explicitly identified in the ratings table. Adjustments are used as part of the algorithm for generating a habitat capability or suitability map.
algorithm	A set of mathematical instructions or problem-solving procedures designed to provide answers to complex problems. Used in modelling applications to portray the inter-relationships between different sets of data. A series of commands that assign habitat capability and suitability ratings for an animal species to ecosystem unit polygons.
anthropogenic	Effects, processes, objects or materials are those that are derived from human activities, as opposed to those occurring in natural environments without human influences.
Canadian Endangered Species Conservation Council (CESCC)	Publishes the Wild Species statistics reports with information on Species at Risk in Nunavut.
carnivore	A flesh-eating animal.
chronology (seasonal habitat)	An arrangement of events in the order in which they occur according to season, as defined by the calendar year. For example, chronological early spring habitat for grizzly bear is defined as occurring during the months of April to late May.
Committee on the Status of Endangered Wildlife in Canada (COSEWIC)	A committee that produces the official list of Canadian endangered species.
ecosystem map unit	A land classification system based on terrain, soils and vegetation, in which areas of similar ecology are identified and mapped.
ecosystem (terrestrial)	A volume of earth-space that is composed of non-living parts (climate, geologic materials, groundwater and soils) and living or biotic parts, which are all constantly in a state of motion, transformation, and development. No size or scale is inferred.
forage	Plant material consumed by animals.
forb	Non-graminoid herbaceous plants.
Geographic Information System (Cornell Lab of Ornithology and the American	A computer based system used to process spatially-referenced data into information for a specific purpose. Primary processes include data input, management, query, analysis and visualization.

Ornithologists' Union)	
habitat	Land and water surface used by wildlife. This may include biotic and abiotic aspects such as vegetation, exposed bedrock, water and topography.
habitat suitability	The ability of the habitat in its current condition to provide the life requisites of a species.
hectare	10,000 m^2 or 0.01 km^2 or 2.47 acres.
herb	A plant, annual, biennial or perennial, with stems that die back to the ground at the end of the growing season.
herbivore	An animal that feeds exclusively on plants.
home range	The area where an animal spends its life. Home range size may vary between winter range and summer range.
life requisites	Specific activities of an animal that are critical for sustaining and perpetuating the species and that depend on particular habitat attributes or conditions. Life requisites include feeding, security, thermal regulation, breeding, migration, hibernation, *etc.*
local study area	A geographic area that encompasses both the proposed port and a 500 m buffer from the centreline of the proposed road.
map unit	A mapped ecosystem.
migration	The regular seasonal or daily movement of animal populations to and from different areas, often considerable distances apart. Migration often occurs in corridors between preferred habitat types.
passerine	Perching birds that are mostly small and living near the ground with feet having four toes arranged to allow for gripping a perch; most are songbirds.
permafrost	Permanently frozen ground.
phenology (seasonal habitat)	The scientific study of successional biological phenomena in relation to climatic conditions (*e.g.,* breaking dormancy, flowering, breeding, migration).
plant association	Subgroups of plant communities, such as the “Non-tussock sedge association” as a subgroup of the “Sedge community”, most of which are too small or indistinguishable to be mapped. This term is sometimes used interchangeably with the term “ecosystem.”
plant community	An assemblage of plants occurring in areas of equivalent environmental conditions. Plant communities are characterized by certain species which are inconspicuous or unrepresented in other communities (RIC, 1998). For the Project, most plant communities could be mapped. This term is sometimes used interchangeably with the term “ecosystem” and “map unit.”
population	A collection of individuals of the same species that can interbreed.
predatory mammal	Mammals that survive by catching living prey or opportunistically scavenging on the prey of other animals (*e.g.,* grizzly bear, wolf, wolverine).
raptor	A bird that hunts by snatching its prey (*e.g.,* peregrine falcon, gyrfalcon,

	snowy owl, rough-legged hawk).
rating scheme	A classification system for wildlife habitat capability/suitability ratings based on the knowledge level about a species and its habitat requirements. Two types of rating schemes (4-class and 2-class) have been defined.
regional study area (RSA)	A geographic area that encompasses approximately 1.5 million hectares. The RSA is situated within two terrestrial ecoregions of the Southern Arctic Terrestrial Ecozone. The Bathurst Hills Ecoregion encompasses the proposed Bathurst Inlet Port area (Port) and approximately the first 12 km of the Road from the Port. The Takijuq Lake Upland Ecoregion includes the remaining Road south of Bathurst Inlet.
rut	The time when antlered ungulates mate. The Rut is triggered by a shortening of the length of daylight hours, but specific dates differ by species, depending on the length of their gestation period (length of pregnancy).
species account	A summary of geographic distribution, life requisites, seasonal use of habitats, limited factors and habitat attributes for an animal species within a geographic range.
stakeholder	An interested party that may be affected by a project and who has specific input into its development.
standard deviation (USDA)	A statistical measure of the spread or variability of a set of data, defined as the average distance of each measurement from a mean of all measurements.
suitability rating	A value assigned to a map unit to express the suitability of that unit to support wildlife species for a particular life requisite and season. The rating is based on assumptions about the species habitat requirements.
telemetry	The wireless transmission and reception for the purpose of remotely monitoring radio-collared animal movements.
traditional knowledge	The knowledge that is gained both by Inuit through personal experience and by passing on information from one generation to the next.
topography	The configuration of a surface, including its relief and the position of its natural and man-made features.
ungulate	A wide taxonomic group of hoofed mammals (*e.g.,* caribou).
valued ecosystem component (VEC)	Any part of the environment that is considered important by the proponent, members of the public, scientists and government involved in the assessment process. Importance may be determined on the basis of cultural values or scientific concerns.
wetland	Semi-terrestrial sites where the water table is at, near, or above the soil surface and soils are water-saturated for a sufficient length of time such that excess water and low soil oxygen levels are principal determinants of vegetation and soils development. Wetlands must have either plant communities characterized by species that normally grow in soils water-saturated for a major portion of the growing season (“hydrophytes”) soils with surface peat (“O”) horizons, or gleyed mineral horizons (Bg or Cg) within 30 cm of the soil surface (MacKenzie and Moran, 2004).

Acronyms and Abbreviations

BIPR	Bathurst Inlet Port and Road
BQCMB	Beverly and Qamanirjuaq Caribou Management Board
CESCC	Canadian Endangered Species Conservation Council
CITES	Convention on International Trade in Endangered Species
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
Cumberland	Cumberland Resources Ltd.
CWS	Canadian Wildlife Service
DEIS	Draft Environmental Impact Statement
Geowest	Geowest Environmental Consultants Ltd.
GNWT RWED	Government of the Northwest Territories Department of Resources, Wildlife and Economic Development
LSA	local study area
NPC	Nunavut Planning Commission
NRCan	Natural Resources Canada
NWT	Northwest Territories
Rescan	Rescan Environmental Services Ltd.
RIC	Resource Inventory Committee
RSA	regional study area
SARA	*Species at Risk Act (Canada)*
TEM	terrestrial ecosystem mapping
the Project	the Bathurst Inlet Port and Road Project
the proponent	Bathurst Inlet Port and Road Project Joint Venture Ltd.
VEC	valued ecosystem component
WHR	wildlife habitat ratings
WKLUP	West Kitikmeot Regional Land Use Plan
WKSS	West Kitikmeot/Slave Study

1. INTRODUCTION

1. Introduction

1.1 Overview

The Bathurst Inlet Port and Road (BIPR Joint Venture Ltd.) Project (the Project) is located in the Kitikmeot region of Nunavut. The terrestrial portion of the Project is a proposed road and marine port facility. The proposed road is a 211 km all-weather road that will extend from Contwoyto Lake northward to Bathurst Inlet. The proposed port will be built on Bathurst Inlet. The road will connect the port facility with inland mining operations, for transporting fuel and supplies.

This report outlines the approach taken to characterize baseline habitat conditions for each wildlife VEC using habitat suitability ratings. As outlined in British Columbia Wildlife Habitat Rating Standards (RIC, 1999), suitability ratings include both the physical attributes (*e.g.*, elevation, slope, aspect, geographic location) and biological components (*e.g.*, vegetation species composition, structure, age) of habitat. Suitability is defined as the ability of the habitat in its current condition to provide the life requisites of a species (RIC, 1999). B.C.'s Resource Inventory Committee (RIC) standards were used because a similar document is not available for Nunavut.

The use of wildlife habitat mapping is a relatively recent application for inventory and identification of areas of special importance to wildlife. Wildlife habitat ratings (WHR) relate mapped ecological units to wildlife populations. Mapping wildlife habitat identifies areas that contain significant wildlife habitat, provides a basis to evaluate the effects of development on wildlife habitat and allows for the loss or alteration of these habitats to be placed in local and regional contexts. The maps are designed for landscape level interpretations; however considering the myriad of natural factors that influence wildlife habitat use that can not be effectively mapped, further interpretation may be required.

1.2 Spatial Boundaries

1.2.1 Habitat Suitability Ratings Regional Study Area

The study area is located within the Southern Arctic Terrestrial Ecozone, one of three Arctic ecozones defined in Nunavut (NRCan, 2007). This ecozone supports the highest diversity of species (both plant and wildlife) and has the most extensive vegetative cover. The climate of the ecozone tends to be cold and dry Arctic, with short, cool summers and long, very cold winters.

The regional study area (RSA) used to assess wildlife habitat suitability for the Project is the same as used for the terrestrial ecosystems and vegetation effects assessment (Appendix D-1 of the DEIS). The area covers over 1.5 million hectares and is based on a 60 km wide corridor centred on the road (Figure 1.2-1).

Important wildlife habitat features of this area include: bedrock outcrops, eskers, waterbodies, wide expanses of heath tundra and major river valleys supporting scattered clumps of stunted birch and willow. Vegetation is dominated by dwarf birch, willow, heath species and lichen, with sedge wetlands occupying low-lying areas (Geowest, 2003).

1.2.2 Local Study Area

Certain habitat features or residences (*e.g.*, nests, dens) are limited to specific locations in which direct impacts from development may occur. Therefore, more in-depth habitat mapping was conducted within an area approximately 1 km wide surrounding the proposed road and associated facilities (roughly 500 m to either side of the road centreline). This area is referred to as the local study area (Kelsall).

Ecosystem mapping of the LSA generally followed the standards and guidelines established for terrestrial ecosystem mapping (TEM) in British Columbia (RIC, 1998). Deviations from this approach were made in order to accommodate the treeless nature of the northern landscape and the differing climatic regime of the central Arctic. Changes to portions of the road centreline and facilities resulted in a few areas being unmapped within the LSA. Mapping developed for the RSA was used in these areas.

The dominant habitat type within the LSA is heath tundra; however, other habitat types of importance to wildlife within the LSA include sedge communities, riparian shrub, avens community, lichen rock, birch seep, esker complex, saxifrage-blueberry community, and bedrock outcrop.

1.3 Data

1.3.1 Data Sources

The Arctic tundra is a fairly homogeneous landscape interspersed with small, but significant habitat communities. The habitat and habitat suitability information presented in this baseline study is derived from wildlife baseline studies and an extensive literature review. Vegetation mapping (including field work) was conducted by Geowest in 2001. Habitat ratings for each species were developed based on B.C. Habitat Rating Standards (RIC, 1999) and adapted for Arctic landscapes based on a literature review.

1.3.2 Assumptions

Different mapping methodologies between the RSA and LSA resulted in the identification of more detailed units in the LSA. The units not specifically identified in the RSA are assumed to occur, but are included in more generalized habitat types (*e.g.,* saxifrage-blueberry from the LSA is likely associated with esker complexes in the RSA).

1.4 Objectives

It is important to understand the type and distribution of habitats available to wildlife prior to development as a project could potentially have direct (*e.g.,* through alteration of habitat during development) or indirect (*e.g.,* influence of increased disturbance on habitat use) impacts on wildlife habitats. The purpose of conducting wildlife habitat suitability ratings is to quantify the amount and distribution of wildlife habitat for selected species or groups prior to development. The overall objective of the development of Wildlife Habitat Ratings and concurrent field evaluation criteria was to associate the ecosystems present within the study area with suitable

550000 600000 650000

7450000 7400000 7350000 7300000 7250000 7200000

N

UTM Zone 12
UTM Zone13

YT
NU
NT
BC
AB
Yellowknife

Kingoak
(Bathurst Inlet)

Bathurst Inlet
Port

Mara River

Contwoyto Lake Camp
Contwoyto Lake
Nose Lake

Ecological Land Classification Units

- Unvegetated
- Lichen (Lichen Veneer)
- Tall Shrub
- Birch Seep
- Water
- Esker
- Sedge Community
- Heath Tundra
- Boulders
- Bedrock
- Road
- Shipping Lane
- Local Study Area
- Regional Study Area

1:750,000
0 15 30
Kilometres

Projection: UTM12, NAD83

The Bathurst Inlet Port and Road Project

FIGURE 1.2-1

Map Units within Regional Study Area

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habitat for the focal VECs. The specific objectives of this report were to:

- combine available ecosystem mapping with information about VEC habitat use to develop algorithms for defining suitable habitat;
- evaluate the distribution of important wildlife habitat; and
- develop habitat maps for directing a future monitoring plan of habitat use.

2. METHODS

2. Methods

2.1 Overview

A number of methods have been identified for mapping habitat suitability based on the combination of a spatial inventory of topographic of vegetation features available for the area of interest with the knowledge of habitat requirements for the species of interest. There are limitations to the applicability of these methods for some wildlife species and as such each species requires specific local knowledge and methods to be incorporated into the mapping process. The selected mapping method requires the development of a set of algorithms tailored to describe a habitat type. The habitat is then identified on maps using indicators of ground conditions in a GIS platform.

The habitat suitability ratings used in this report was developed in three steps:

1. a description of the ecology of each wildlife VEC, including characteristics of habitats used or likely to be used in (based on literature) the region;
2. the development of suitability ratings for each species of interest using vegetation map units (from the ecosystem map) and the general features identified in (1); and
3. the input of ratings into a GIS platform to create maps showing the locations of suitable habitat.

The first step is commonly a desk-based exercise and was accomplished by reviewing literature to identify critical habitats (*e.g.*, habitats most limiting to a wildlife species, such as winter range for ungulates) and biophysical components that constitute the habitat. Critical habitat can be defined using slope, aspect, elevation and/or biological features such as vegetation, which provides forage and/or shelter. As regional differences in climate often influence wildlife use of an area, site specific field studies, caribou and grizzly bear satellite collar studies, and Traditional Knowledge were used to identify features associated with important habitats that would feed into map development. These important habitat features are described in detail for each species in their individual sections.

The second step of map development was to develop suitability ratings for habitat used by each wildlife species. Ecosystem mapping products identify a variety of ecosystems throughout the study area, termed map units. A suitability rating was assigned to each map unit, based on the characteristics of each species and season and its requirements to meet the species combined daily need (*Living*) or specific habitat features required for breeding (*Reproducing*).

2.2 Identification of Wildlife Valued Ecosystem Components

Local Inuit, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and wildlife biologists have identified nine terrestrial wildlife VECs within the Project area. These VECs are caribou, muskox, grizzly bear, wolf, wolverine, migratory birds, cliff and ground-nesting raptors and waterfowl.

For each VEC, species accounts describing their geographic distribution, life requisites, seasonal habitat use, limiting factors and habitat attributes were prepared following B.C.'s RIC standards (RIC, 1999). The species accounts were developed from literature reviews and historical data with particular emphasis on the ecology of the study area. Satellite collar records and Traditional Knowledge of wildlife importance, movements, patterns and use of habitat features were incorporated into this report where available.

Species account information was used to rate each ecosystem unit for its suitability as habitat for each VEC. The use of ecosystem mapping in rating habitat suitability is most effective when habitat features are readily mapped (*i.e.*, strongly linked to ecosystem or topographic characteristics). Carnivore habitat was less successfully mapped using this method, as access to prey tended to be the greatest influence on habitat use by predators.

2.3 Identification of Ecosystem Units

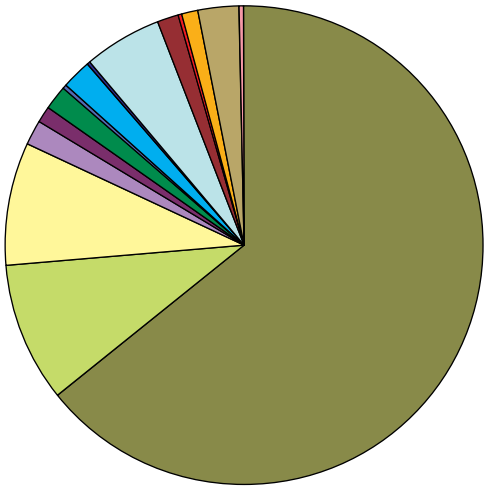
Ecosystem mapping using Landsat satellite imagery and digital image classification techniques was carried out in 2007 in an effort to characterize a study area that would also contribute to the assessment of wildlife habitat (*i.e.*, the RSA). Mapping developed for the West Kitikmeot/Slave Study (WKSS) region (Matthews *et al.*, 2001) was available; however, a number of inconsistencies were identified in the area of interest that rendered the data suspect (*e.g.*, many larger waterbodies had been classified as wetlands and information for a large area was missing at the port site).

Consequently, an area 60 km wide (30 km to either side of the road centreline) was mapped using Landsat 7 satellite imagery from August, 2000 that was obtained free of charge through GeoGratis (http://geogratis.cgdi.gc.ca/geogratis/en/index.html). The image selected was a 742 false colour composite with a pixel size of 14.25 m. This band combination is commonly used for geological applications and works well in arid areas (Quinn, 2001). It provides a clear land-water interface and allows for the identification of different vegetation types. Vegetated areas appear as various shades of green while un-vegetated areas generally appear as shades of pink-magenta.

A classification was run using the ISODATA algorithm and software from PCI Geomatics (Geomatica Focus). The resulting classes were grouped into map units that aimed to provide sufficient information regarding the distribution and extent of ecosystems present in the area.

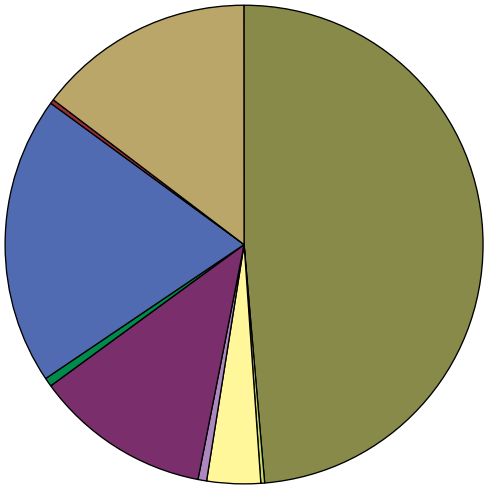
Vegetation baseline studies for the LSA were conducted by Geowest in 2001. Field surveys were completed and an ecosystem map was developed to characterize the plant communities and species present in the LSA. The type and area of habitat within the spatial boundaries of the Project were calculated for the RSA and the LSA separately (Figure 2.3-1 and Table 2.3-1). Map units within each study area are described in Appendix 1.

Habitat Types within the BIPR LSA



Heath Tundra	64.1%
Birch Seep	9.5%
Sedge	8.3%
Lichen Rock	1.8%
Boulder Field	1.1%
Riparian Shrub	1.6%
Open Water	0.19%
Lake	1.92%
River	0.26%
Pond	5.4%
Esker Complex	1.3%
Saxifrage-Blueberry	0.5%
Avens	1.1%
Bedrock Outcrop	2.6%
Gravel Bar	0.1%
Exposed Soil	0.14%
Beach Materials	0.083%
Disturbance Feature	0.004%
Permanent Snow	0.003%

Habitat Types within the BIPR RSA



Heath Tundra	49%
Birch Seep	0.03%
Sedge	3%
Lichen Veneer	0.4%
Boulder Field	13%
Riparian Tall Shrub	0.4%
Water (includes): Open Water, Lake, Pond	22%
Esker Complex & Saxifrage-Blueberry	0.2%
Bedrock Outcrop & Avens	12%
Unvegetated (includes): Gravel Bar, Exposed Soil, Beach Materials, Disturbance Feature, Permanent Snow	0.03%

the Bathurst Inlet Port and Road Project

Ecological Land Classification Units by Proportion within the LSA and RSA

FIGURE 2.3-1

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Table 2.3-1
Distribution of Map Units within Regional and Local Study Areas

Map Unit	RSA (ha)	Percent of RSA	LSA (ha)	Percent of LSA
Heath Tundra	738,315	49.17	19,464	63.00
Water	332,442	22.14	0	0.00
Boulder Field	191,720	12.77	782	2.53
Bedrock	173,779	11.57	1,228	3.97
Sedge	50,195	3.34	2,363	7.65
Riparian Tall Shrub	5,982	0.40	421	1.36
Lichen Veneer	6,018	0.40	3	0.01
Birch Seep	455	0.03	2,511	8.12
Esker Complex	2,328	0.16	347	1.12
Pond			1,376	4.45
Lake			1,087	3.52
Lichen-Rock			482	1.56
Un-vegetated	450	0.03	0	0.00
Avens			291	0.94
Ocean			206	0.67
Saxifrage-Blueberry			119	0.39
River			69	0.22
Open Water			53	0.17
Exposed Soil			37	0.12
Gravel Bar			24	0.08
Beach Materials			22	0.07
Disturbance Features			1	0.00
Permanent Snow			1	0.00
Total	**1,501,684**	**100**	**30,887**	**100**

2.4 Development of Wildlife Suitability Ratings

Wildlife suitability ratings are relative values used to characterize the potential of a habitat to support a wildlife species for a particular life requisite (*e.g.*, feeding, cover, breeding, hibernation) and season (RIC, 1999). Ratings are based on assumptions regarding the habitat requirements of the species as defined in species accounts. Species accounts helped guide the formulation of habitat ratings for the Project.

Assigning suitability ratings accurately is dependent on knowledge of the species and its habitat use. A modified RIC (1999) rating scheme was used. A four-class scheme, using high (H),

moderate (M), low (L) and nil (N) ratings, reflects an intermediate level of knowledge about a species' habitat use and was assigned to rate habitat for barren-ground caribou, muskox, barren-ground grizzly bear, wolf, wolverine and cliff-nesting raptors. A 2-class scheme, using suitable (U) or not suitable (X) ratings, reflects a limited level of knowledge about a species' habitat use and was assigned to rate habitat for ground-nesting raptors, migratory birds and waterfowl (RIC, 1999). The suitability ratings were based on the vegetation composition and structure of each ecosystem unit. Habitat benchmarks, against which to rate the quality of habitat within the study area, have not been developed for Nunavut. However, all suitability ratings assigned to ecosystem units were developed relative to one another in the study area, allowing for future adjustments if territorial benchmarks are developed.

How an animal uses habitat is closely associated with the season or time of year and the specific activity or life requisite. Habitats that provide food and cover in the winter season may be different from habitats used for food and cover in the spring, summer or fall (*e.g.*, growing season). Habitats used for reproductive activities may be important in the fall (courting/mating), spring (birthing), or summer (rearing). Often the season required for each seasonal activity will vary from one species to another, from low to high elevations and from southern to northern locations. The seasons identified for each VEC were selected based on when the VECs were in the study area, as well as on critical periods for the species (*e.g., Reproducing*).

Life requisites are supported by the species' habitat and include food, cover (security, thermal), reproduction, migration and hibernation. For the purposes of developing habitat suitability ratings for the Project, life requisites have been divided into two categories: *Living* and *Reproducing*.

Living refers to habitat used for food, cover and security. As seasons change, the living requirements of wildlife will change (*e.g.*, winter cover for caribou may refer to shelter from storms, while summer cover may refer to habitat used for insect avoidance). For mammals, *Reproducing* refers to habitat used specifically for giving birth to live young. For birds, *Reproducing* refers to habitat used for building a nest, laying eggs, incubation, hatching and feeding non-mobile young.

The use of habitat types by each VEC species was evaluated for specific seasons and life requisites (Table 2.4-1). In order to address the habitat requirements for VEC groups (*e.g.*, waterfowl), one species or subspecies was chosen to represent the habitat requirements for all species within the group. The representative species chosen and the rationale behind the choice are discussed in the appropriate section.

Suitability ratings were based on a combination of vegetation phenology expected during a chronological season. Vegetation phenology refers to the developmental status or observed state of plants (in this case forage species) at a particular season or time of year (*e.g.*, vegetation emergence, flowering, berry production). The timing of these events is dependent upon factors such as temperature, elevation, aspect and latitude. For example, during the spring, vegetation may emerge sooner at lower elevations compared to higher elevations, highlighting the idea that the phenology of vegetation based on location must be considered in addition to the calendar date.

Table 2.4-1
Focal Species and Habitats Rated

Common Name	Scientific Name	Important Season(s)	Life Requisite	Sensitive Time of Year	Specific Life Requisite	Preferred Habitat
Caribou	*Rangifer tarandus*	Early Spring, Calving, Post-calving, Migration	Living	Early Spring	Travelling, forage	lichen, esker, heath tundra
			Living and Reproducing	Calving	High forage, security, space	Heath tundra, lichen veneer, open, flat, rocky, high elevation, sedge wetland
			Living	Post-calving/Summer	Insect and heat relief, forage, predator avoidance	Riparian, sedge wetlands, ocean and lake shorelines, eskers
Muskox	*Ovibos moschatus*	Winter, Growing	Living	Late Winter	Forage	lowlands, windswept ridges
			Living and Reproducing	Early Spring	Forage, lack of human disturbance (calves)	river corridors, riparian drainages, floodplains, upland tussock
			Living	Summer/Rutting	High forage	wet meadows
Grizzly bear	*Ursus arctos horribilis*	Winter, Growing	Living and Reproducing	Denning	Denning, lack of human disturbance	eskers, tundra
			Living	Growing	Cub rearing, high forage	eskers (ground squirrels), wetland, tundra (berries)
Wolf	*Canis lupis*	Winter, Growing	Living	Winter	Following prey (in pack)	where the caribou are
			Living and Reproducing	Growing (denning)	Denning, security, local prey source	eskers, riparian
			Living	Growing (pup rearing)	Small, local prey source	eskers, riparian
Wolverine	*Gulo gulo*	Winter, Growing	Living	Late Winter (denning)	Denning, food source	rocky heath tundra, boulder fields, wolf kills, winter kills
			Living and Reproducing	Growing (denning, kit rearing)	Kit rearing habitat (security), small prey source	rocky heath tundra near eskers, riparian
			Living	Early Winter	Prey source	wolf kills
Migratory Birds	*Aves*	Nesting, Brood Rearing	Living and Reproducing	Living and Reproducing	Nesting	3 communities: birch seep/riparian; sedge wetland; heath tundra
			Living	Living	Fledging	4 communities: birch seep/riparian; sedge wetland; heath tundra
Peregrine Falcon	*Falco peregrinus*	Nesting, Brood Rearing	Living and Reproducing	Living and Reproducing	Nesting	Cliffs along water/lakes
			Living	Living	Fledging	Cliffs along water/lakes
Short-eared Owl	*Asio flammeus*	Nesting, Brood Rearing	Living and Reproducing	Living and Reproducing	Nesting	Ground/sedge near water with lots of songbirds
			Living	Living	Fledging	Ground/sedge near water with lots of songbirds
Waterfowl	*Clangula hyemalis*	Nesting, Brood Rearing	Living and Reproducing	Living and Reproducing	Nesting	Port (size of lake, less oligotrophic)
			Living	Living	Brood Rearing	Port (size of lake, less oligotrophic)
			Living	Living	Migration/Staging	Port (size of lake, less oligotrophic)

Chronological seasons refer to seasonal shifts that follow the calendar year. The B.C. RIC Standard (1999) assigns months of the year to a particular season based on the region in which the study is being conducted. Developing habitat ratings based on vegetation phenology and chronology allows for the identification of habitat with the greatest value during a period of time. This method also allows for the refinement of habitat maps such that they reflect changes in climate, annual weather variation (*e.g.*, mild versus severe winters) and/or influences of elevation, slope and aspect.

The relative ranking of map units was specific to each species and, where applicable, to each season. Although data from a variety of sources were used to rate habitat suitability for each species, the rankings were applied as consistently as possible. For VECs rated using the four-class scheme, ratings were as follows:

1. **High (H)**: map units that are preferred or represent critical habitat;
2. **Moderate (M)**: map units that are neither preferred nor selected against;
3. **Low (L)**: map units that are generally selected against; and
4. **Nil (N):** map units that are most selected against, are not used by the species, have no positive value, or for which no acceptable data exists to rate suitability.

For VECs rated using the two class scheme, the ratings were as follows:

1. **Suitable (U)**: map units that are preferred or represent usable habitat; and
2. **Not Suitable (X)**: map units that have no positive value for the VEC.

Migratory birds were not rated using the two class scheme, but were grouped using cluster analysis into associated and not-associated habitats.

2.5 Development of Habitat Suitability Ratings

Following the habitat rating standards used in BC (RIC, 1999), this section describes the procedures for applying the habitat rating criteria to the map units. Suitability ratings define the relative importance of various mapped ecological units to wildlife populations for the purpose of making land management decisions. In assigning a suitability rating to a particular habitat, that habitat was assessed for its potential to support a particular VEC for a specified season and life requisite. Once the vegetation units were mapped using a GIS , the habitat ratings layer based on Table 2.4-1 was added to the GIS.

3. CARIBOU

3. Caribou

3.1 Introduction

3.1.1 Overview

Barren-ground caribou are a keystone species in the Arctic, supporting grizzly bear, wolf and wolverine populations. Historically, caribou determined the survival of the Inuit people and they continue to be a central aspect of Inuit culture, identity, recreation and kinship (Appendix F-5 of the DEIS).

There are four caribou herds potentially affected by the development of the Project: Bathurst, Ahiak, Dolphin and Union and Peary herds. Currently, the proposed road and port site project area overlap the ranges of the Bathurst and Ahiak herds while the proposed shipping route crosses the migration routes of the Dolphin and Union and Peary caribou herds. Habitat requirements on the tundra for all barren-ground caribou are similar. As such, the Bathurst caribou herd, the most abundant herd in the Project area during the calving and post-calving/summer seasons, was the focus of habitat suitability ratings during those seasons. During the winter season, the Ahiak caribou herd is the only abundant herd in the Project area. Therefore, the Ahiak caribou were the focus of habitat suitability ratings in winter.

Bathurst caribou use the Project area during spring migration, calving, summer, and fall migration. During spring migration, Bathurst caribou migrate north from wintering grounds in the Taiga (southern NWT) to their calving grounds on the northern tundra (near Bathurst Inlet). They tend to follow frozen lakes and rivers, open snow-free uplands and eskers, or long narrow hills of soil and rock dumped by glaciers. The calving ground is currently concentrated between the Hood and Burnside Rivers (Gunn and D'Hont, 2002). Cows return to the same area to calve every year. However, over the years, the calving ground has gradually shifted from the western side of Bathurst Inlet (in the 1950s) to the eastern side (1960s to mid-1980s) and in recent years back to the western side (Gunn *et al.*, 1997; Gartner Lee Limited, 2002; Gunn and D'Hont, 2002). Bathurst caribou leave the calving ground soon after calving and disperse across the Project area for the summer. After several months, they begin the fall migration south towards the Taiga.

3.1.2 Biology and Life Requisites

Habitat suitability for barren-ground caribou is based on their seasonal life requisites and habitat preferences (Table 3.1-1). Based on Traditional Knowledge, satellite imagery of Bathurst caribou, and a literature review, the critical seasons for caribou within the study area were identified as calving and post-calving/summer.

Bathurst caribou migrate through the BIPR study area in April and May on their way north to their calving grounds (Griffith *et al.*, 2001; Johnson *et al.*, 2005). Pregnant females lead the way and have often left the calving grounds before the rest of the herd arrives (CWS, 2005b). Caribou calves are born in early summer and are dependent on milk until they are about three weeks old (CWS, 2005b). Cows spend two weeks on the calving grounds and then move to high

forage areas with their calves for the post-calving and summer seasons. By the end of the summer, herds begin the slow migration back to their winter range (Johnson *et al.*, 2005).

Table 3.1-1
Seasonal Life Requisites of Bathurst Caribou

Season	Date	Life Requisite	Habitat Preference
Spring Migration	April 15 – June 4[1]	Living	Since caribou are migrating to their calving grounds, it is difficult to select areas of habitat preference. They travel along eskers and frozen waterways, foraging on lichen in early spring before new green vegetation is available.
Calving	June 5 – June 15[2]	Living and Reproducing	Caribou calve on open, flat tundra with bare ground to allow feeding on cotton-grass flower buds and green sedge leaves. Lichen is eaten before vascular plant green-up.
Post-calving/ Summer	June 16 –August 31[3]	Living	Caribou use eskers for insect and heat relief, lakes for predator avoidance, insect and heat relief, eat green plants from riparian and sedge communities. Cows require high quality forage to replenish fat reserves.
Fall Migration	September 1 – October 31[4]	Living	Since caribou are migrating, we are unable to select areas of habitat preference. They travel along eskers and forage on shrubs, grasses, mushrooms and lichens (NWT). Cows must gain enough weight to breed and build up fat reserves for the winter.
Winter	November 1 – April 14[5]	Living	Caribou forage primarily on lichens.

1: Spring migration start date used for Bathurst herd in Johnson *et al.* (2005); Gunn *et al.* (2002) use April 16 as spring migration start date for analyses on satellite-collared cows from Bathurst herd.
2: Peak of calving for the Bathurst herd based on Russell *et al. (2002)*.
3: Five weeks post-calving, based on the conservative definition in Russell *et al.* (2002); summer end date used for Bathurst herd in Johnson *et al.(2005)*).
4: Fall migration period used for Bathurst herd in Johnson *et al. (2005)*.
5: All months not dedicated to previous categories; mapped for Ahiak caribou winter season.

3.1.3 Habitat Requirements

3.1.3.1 Overview

The seasonal distribution of caribou is largely dictated by their nutritional requirements and the distribution and availability of forage (Calef, 1981; Russel, 1998). Although caribou migrate through the BIPR study area in the spring and fall, it is difficult to map their preferred habitat during migration. Therefore, although all seasons will be discussed, habitat requirements were only mapped for suitability during the winter, calving and post-calving/summer seasons.

3.1.3.2 Migration

During spring migration, caribou tend to travel along frozen lakes and rivers, eskers and open snow-free uplands where movement is easier (Thorpe *et al.*, 2001). In the spring, caribou tend to forage on ridges and other high points of land where the snow is relatively shallow (BQCMB, 1999). They are also associated with lichen veneer, heath tundra and low shrub habitats that provide forage (Johnson *et al.*, 2005). Few data exist on habitat selection by Bathurst caribou during the fall migration; however, suitable fall forage is likely found within the same map units that are used in the spring (Cumberland, 2005). Bathurst caribou select heath tundra, lichen veneer and sedge wetland habitats for forage (Thorpe *et al.*, 2001).

3.1.3.3 Winter

Caribou are primarily grazers. In winter, they forage primarily on ground lichens which, though low in protein (necessary for maintaining rumen micro fauna), are high in both digestible carbohydrates and abundance (Cooperrider *et al.*, 1980). Caribou have an excellent sense of smell, which enables them to locate lichens under the snow, and wide hooves with which to dig out the snow (CWS, 2005b).

3.1.3.4 Calving Season

When the snow melts and fresh green vegetation becomes available, caribou are eager to switch to foraging on nitrogen-rich leaves of willows and other shrubs (Table 3.1-1). Pregnant and lactating cows are especially in need of protein to facilitate increased rumen function required for the physiological demands of milk production. The calving grounds of the Bathurst herd are located on flat or rolling terrain with abundant lichen and green vegetation (Plate 3.1-1), which fulfill the high energy requirements of lactating females (Griffith *et al.*, 2001; Thorpe *et al.*, 2001). Lichen dominates the diet of Bathurst caribou until relatively protein-rich green vegetation, including sedges, mosses, grasses, and shrubs, become available. The timing of snow melt and green-up determines the proportion of lichen and green vegetation consumed by caribou. The calving grounds are located where Lichen Heath and Riparian Shrub vegetation dominates. Wet graminoid vegetation types are also used (Griffith *et al.*, 2001). A habitat suitability study by Johnson *et al*. (2005) found that caribou have high preference for lichen veneer, heath tundra and low shrub habitat during the calving season. Griffith *et al*. (2001) suggest that caribou select calving grounds that provide a diversity of vegetation types that may provide variable benefits depending on the timing of green-up.

Plate 3.1-1. Caribou cow and current year calf.

3.1.3.5 Post-calving/Summer Season

Shortly after birthing, cows and calves leave the calving grounds in search of preferred habitat. During post-calving and summer, caribou require habitats that provide nutritious forage, salt and escape from heat, insects and predators. This is a time when calves are growing and, in the late summer, when animals are fattening-up for the winter. The post-calving and summer diets of caribou mainly consists of willows, grasses, sedges and other green vegetation, which are relatively high in protein (VanEgmond and Rowell, 1998; Griffith *et al.*, 2001; Thorpe *et al.*, 2001). Lichens may still be eaten in summer, but to a lesser extent than in winter (Bergerud, 1974.; Boertje, 1984; Barten *et al.*, 2001). Traditional Knowledge indicates that cottongrass is important forage for newly weaned calves (Thorpe *et al.*, 2001).

Post-calving areas have a high level of green plants available at the peak of nursing, which occurs at approximately June 21 (Griffith *et al.*, 2001). Heath tundra, the most abundant habitat type in the tundra, is also used by caribou (Thorpe *et al.*, 2001). Caribou select cool, moist areas where vegetation is abundant, primarily riparian shrub communities, sedge wetlands, or along ocean and lake shorelines (Griffith *et al.*, 2001; Thorpe *et al.*, 2001). Ocean shorelines along Bathurst Inlet provide a source of salt for caribou (Thorpe *et al.*, 2001).

Caribou select habitat that provides relief from insects and heat throughout the post-calving season. Insects are abundant on warm days with low wind speeds (Gunn *et al.*, 2002), especially for two weeks starting in late June or early July (Thorpe *et al.*, 2001). Insect harassment is particularly detrimental because it can interfere with foraging, increase energy expenditure, cause calf-cow separation and may cause over-heating when caribou run to avoid insects. Caribou select cool, windy or shaded areas to avoid insects and heat, including eskers, riparian communities, snowbanks and the shores of lakes, rivers and the ocean (Murphy and Curatolo, 1987; Russel *et al.*, 1993; Gunn *et al.*, 2002). Caribou are often seen swimming in lakes to escape the heat and insects (Thorpe *et al.*, 2001).

Bathurst caribou also require habitats that provide protection from predators. Caribou often gather along lake shorelines, especially at night, because they can enter the water to escape predators such as wolves (Thorpe *et al.*, 2001). Habitats with extensive shrub cover (*e.g.*, riparian tall shrub communities) may increase the vulnerability of caribou to predation because they conceal predators (Curatolo, 1975; Heard and Gray, 1989), however, caribou select these habitats for the relatively high quality of forage they provide (AXYS Environmental Consulting Ltd. and Penner and Associates Ltd., 1998).

During the summer, Bathurst caribou require habitats that provide nutritious forage and escape from heat and insects (Plate 3.1-2). The summer is a time when calves are growing and, in the late summer, when animals are fattening-up for the winter. The summer diet of Bathurst caribou mainly consists of willows, grasses, sedges and other green vegetation (Griffith *et al.*, 2001; Thorpe *et al.*, 2001). Caribou select cool, moist areas where vegetation is abundant, primarily riparian shrub communities, sedge wetlands, or along ocean and lake shorelines (Griffith *et al.*, 2001; Thorpe *et al.*, 2001; Boulanger *et al.*, 2004). Heath tundra, the most abundant habitat type in the tundra, is also selected by caribou (Thorpe *et al.*, 2001; Boulanger *et al.*, 2004; Johnson *et al.*, 2005).

Plate 3.1-2. Caribou feeding along a lakeshore in summer.

As summer progresses and the quality of green vegetation declines, caribou once again forage on lichens. The sedge, esker, birch and riparian shrub communities provide good forage for caribou in the growing season (Cumberland, 2005). Caribou may experience a trade-off between foraging value and predator avoidance at certain times of the year. For example, while heath tundra, heath boulder and tall shrub are ranked as high suitability for summer foraging in the central Canadian Arctic (AXYS Environmental Consulting Ltd. and Penner and Associates Ltd., 1998), caribou tend to avoid habitats such as boulder fields, birch seep and tall shrub communities that conceal predators (Cumberland, 2005). Late summer habitat is important for growth and restoration of fat reserves (AXYS Environmental Consulting Ltd. and Penner and Associates Ltd., 1998).

Other factors influencing distribution include avoidance of predators and (in summer) heat and parasitic insects (Curatolo, 1975; Heard and Gray, 1989; Russel, 1998). The fall diet of caribou is varied, consisting of grasses, woody plants, lichens and mushrooms (Miller, 1976; Russel, 1998).

3.2 Results and Discussion

Habitat requirements for all barren-ground caribou are similar. As such, the Bathurst caribou herd, the most abundant herd in the Project area during the calving and post-calving/summer seasons, was the focus of habitat suitability ratings during those seasons. However, during the winter season, the Ahiak caribou herd is the only herd that has been abundant in the Project area. Therefore, Ahiak caribou were the focus of winter habitat suitability ratings.

For caribou, habitat suitability was assessed for calving and post-calving/summer seasons. The life requisites assigned to calving were *Living* and *Reproducing*, while the only life requisite assigned to post-calving/summer habitat was *Living*.

The majority of the habitat occurring in the RSA and LSA in both seasons was moderate quality habitat (Table 3.2-1). There is a higher proportion of high quality habitat within the LSA compared to the RSA for calving (Figure 3.2-1) and post-calving/summer seasons (Figure 3.2-2). Conversely, there is a higher proportion of low quality habitat in the RSA compared to the LSA. The majority of the habitat occurring in both the RSA and the LSA in the winter season was high quality habitat (Table 3.2-1). There is a higher proportion of high quality habitat within the LSA compared to the RSA for the winter season (Figure 3.2-3).

Table 3.2-1
Area and Proportion of High, Moderate, Low and Nil-rated Habitat within the LSA and RSA for Caribou

Calving Season				
Suitability Rating	**Area in LSA (ha)**	**LSA (%)**	**Area in RSA (ha)**	**RSA (%)**
High	3,414	12.90	12,455	0.83
Moderate	21,151	79.98	1,120,953	73.94
Low	1,789	6.79	368,277	25.23
Nil	84	0.33	0	0
Post-Calving/Summer Season				
Suitability Rating	**Area in LSA (ha)**	**LSA (%)**	**Area in RSA (ha)**	**RSA (%)**
High	7,538	28.52	286,977	19.1
Moderate	17,294	65.46	738,316	49.2
Low	1,521	5.69	476,391	31.7
Nil	85	0.33	0	0
Winter Season				
Suitability Rating	**Area in LSA (ha)**	**LSA (%)**	**Area in RSA (ha)**	**RSA (%)**
High	17,876	67.9	746,662	49.7
Moderate	591	2.2	191,720	12.8
Low	7,971	30.2	563,303	37.5
Nil	0	0	0	0

525000 550000 575000 600000 625000 650000 675000

7450000 7425000 7400000 7375000 7350000 7325000 7300000 7275000 7250000 7225000 7200000

N

UTM Zone 12
UTM Zone 13

Kingaok
(Bathurst Inlet)

Bathurst
Inlet

Port

Mara River

Burnside River

Hackett River

Contwoyto
Lake Camp

Contwoyto
Lake

Nose Lake

Suitability Ratings

- High
- Moderate
- Low
- Nil

- Caribou Locations during Calving Season
- Road
- Shipping Lane
- Regional Study Area

Collar data source: Adrian d'Hont, GNWT, ENR, unpublished data (1996 - 2007)

1:750,000
0 10 20
Kilometres

Projection: UTM12, NAD83

FIGURE 3.2-1

Suitable Habitat for Bathurst Caribou during the Calving Season

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Suitable Habitat for Bathurst Caribou during the Post-Calving / Summer Season

FIGURE 3.2-2

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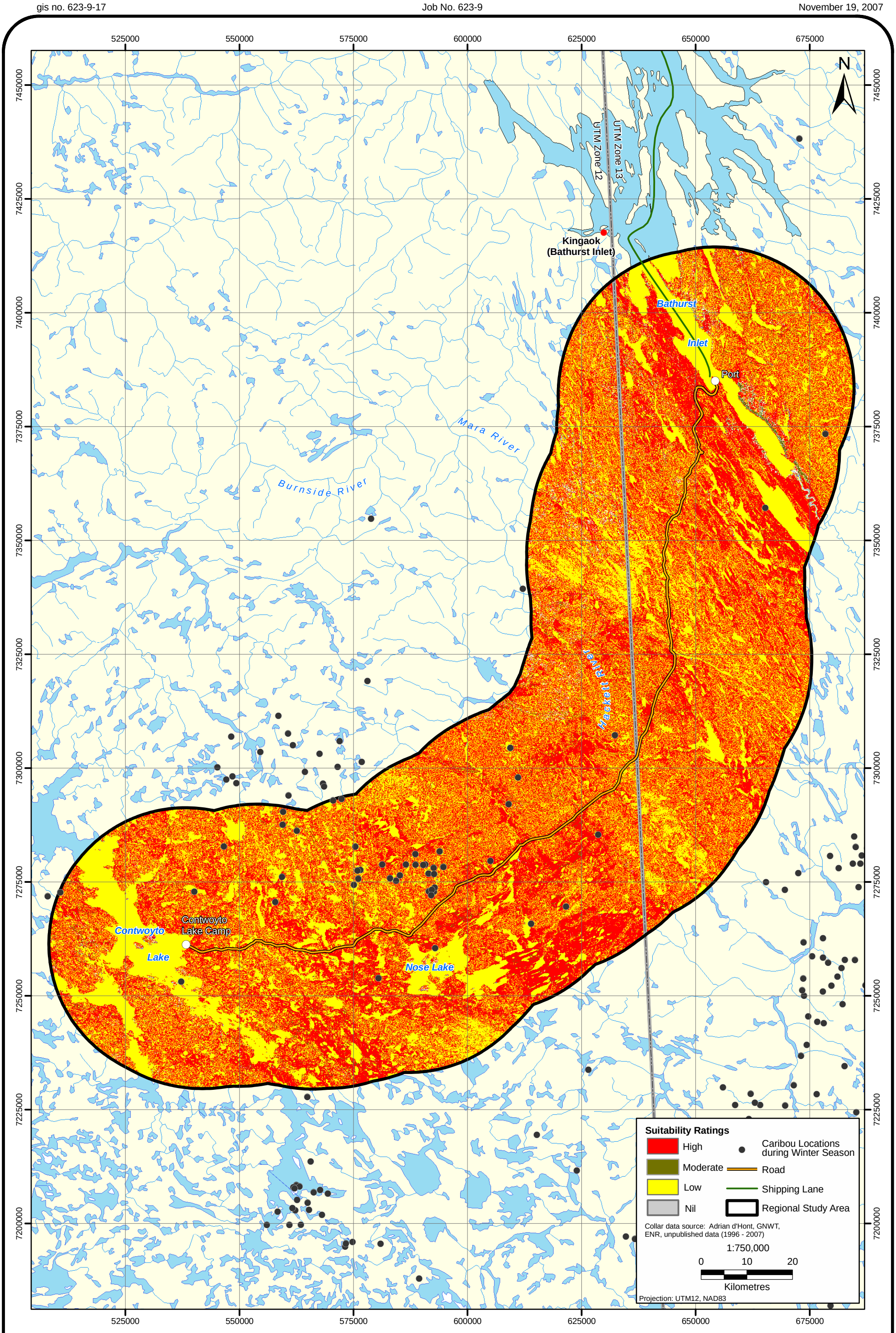

FIGURE 3.2-3

Suitable Habitat for Ahiak Caribou during Winter Season

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4. MUSKOX

4. Muskox

4.1 Introduction

4.1.1 Overview

Muskox (*Ovibos moschatus*) are included in habitat suitability ratings as they are important for harvest by Inuit in the area. While similar in many respects, suitable habitat for muskox may differ from that of caribou in certain seasons. Muskox do not migrate to the same extent as caribou and tend to concentrate habitat use in areas of willow growth in river valleys. Muskox are not as reliant on lichen as caribou, but require more abundant herbaceous and shrub vegetation for sustenance.

Muskox are listed as secure in Nunavut (CESCC, 2005) and are not listed nationally (COSEWIC, 2002); however, the species is sensitive to disturbance and over-harvest and has only recently begun to re-establish populations in parts of Nunavut (Campbell and Setterington, 2001). They are distributed throughout most of the Kitikmeot region of Nunavut and the BIPR Wildlife Baseline Studies (Appendix D-7 of the DEIS) confirm that muskox are present along the proposed road throughout the year. Muskox were observed throughout the RSA, though observations were concentrated along the upper third of the road (closest to Bathurst Inlet) and the lower third of the road (closest to Contwoyto Lake) (Appendix D-7 of the DEIS).

4.1.2 Biology and Life Requisites

Habitat suitability for muskox is based on their seasonal life requisites and habitat preferences (Table 4.1-1). Based on Traditional Knowledge, observations of muskox and a literature review, critical seasons for muskox survival within the BIPR study area were identified as late "winter/calving" and "rutting/autumn."

Table 4.1-1
Seasonal Life Requisites of Muskox

Season	Date	Life Requisite	Habitat Preference
Late Winter/Calving	April – June	Living and Reproducing	Sedge, esker, riparian shrub, heath tundra
Summer	June – July	Living	Sedge, birch seep, riparian shrub, heath tundra, fringes of waterbodies; moist habitats and wetlands
Rutting/ Autumn	August – September	Living	Wetlands, riparian communities, valleys/lowlands
Winter	October – April	Living	Sedge, esker, birch seep, riparian shrub

In late winter/calving, fat reserves may be low or depleted and any combination of old age, worn teeth, heavy parasite infestation, or poor range and weather conditions, such as impenetrable crusts of snow and unusually fierce storms, may result in death by starvation (CWS, 1990). In addition, calving occurs between April and June and pregnant or lactating cows need high quality forage to replenish fat stores (Gunn and Sutherland, 1997).

The breeding season, or rut, begins in late summer. Bulls challenge other males and engage in elaborate fights or clashes to determine dominance and possession of a herd. They also need to fatten up for the coming winter, so high quality forage is important.

4.1.3 Habitat Requirements

4.1.3.1 Overview

Muskox have relatively small home ranges (average home range size = 70 km^2); (Reynolds, 1998) since they move relatively short distances between calving, rutting and wintering areas. Locations used during these life history stages vary from year to year and are dependent on the availability of forage due to snow conditions in the early spring and forage quality and abundance as the season progresses.

Although all seasons will be discussed, habitat requirements were only mapped for suitability during the winter, late winter/calving and rutting/autumn seasons.

4.1.3.2 Winter

During the winter, snow limits the availability of forage for muskox (Jingfors, 1980). Their keen sight in combination with acute smell is beneficial during the long winter darkness for finding food when snow may cover the ground for 9 to 10 months. Winter forage for muskox includes grasses, sedges and woody plants (Gunn and Sutherland, 1997; Nellemann and Reynolds, 1997). In the winter, muskox are known to move to higher windswept terrain and areas with shallow snow accumulation (*e.g.*, hilltops, slopes or plateaus) where forage is more accessible (Banfield, 1974; Nellemann and Reynolds, 1997).

In the high Arctic, the sun does not appear above the horizon between November and February. The arctic winter is extremely long; temperatures are below -18°C for up to eight months and muskox partake in their daily activities in large mixed herds. Despite the cold, wind, and dark, muskox disrupt their normal feeding and resting patterns only during severe storms, which they endure lying down, backs to the wind.

4.1.3.3 Late Winter/Calving

In late winter and early spring, fat reserves may be low or depleted. In north-eastern Alaska, muskox showed a preference for rugged terrain in the late winter as less snow made access to forage easier (Nellemann and Reynolds, 1997). On Victoria Island in the high Arctic, muskox pellet sign was most strongly associated with lowland vegetation in the winter (Schaeffer *et al.*, 1996). Muskox winter habitat use in the Project area is likely intermediate between that observed in Alaska and that observed in the high Arctic. In addition, calving occurs between April and June and pregnant or lactating cows need high quality forage to replenish fat stores (Reynolds *et al.*, 2002). Around calving time, large winter herds break up into smaller loosely organized herds of about seven animals. Pregnant cows remain with the herd and cow-calf pairs can move with the herd within hours of birth. Young calves are able to feed on vegetation, though they suckle occasionally throughout their first year (CWS, 1990).

4.1.3.4 Summer

Early in the summer, muskox are known to feed on sedges as they are greening up (Gunn, 1984). As the summer progresses, the main forage of muskox includes graminoids such as sedges and grasses, willows and forbs which grow quickly, producing rich forage (Gunn and Sutherland, 1997; Nellemann and Reynolds, 1997; Gunn and Adamczewski, 2003). Muskox use wetland and tundra habitats in the summer (Gunn and Sutherland, 1997). Gunn and Sutherland (1997) also found that single bulls and immature males used the immediate vicinity of waterbodies more often than any other age or sex class. Small waterbodies are relatively common in the Project area. The fringes of these waterbodies may support muskox forage such as sedges.

Throughout the summer, herds alternate periods of feeding and periods of resting. During a resting period, muskox lie down to ruminate (chew their cud, or partly digested food) or sprawl on their sides with their legs extended, often on remaining snowbanks within the heath tundra community (Plate 4.1-1).

Plate 4.1-1. Small herd of muskox foraging and resting in summer.

4.1.3.5 Rutting/Autumn

The summer and early fall seasons are critical for muskox, as they must accumulate sufficient fat reserves to survive the winter during this time (Reynolds *et al.*, 2002). Furthermore, there is evidence that the likelihood of pregnancy and successful parturition is positively related to the fat reserves a female is able to accumulate during the summer and early fall (White *et al.*, 1989; Adamczewsk *et al.*, 1998). Habitat use in these seasons is presumed to be similar to that of other seasons; that is, wetter habitat types that support abundant sedges and grasses are preferred (Plate 4.1-2). On the mainland, muskox feed extensively on the shrubby willows that follow the river

courses. These riparian areas also provide protection from mosquitoes and biting flies (Gunn and Sutherland, 1997).

Plate 4.1-2. Early autumn forage on the tundra.

By September, snow may cover the ground and muskox must dig craters through the snow to find willows, grasses and sedges that form the majority of their diet. In most areas on the tundra, snow cover is relatively shallow and does not usually impede feeding and movement. Muskox often feed in valleys or lowlands where the snow is less than 20 cm deep. The wind shifts the snow constantly until the crust hardens and muskox must break through it by lifting and dropping their head onto the crust. The animal pushes the broken chunks of hardened snow away by pawing and exposes the vegetation below. Dominant muskox often displace individuals of lower rank from these feeding craters.

4.2 Results and Discussion

Habitat selection by muskox is dependent on the availability of forage due to snow conditions in the early spring, as well as forage quality and abundance as the season progresses (Gunn and Adamczewski, 2003).

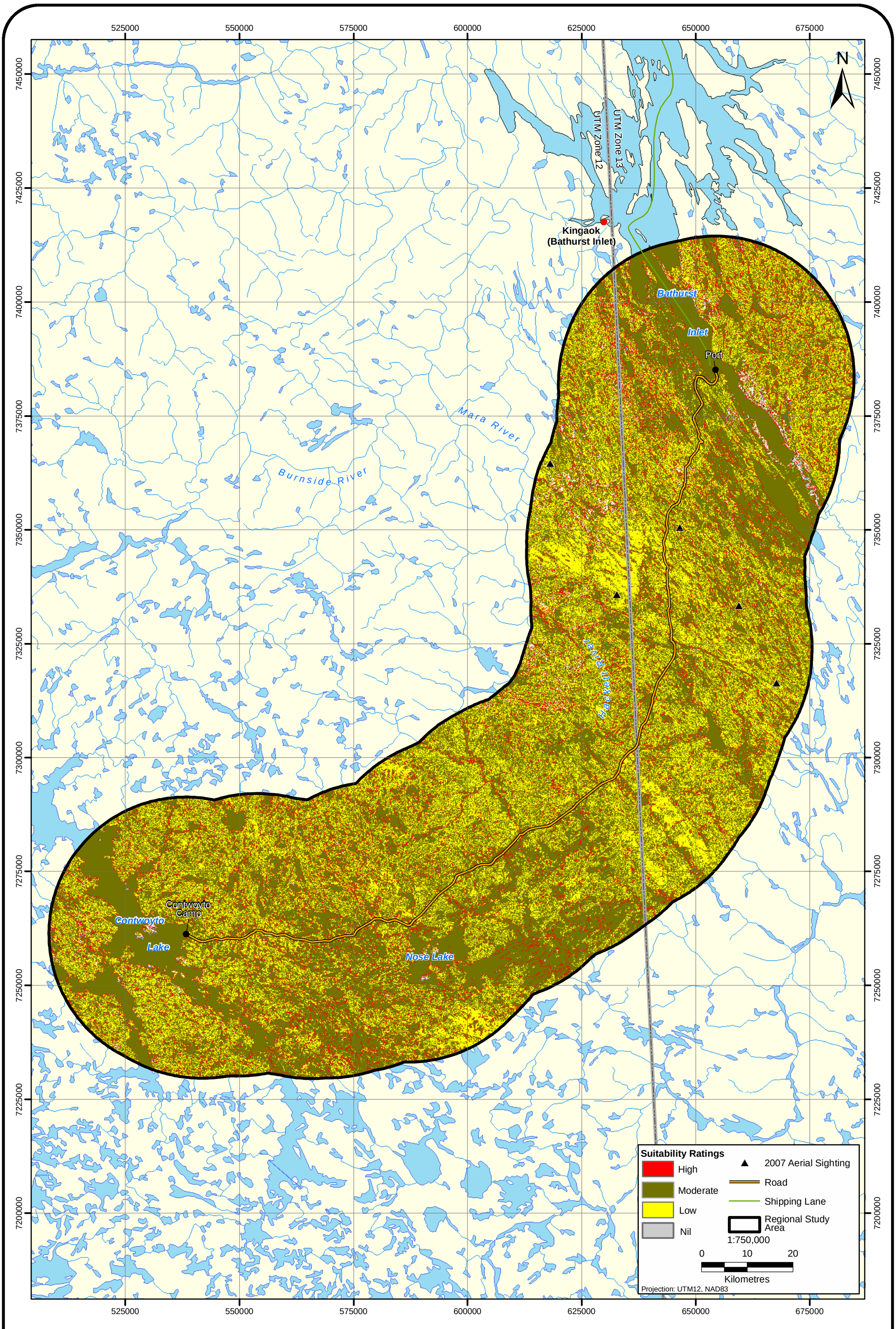
During the summer season, muskox primarily forage on sedges and willows (Gunn and Sutherland, 1997). Forbs are also consumed by muskox, but to a lesser extent than other vegetation. Muskox use heath tundra and moist areas where this vegetation is abundant, including sedge wetlands, birch seep and riparian shrub areas (Gunn and Sutherland, 1997). For

muskox, habitat suitability was assessed for late winter/calving and rutting/autumn seasons. The life requisites assigned to late winter/early spring were *Living* and *Reproducing*, while the only life requisite assigned to rutting/autumn habitat was *Living*.

The majority of the habitat in the RSA and LSA during both seasons was moderate quality habitat (Table 4.2-1). There is a higher proportion of high quality habitat within the LSA compared to the RSA for both late winter/calving (Figure 4.2-1) and rutting/autumn seasons (Figure 4.2-2). Conversely, there is a higher proportion of low quality habitat in the RSA compared to the LSA for the same seasons. Therefore, the LSA contains proportionally better habitat than the RSA.

Table 4.2-1
Area and Proportion of High, Moderate, Low and Nil-rated Habitat within the LSA and RSA for Muskox

Suitability Rating	Area in LSA (ha)	Percent of LSA	Area in RSA (ha)	Percent of RSA
Late Winter/Early Spring				
High	5,647	21.40	58,996	4.00
Moderate	19,719	74.57	1,250,519	83.00
Low	987	3.70	191,720	13.00
Nil	85	0.33	450	0.03
Rutting/Autumn				
High	22,062	83.50	794,948	52.37
Moderate	3,014	11.37	340,788	22.6
Low	1,277	4.80	365,499	25.00
Nil	85	0.33	450	0.03



the Bathurst Inlet Port and Road Project

Suitable Habitat for Muskox during the Late Winter / Calving Season, 1 April to 15 June

FIGURE 4.2-1

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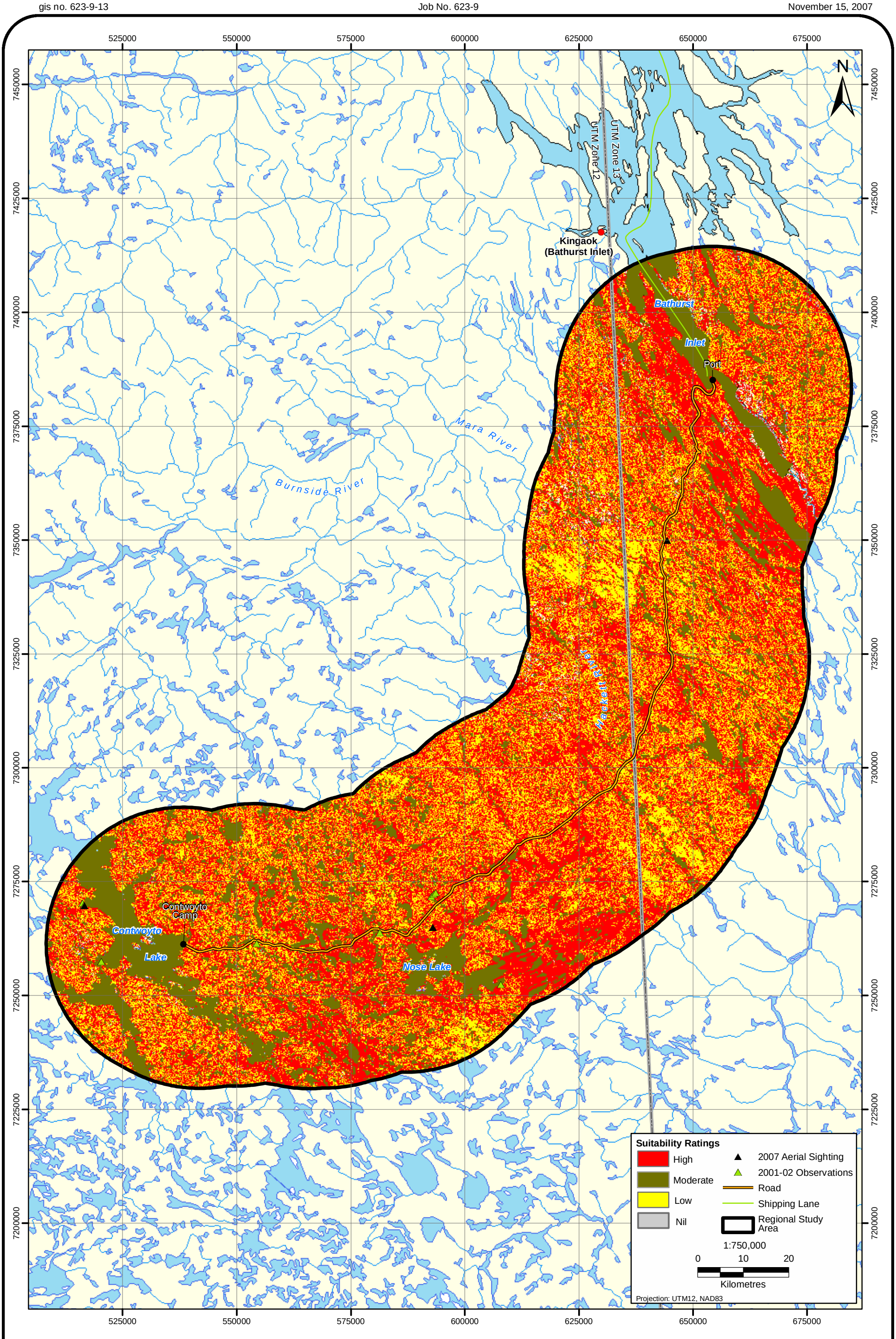
gis no. 623-9-13 | Job No. 623-9 | November 15, 2007



the Bathurst Inlet Port and Road Project

Suitable Habitat for Muskox during the Rutting / Autumn Season, 15 August to 15 September

FIGURE 4.2-2

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5. GRIZZLY BEAR

5. Grizzly Bear

5.1 Introduction

5.1.1 Overview

Grizzly bears occur throughout the RSA and are known to frequent the vicinity of the proposed road route (Appendix D-7 of the DEIS). Nationally, they are a species of Special Concern (a species that is particularly sensitive to human activities or natural events but is not an endangered or threatened species; COSEWIC, (2002a)). In Nunavut, they have been designated Sensitive (a species that is not at risk of extinction or extirpation but may require special attention or protection to prevent them from becoming at risk; (NWT RWED, 2000; CESCC, 2005). Grizzly bears have low ecological resiliency, are sensitive to human activity, and are frequently displaced by industrial developments (McLellan, 1990; Weaver *et al.*, 1996; Ross, 2002). Bears living in the central Canadian Arctic may be at relatively elevated risk because they naturally occur at low density and because they may be more vulnerable to disturbance on the open tundra landscape (Ross, 2002).

5.1.2 Biology and Life Requisites

Habitat suitability for the grizzly bear is based on their seasonal life requisites and habitat preferences (Table 5.1-1). Based on Inuit Traditional Knowledge, satellite collar data and a literature review, the critical seasons for grizzly bear survival within the study area were identified as spring, summer, autumn and winter torpor.

The population of grizzly bears in the central Arctic is estimated to be at least 800 bears within a 235,000 km^2 area (McLoughlin *et al.*, 2003a). The average reported harvest for this population was 13.4 bears per year from 1958 to 2000. Currently, the population appears to be stable and according to Traditional Knowledge, there has been an increase in the population and distribution of grizzly bears within the region (Appendix F-5 of the DEIS). However, any increase in mortality may place the population at risk (McLoughlin *et al.*, 2003a). Barren-ground grizzly bears have very large spatial requirements (McLouglin *et al.*, 1999) (McLoughlin *et al.*, 2000), which may expose them to a variety of anthropogenic disturbances even when developments are a considerable distance from the core of their home range (McLoughlin *et al.*, 2002). Inuit have recently reported grizzly bear sightings on Victoria Island, south of Cambridge Bay, as evidence of environmental change, particularly in the last few decades (Thorpe *et al.*, 2001).

Grizzly bears in the central Arctic have the largest annual home ranges and likely the lowest densities of any grizzly bears in North America (McLouglin *et al.*, 1999; McLoughlin *et al.*, 2000). For example, the average home range of adult male bears was estimated at 7,245 km^2, while home range was 1,955 km^2 for sows without young, and 2,239 km^2 for sows with young (McLoughlin *et al.*, 2002). It is hypothesized that their home ranges are large in the tundra to meet their nutritional and energetic requirements in an environment that is relatively less productive compared to coastal and alpine areas (McLouglin *et al.*, 1999). Bears mate in June and July and cubs are born in the den between mid-January and mid-March. Typically, two cubs are born and they stay with their mother for two to three years. A significant limiting factor for

grizzly bear populations is that females often do not bear their first cubs until the age of six to nine years, provided they are in good body condition (McLoughlin *et al.*, 2003b). Therefore, female survival rates are also a major limiting factor. Increased contact with humans usually leads to an increase in problem bears and potential mortality and the barren ground population is considered to be most susceptible to direct mortality as a result of human activity (McLoughlin *et al.*, 2003b). Currently, barren ground grizzly bear populations are considered stable or slightly increasing (McLoughlin *et al.*, 2003b).

Table 5.1-1
Seasonal Life Requisites of Grizzly Bear

Season	Date[1]	Life Requisite	Habitat Preference
Spring	May 16 –June 20	Living	Esker, saxifrage blueberry, sedge, riparian shrub
Summer	June 21 – September 9	Living	Esker, saxifrage blueberry, sedge, riparian shrub
Autumn	September 10 –October 15	Living	Esker, saxifrage blueberry, sedge, riparian shrub
Winter (Denning)	October 16 – May 15	Living (cover only) and Reproduction	Denning Habitat: tundra, esker, heath boulder fields

[1] Dates used in habitat suitability ratings by Johnson *et al*. (2005). Dates reflect seasonal shift in diet.

5.1.3 Habitat Requirements

5.1.3.1 Overview

Grizzly bears are omnivorous and opportunistic in their feeding habits (McLellan *et al.*, 1999) and habitat selection is governed by season and forage availability to make use of the most digestible foods. Wellwood (2003) suggests that forage productivity is the main variable for rating grizzly bear habitat suitability in the growing season.

Grizzly bear habitat suitability for *Living* was based on an assessment of the capability of ecosystems to produce suitable forage species such as herbaceous plants and berries in the growing season (Spring, Summer and Fall). Wildlife habitat ratings based on the phenotype of vegetation forage (observable characteristics) were put into a chronological context (as per calendar year) for evaluation of available habitat. Differences in plant phenology associated with microclimate differences can also influence habitat use, in areas with diverse topography; bears may exploit these differences to optimise high protein vegetation stages associated with preferred forage, thus providing a longer window of opportunity to use them. Fuhr and Demarchi (1990) suggest there is a degree of selectivity and bears often prefer certain high energy food items when available and will often track phenologies of various plant species.

5.1.3.2 Spring

Both scientific observation and Traditional Knowledge indicate that male grizzly bears are the first to emerge from their dens in early spring with females following shortly thereafter. Spring habitat is important for grizzly bears because it provides the first forage for them following winter torpor. Habitat ratings for grizzly bears were based on an assessment of the capability of ecosystems to produce suitable forage species such as herbaceous plants and berries in the growing season. In the spring, grizzly bears show a preference for esker habitat and exposed

bedrock (Plate 5.1-1). Over-wintered berries are most accessible in these habitats because they are the first to become snow-free in the spring (McLoughlin *et al.*, 2002; Johnson *et al.*, 2005).

Plate 5.1-1. Spring feeding habitat for grizzly bears in esker complex, showing crowberries and ground squirrel burrows.

In addition to plant forage, grizzly bears opportunistically prey on winter-weakened ungulates, carrion and carcasses and caribou calves (BC MOE MWALP, 2003) in the spring. Research by Gau *et al*. (2002) in the central Canadian Arctic indicated that caribou are a very important food item for barren-ground grizzly bears, particularly during spring and fall migration when caribou were plentiful in the study area. Arctic ground squirrels frequently occurred as a food item in all active seasons in the central Canadian Arctic (Gau *et al.*, 2002). Baseline surveys indicate that squirrels are present in the RSA and LSA, but their abundance is unknown. Animal protein, primarily Bathurst caribou migrating north to their calving grounds, makes up a significant portion of grizzly bear diet in the spring (Gau *et al.*, 2002).

5.1.3.3 Summer

The summer diet of barren-ground grizzly bears is highly variable. Early in the season, when caribou are scarce, grizzlies feed primarily on horsetails (*Equisetum* sp.), Arctic cottongrasses and sedges. Berries are fed on to some extent in the spring and then again later in the year (Gau *et al.*, 2002).

By mid-summer, caribou becomes the primary component of the grizzly bear diet as post-calving herds move southward. However, vegetation is still an important source of food. Grizzly bears also resume consumption of Arctic ground squirrels in mid-summer (Gau *et al.*, 2002).

In the late summer in the central Arctic, crowberry, bog blueberry, cranberry and bearberry were eaten more commonly than at any other time of the year (Gau *et al.*, 2002). Berry-producing habitats, represented by the Heath Tundra community, are relatively common in the study areas, particularly within the LSA (Plate 5.1-2).

Plate 5.1-2. Late summer crowberry forage for grizzly bears.

5.1.3.4 Autumn

Fall is a critical season for grizzly bears because individuals must gain weight rapidly in order to survive the winter. Barren ground grizzly bears spend about 7.5 months in winter torpor (not true hibernation). This lengthy period of winter lethargy, within which they are essentially inactive, restricts their active season to 4.5 months. Within the 4.5 months that grizzly bears are active, they must find enough food to store energy reserves to make it through winter. Additionally, there are energy costs associated with reproduction, foraging movements, and exposure to weather.

Important grizzly bear habitat in the fall includes riparian tall shrub, lichen veneers and heath tundra. These habitats provide grizzly bears with a relatively abundant source of caribou; their habitat selection is strongly influenced by the occurrence of caribou during this period (Johnson

et al., 2005). However, females with cubs significantly avoid riparian tall shrub habitat and select bedrock habitats, which are avoided by males. Females without young continue to prefer eskers in the fall season (McLoughlin *et al.*, 2002). A habitat modelling study by Johnson *et al*. (Johnson *et al.*, 2005) shows that habitat selection by grizzly bears is strongly influenced by the presence of esker, heath rock, low shrub and peat bog vegetation types.

5.1.3.5 Winter

Although eskers are often cited as the dominate habitat used for denning (Mueller, 1995), research in the central Canadian Arctic suggests that, while they are used, they are not the most common denning habitat (McLoughlin *et al.*, 2002). Most dens (60%) were found in heath tundra and heath-boulder habitats, with most of the remaining dens in riparian tall shrub and birch seep habitats. Although eskers accounted for only seven of 56 den sites studied, this habitat type was selected more than expected by chance, given its low availability in the central Arctic.

5.2 Results and Discussion

5.2.1 Habitat Selection

Habitat selection by barren-ground grizzly bears mainly reflects the availability and abundance of a wide variety of food items (McLoughlin *et al.*, 2002). Habitat selection within the home ranges of grizzly bears varies by season, sex and reproductive status (McLoughlin *et al.*, 2002).

Habitat suitability for grizzlies was assessed for each season throughout the entire year and forage productivity was the main variable used for rating habitats during the spring, summer and autumn seasons. Therefore, the *Living* requirements for grizzly bear during those seasons are satisfied by food availability. However, for rating habitat during the winter season, both the *Living* and *Reproducing* requirements of grizzly bears are satisfied by suitable cover or denning habitat.

The majority of the habitat in the RSA and LSA during spring green-up and summer was moderate quality (Table 5.2-1, Figures 5.2-1 and 5.2-2). However, during the autumn (Figure 5.2-3) and winter seasons (Figure 5.2-4), the highest quality habitat was also the most abundant in both the RSA and the LSA. In all seasons, there was a greater proportion of high quality habitat within the LSA compared to the RSA. Conversely, there is a higher proportion of low/nil quality habitat in the RSA than in the LSA, though this difference is minimal during the winter season.

McLoughlin *et al.* (2002) predicted that habitat selection patterns of grizzly bears would reflect food availability and abundance, and their results supported this prediction. For example, two highly-important grizzly bear food sources are prevalent on eskers: berry-producing shrubs and ground squirrels (Gau *et al.*, 2002). Eskers are heavily used by bears during spring and fall when overwintered and fresh berries are available, and during summer when ground squirrels are active. Riparian zones dominated by tall shrubs contain bear foods including horsetails, sedges, willow buds and caribou and are generally preferred by bears in most seasons. However, some bear habitat selection patterns may be influenced by factors other than food availability. Female bears with cubs demonstrated different use of habitat than males or lone females. McLoughlin *et al.* (2002) suggested that this habitat selection pattern illustrates avoidance of potentially predatory or aggressive male bears by mothers with cubs.

Table 5.2-1
Area and Proportion of High, Moderate, Low and Nil-rated Habitat within the LSA and RSA for Grizzly Bears

Suitability Rating	Area in LSA (ha)	Percent of LSA	Area in RSA (ha)	Percent of RSA
Spring				
High	1,010	3.86	8,346	0.6
Moderate	21,286	80.5	1,126,935	74.34
Low	3,371	12.71	365,954	25.03
Nil	771	2.93	450	0.03
Summer				
High	5,467	20.7	58,960	3.63
Moderate	17,123	64.86	738,316	48.94
Low	1,735	6.5	506,221	34
Nil	2,113	7.94	198,188	13.43
Autumn				
High	18,297	69.3	752,644	49.94
Moderate	4,706	17.8	50,650	3.03
Low	1,804	6.76	506,221	34
Nil	1,631	6.14	192,170	13.03
Winter				
High	17,275	65.4	740,644	49.14
Moderate	784	2.9	197,738	13.4
Low	5,210	19.72	57,082	3.46
Nil	3,169	11.97	506,221	34

Grizzly bears are opportunistically omnivorous (Schwartz *et al.*, 2003) and habitat selection generally reflects the availability and abundance of a wide array of food items (McLoughlin *et al.*, 2002). Caribou are essential food sources for barren-ground grizzly bears during the spring, mid-summer and fall (Gau *et al.*, 2002). Eskers, riparian tall shrub habitat and lichen veneer habitat may be favoured partly to gain greater access to caribou during these times (McLoughlin *et al.*, 2002). Eskers, in particular, are frequented by bears during spring and fall when overwintered and fresh berries are available and during summer when ground squirrels are active (Gau *et al.*, 2002). Fall berries obtained at eskers are essential for fat deposition prior to denning. Riparian tall shrub habitat is preferred by bears in most seasons due to the prevalence of horsetail, sedge, willow buds and Arctic cottongrass (McLoughlin *et al.*, 2002); these are the most prevalent food items in the early-summer diet when caribou are scarce (Gau *et al.*, 2002). Grizzly bears also prefer tussock/hummock tundra habitats (McLoughlin *et al.*, 2002). However, bear habitat selection patterns may be influenced by factors other than food availability. For example, female bears with cubs demonstrate different habitat use than do males or lone females, potentially to avoid predatory male bears (McLoughlin *et al.*, 2002).

525000 550000 575000 600000 625000 650000 675000

7450000 7425000 7400000 7375000 7350000 7325000 7300000 7275000 7250000 7225000 7200000

N

UTM Zone 12
UTM Zone 13

Kingaok
(Bathurst Inlet)

Bathurst
Inlet
Port

Mara River
Burnside River
Hackett River

Contwoyto
Camp
Contwoyto
Lake
Nose Lake

Suitability Ratings
- High
- Moderate
- Low
- Nil

Grizzly Bear Spring Satellite Collar Location
Road
Shipping Lane
Regional Study Area

Source collar data: R. Mulders, GNWT, ENR (1995 - 1997)
1:750,000
0 10 20
Kilometres
Projection: UTM12, NAD83

FIGURE 5.2-1

Suitable Habitat for Grizzly Bear during the Spring Season

the Bathurst Inlet Port and Road Project

Rescan™

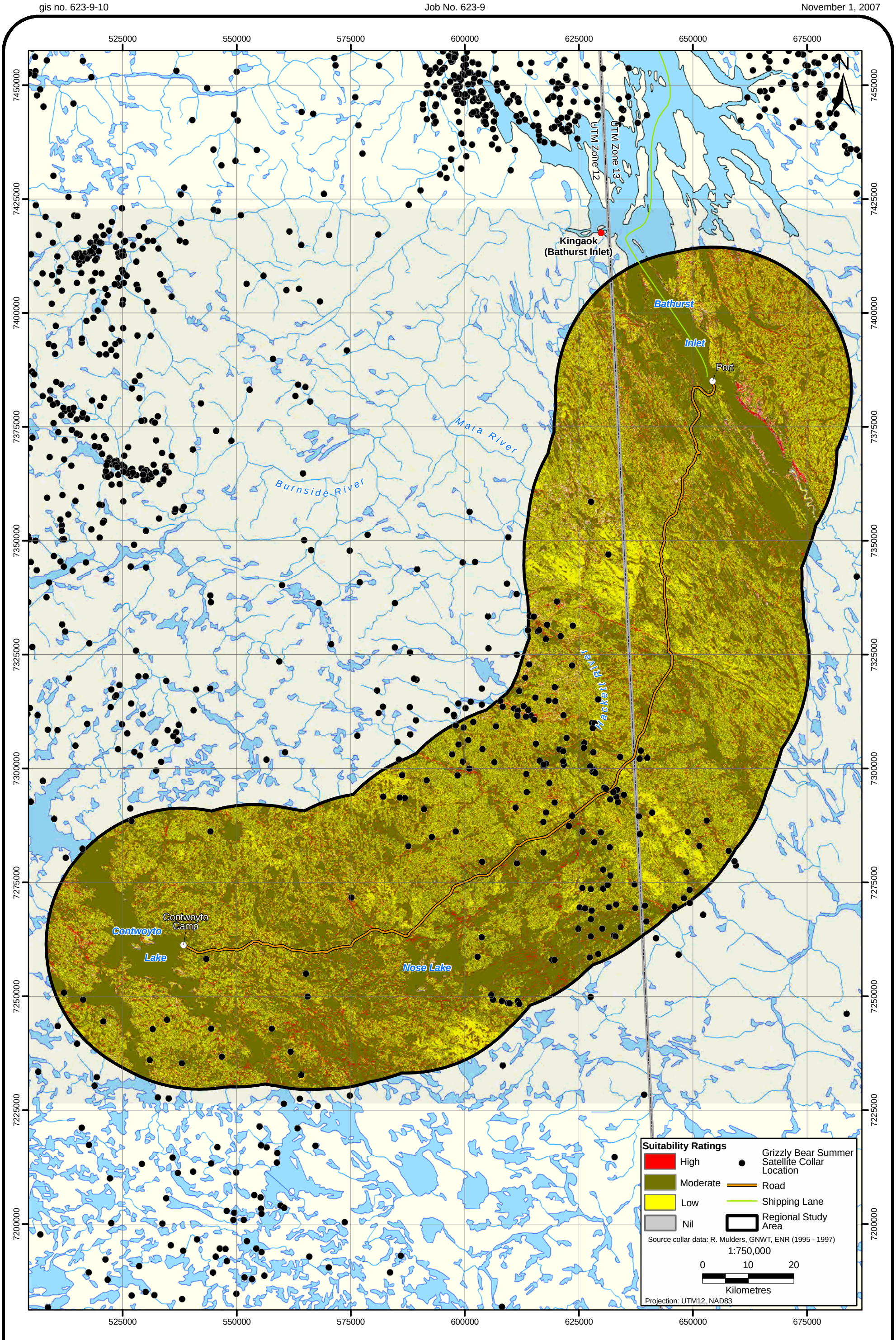

FIGURE 5.2-2

Suitable Habitat for Grizzly Bear during the Summer Season

the Bathurst Inlet Port and Road Project

Rescan™

gis no. 623-9-11 | Job No. 623-9 | October 26, 2007

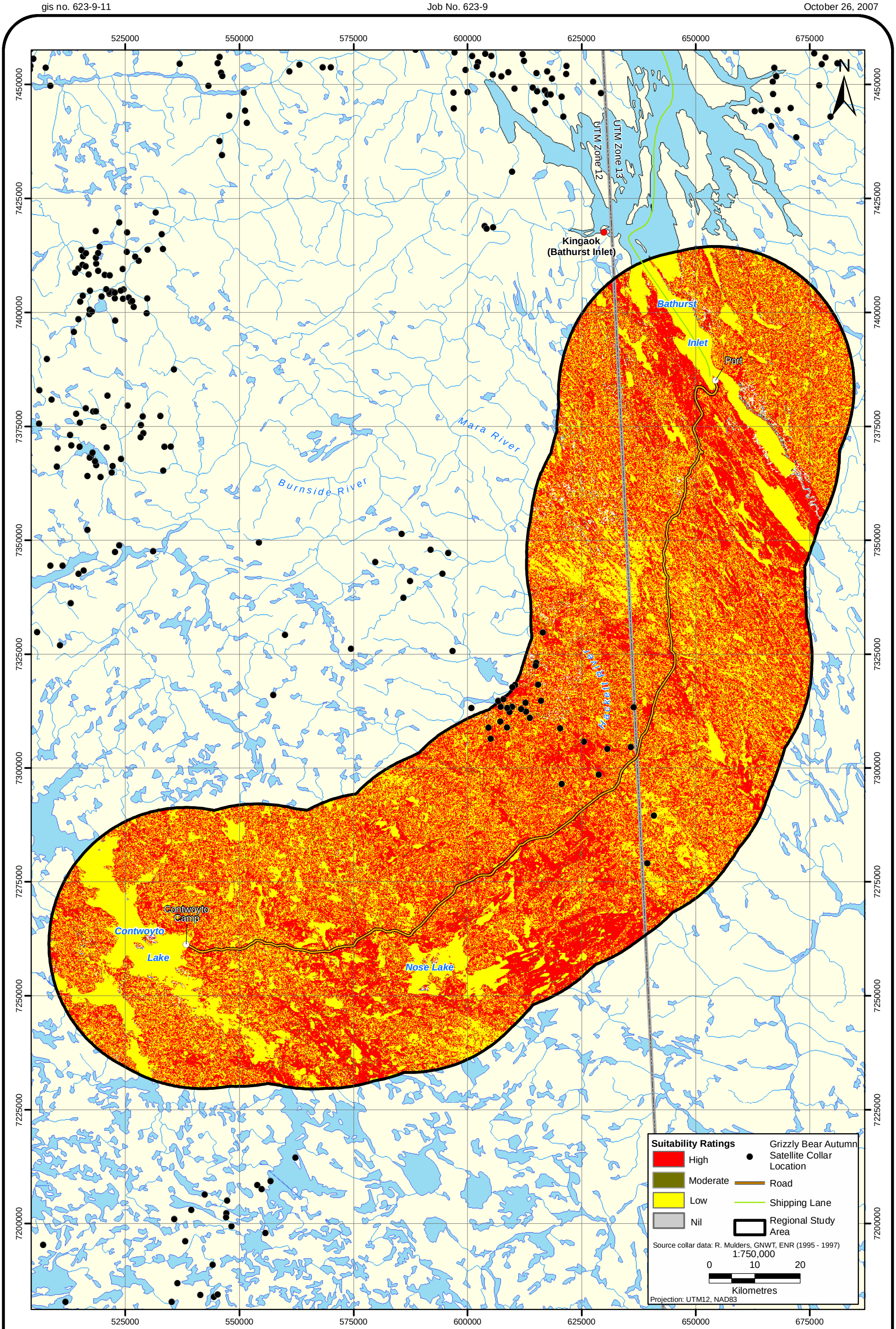

FIGURE 5.2-3

Suitable Habitat for Grizzly Bear during the Autumn Season

the Bathurst Inlet Port and Road Project

Rescan™

gis no. 623-9-14 | Job No. 623-9 | October 26, 2007

FIGURE 5.2-4

the Bathurst Inlet Port and Road Project

Suitable Habitat for Grizzly Bear during the Winter Season

Rescan™

All bears moved greater distances in spring and early summer, with decreasing travel distances in autumn. The movement patterns and large home range sizes allow the bears to access certain key habitats, especially eskers, tall shrub riparian and birch seep. Choice of habitat is thought to be guided by availability of different foods, for example:

- eskers and exposed bedrock in early spring as these are the first areas to become snow free, providing access to the previous year's berry crop; and
- tall shrub riparian habitat for willow buds, sedges and horsetails.

5.2.1.1 Winter/Denning

The WKSS funded research on grizzly bear denning ecology in the general region of the Project area (McLoughlin *et al.*, 2002). During this research, 81 satellite-collared grizzly bears were followed to determine den site locations and timing of entrance into and emergence from dens. The locations permitted the researchers to visit each den site, once inactive, to record physical characteristics of the den site such as the presence of vegetation and soil characteristics.

McLoughlin *et al.* (2002) visited 56 grizzly bear den sites. Most dens (60%) were found in heath tundra and heath-boulder habitats, with most of the remaining dens in riparian tall shrub and birch seep habitats. Eskers, which had previously been regarded as the major denning habitat for barren-ground Grizzly bears, accounted for only seven of 56 den sites studied. However, this habitat type was selected more than expected by chance, given the low availability of eskers in the central Arctic. Four other habitat types accounted for the remaining 15 dens. Most dens were on south facing slopes, constructed under cover of tall shrubs, and containing mats of crowberry vegetation for bedding.

Most bears denned in late October of each year and emerged in early May. Many dens were constructed under cover of tall shrubs and contained mats of crowberry vegetation for bedding. Grizzly bear den sites in the study most commonly faced south (25), followed by west (13), and east (10); only eight faced north (McLoughlin *et al.*, 2002). Others (*e.g.*, (Reynolds *et al.*, 1976; Banci and Moore, 1997)) who have studied denning in grizzly bears in the Arctic have also found a tendency for den sites to have a more southerly aspect. The benefit of a southern exposure may be insulation (*i.e.*, warmth) at emergence in the spring (and possibly at denning in the fall) or the accumulation of an insulating layer of snow that would result from the prevailing northerly winds.

Grizzly bears also select den sites based on the slope of the topographic feature that they wish to den in. McLoughlin *et al.* (2002) found that grizzly bears chose den sites on relatively steep slopes, averaging 25°. Pearson (1975) and Lentfer *et al.* (1972), working in the southwestern Yukon and on Kodiak Islands of Alaska also reported that den sites tended to be on steeper slopes. Steep slopes may permit the bears to construct horizontal or even upward-sloping tunnels, which would result in a warm air trap in the hibernation chamber (Harding, 1976).

Grizzly bear den sites are predominantly located in heath tundra and heath tundra/boulder habitats (McLoughlin *et al.*, 2002); however, although esker habitat supported fewer bear dens, it was selected more than expected by chance, given its low availability on the tundra. In general,

den sites have a southerly aspect which increases insulation through increased sun exposure, or through the accumulation of an insulating layer of snow that results from prevailing northerly winds (Banci and Moore, 1997; Reynolds, 1998; McLoughlin *et al.*, 2002). Furthermore, dens are located in relatively steep slopes which may permit bears to construct horizontal or even upward-sloping tunnels, which would result in a warm-air "trap" in the hibernation chamber (Harding, 1976). The substrates of den sites are well-drained, containing a large component of sand, as well as coarse material, including cobble- and boulder-sized stones (McLoughlin *et al.*, 2002). The structural integrity of den sites is maintained through root mats from dwarf birch and other shrubby vegetation located in the ceilings of dens (McLoughlin *et al.*, 2002). Few den sites were located along the proposed road alignment (Appendix F-5 of the DEIS), however, bears in general dig new dens each year, and given the high proportion of heath tundra and heath/boulder habitat in the area, it is likely that new dens will emerge.

The substrates of den sites are well-drained and contain a large amount of sand and coarse material, including cobble- and boulder-sized stones (McLoughlin *et al.*, 2002). The structural integrity of den sites is maintained through root mats from dwarf birch and other shrubby vegetation located in the ceilings of dens (McLoughlin *et al.*, 2002). The grizzly bear dens studied by McLoughlin *et al.* (2002) did not last long; by mid-summer, about 80% (44/56) had partially or completely collapsed, which is why grizzly bears must usually dig new dens each year. In the south-western Yukon, Pearson (1975) reported that some dens may be used for several years.

6. WOLVES

6. Wolves

6.1 Introduction

6.1.1 Overview

The grey wolf, *Canis lupus*, was once the world's most widely distributed mammal. The largest member of the *Canis* genus, the grey wolf was once abundant over much of North America and Eurasia; however, their range has contracted due to habitat destruction and hunting. The wolf is still widespread throughout much of northern Canada, including the West Kitikmeot region of Nunavut. Wolves are still found in 90% of their original range in Canada, including the West Kitikmeot region of Nunavut. Except in northern Alberta and some parts of the NWT, populations are stable or increasing within their Canadian range, which is home to an estimated 60,000 individuals (Hayes and Gunson, 1995; Walton *et al.*, 2001).

The wolf is listed as secure in Nunavut (CESCC, 2005) and is not listed nationally (COSEWIC, 2002b). Their patterns of distribution, densities, territory boundaries and dispersal movements are influenced by interactions between packs, and by prey abundance and distribution (Fuller and Keith, 1980; Ballard and Dau, 1983). Densities in northern Canada have been recorded as low as one wolf per 944 km^2 (vanZylldeJong and Carbyn, 1998). The annual ranges of Arctic wolves are much larger than those of wolves that rely on resident rather than migratory (*i.e.*, barren-ground caribou) prey (Walton *et al.*, 2001). A study in the central Canadian Arctic estimated annual range sizes of approximately 63,000 km^2 for males and 45,000 km^2 for females (Walton *et al.*, 2001). The same study also indicated that winter ranges are much larger than summer ranges and show a clear seasonal separation from denning and pup rearing areas in the summer.

In Nunavut and parts of the NWT, wolf populations are stable or increasing (Hayes and Gunson, 1995). Population estimates have not recently been attempted. Wolves have been identified in the BIPR Project area during baseline studies in 2001-2002 and 2007. Observations of over 100 wolves have been made during surveys in the region and numerous den sites have been located.

6.1.2 Biology and Life Requisites

Habitat suitability for wolves is based on their seasonal life requisites and habitat preference (Table 6.1-1). Based on Traditional Knowledge, observations of wolves and a literature review, the critical seasons for wolf survival within the BIPR study area were identified as growing/denning, summer/pup rearing, and winter.

Wolves breed only once a year and breeding time varies with the latitude, but most commonly occurs in March and April. After a nine-week gestation period, litters of five to eight pups are born. The pups remain inside dens for approximately two weeks. Occasionally, the pups are left alone while the pack goes hunting, but by mid-autumn they travel with the pack and participate in hunting and other pack activities. Adolescent wolves have been learning to hunt for at least a year, so they can usually hunt with the rest of the pack.

Table 6.1-1
Seasonal Life Requisites of Wolves

Season	Date[1]	Life Requisite	Habitat Preference
Denning/Pup Rearing	May 16 – August 31	Living and Reproducing	Eskers, near prey
Autumn	September – October	Living	See locations of caribou
Winter	November – May	Living	See locations of caribou

[1]**Dates based on Walton *et al.* (2001).**

The primary prey of wolves inhabiting the study area is barren-ground caribou, which they follow for hundreds of kilometres every year (Frame, 2005). Caribou in the Canadian Arctic are the only species that occur at densities sufficient to support the wolf population (Walton *et al.*, 2001). Wolves on the tundra also feed on muskox. When in or near the treeline during the denning season, wolves feed on moose, deer and caribou. Although wolves primarily hunt larger animals, their diets also contain small mammals like hares, foxes, rodents and even small amounts of plant material.

6.1.3 Habitat Requirements

6.1.3.1 Overview

Wolves in the Canadian Arctic behave differently than wolves inhabiting the rest of North America because they make long seasonal migrations every year to follow barren-ground caribou (Heard and Williams, 1992; Walton *et al.*, 2001; Frame, 2005). Wolves are territorial; each pack occupies an area that it defends against intruders. Sizes of territories vary greatly and are dependent on the kind and abundance of available prey. Satellite-collared wolves in the central Arctic showed a distinct migratory pattern: they leave tundra denning areas in the autumn and move over large areas throughout the winter, before returning to the tundra to give birth in the early spring (Walton *et al.*, 2001). Wolves follow caribou for most of the year, except from parturition (mid- to late-May) until pups are able to travel with their mother (September to October). Between those periods, wolf movements are restricted to areas surrounding den site and individuals may travel large distances in search of prey (Frame *et al.*, 2004). In summer, much of the wolves' diet consists of young animals born that year, because they are easiest to catch. In winter, wolves usually kill old or young animals, when available, but when prey numbers decline, wolves prey on all age groups, and it may take the entire pack to bring an animal down.

6.1.3.2 Denning/Pup Rearing

Wolf pups are usually born in a den. On the open tundra this den is commonly dug in a type of soil that lends itself to digging, such as in an esker, gravel ridge, or similar area. The pack usually remains at the birthing den for a month or more unless it is disturbed. In summer, when the pups are young, the adults seldom go on long forays. They may hunt together occasionally after meeting at the den or home site where the pups are being cared for. High quality habitat supports an abundance of prey close to a denning site (Plate 6.1-1).

Plate 6.1-1. High quality wolf denning/pup rearing habitat showing denning area in esker complex. The riparian complex along the side of the esker provides an abundance and diversity of prey for wolves and pups.

6.1.3.3 Autumn/Winter

Caribou are essential to the existence of wolves in the Arctic. In the Thelon River area, caribou was the main prey species in the spring and summer (Kuyt, 1972). Other prey items (*i.e.*, muskox, ermine, wolverine, wolf, fox, Arctic hare, Arctic ground squirrel, lemmings, voles, geese, ptarmigan, fish and insects) were taken rarely during that period (Kuyt, 1972). In the Project area, caribou is the only ungulate that occurs in sufficient numbers to support wolves; therefore, prey (*i.e.*, caribou) availability, rather than habitat availability, is most likely to be the determining factor regarding habitat suitability for wolves.

6.2 Results and Discussion

For wolves, habitat suitability was assessed for the denning/pup rearing season. The life requisites assigned to the denning/pup rearing season were *Living* and *Reproducing*. Since wolves remain close to the den site until the young are ready to travel with the rest of the pack (*i.e.*, September), the LSA was used to map suitable habitat for wolves during this season (Frame *et al.*, 2004).

Kuyt (1972), states that in winter wolves appeared to feed almost exclusively on caribou. Habitat requirement for wolves in the winter season, therefore, is primarily based on the location of caribou at that time which can be assessed by studying the habitat map for the caribou winter season (Figure 3.2-3).

The majority of habitat during the denning/pup rearing season and within both study areas was assessed as moderate quality habitat (Table 6.2-1 and Figure 6.2-1). There is a higher proportion of high quality habitat within the LSA than within the RSA for all seasons. Conversely, there is a higher proportion of low quality habitat in the RSA than in the LSA for all seasons.

Table 6.2-1
Area and Proportion of High, Moderate, Low and Nil-rated Habitat within the LSA and RSA for Wolf

Suitability Rating	Area in LSA (ha)	Percent of LSA	Area in RSA (ha)	Percent of RSA
Denning/Pup Rearing				
High	347	1.12	2,328	.16
Moderate	62	.20	<450	<.03
Low	782	2.53	191,720	12.80
Nil	29,696	96.15	1,307,187	87.01

A study recently conducted in the region surrounding the Project area found that the home range of wolves contained proportionally more esker habitat, followed by heath tundra (McLoughlin *et al.*, 2004). In addition to these two habitat types, wolves selected areas with heath boulder, heath bedrock, bedrock, tussock/hummock, wetland, lichen, tall shrub and birch seep (McLoughlin *et al.*, 2004). McLoughlin *et al.* (2004) found that boulder fields were much less preferred and that within the selected home ranges, exposed bedrock was the most preferred habitat type. These results show that wolves have a strong habitat association with eskers.

6.2.1 Denning Ecology

Wolves arrive at denning site in mid- to late- May and give birth shortly thereafter. Pups are weaned in the den and the immediate area surrounding the den. Wolves leave the den site when young are able to travel with adults, usually in September or October (Walton *et al.*, 2001). After migrating long distances to follow caribou, wolves often return to the same den in subsequent years (Ballard and Dau, 1983; Mech and Packard, 1990).

Eskers are the preferred habitats for wolf den construction. Esker habitats are granular and sandy, likely facilitating soil excavation for dens in a landscape dominated by bedrock, boulders, standing water and permafrost (Mueller, 1995; McLoughlin *et al.*, 2004). In the tundra of the Canadian Arctic, esker habitat only comprises 1-2% of the landscape (McLoughlin *et al.*, 2004). Therefore, suitable denning habitat for wolves inhabiting northern tundra is likely a limiting factor and areas containing eskers should be considered ecologically sensitive (McLoughlin *et al.*, 2004).

Section 1

Section 2

N

Section 1

Section 2

Bathurst Inlet Port

Bathurst Inlet

0

20

40

60

80

100

120

140

160

180

200

Mara River

Nose Lake

Contwoyto Lake

Contwoyto Lake Camp

UTM Zone 12

UTM Zone 13

Baseline Data (Rescan)

Wolf Den (2001)

Wolf Den (2007)

Government Data

Wolf Den (1996-2007)

TK Identified Denning Area

TK Identified Denning Area

Suitability Rating

High

Moderate

Low

Nil

Esker

Local Study Area

TK Source: Naonaiyaotit Traditional Knowledge Project (2006)

1:250,000

0 5 10

Kilometres

Projection: UTM12N, NAD83

Suitable Habitat for Wolves during Spring / Denning and Summer / Pup Rearing Seasons

FIGURE 6.2-1

the Bathurst Inlet Port and Road Project

Rescan

7. WOLVERINE

7. Wolverine

7.1 Introduction

7.1.1 Overview

The wolverine *(Gulo gulo)* is ranked as secure in Nunavut (CESCC, 2005), while the western Canadian wolverine population (which includes Nunavut) is listed as a species of Special Concern (COSEWIC, 2003). In 2004, it was proposed that wolverines be listed under Schedule 1 of SARA. However, they were not added to the list as further consultation with the Nunavut Wildlife Management Board was required on their demography and ecology.

The wolverine is a solitary mustelid that ranges throughout most of northern and western Canada, and is distributed at moderate densities in the Kitikmeot region of Nunavut (COSEWIC, 2003). Wolverine densities are generally low relative to other carnivores (Banci, 1994). Few data exist on the ecology of wolverines in the central Arctic barren-grounds due to the elusive nature of this species, relatively low densities, large home ranges and the general lack of success in tracking studies to date; however, a study by Mulder *et al.* (2000) has provided some insight into the ecology of this species in the Arctic.

The wolverine population in the central Arctic barren-grounds appears to be healthy, and may serve as a source population that maintains wolverine populations in adjacent areas. However, wolverine populations have low resiliency and are at high risk of decline because they require large tracts of land to maintain viable populations, have low reproductive rates, low population densities and large home ranges, which increase their interactions with humans. Wolverine populations are therefore sensitive to industrial and other developments, regardless of their current health.

Wolverines are an important cultural and economic resource for the Inuit and the maintenance of a healthy population of the species is important for local trappers. Trapping data indicate that wolverine populations have decreased in many regions of the NWT in the last 20 years (Banci, 1994; Petersen, 1997); however, other population estimates for the NWT (including Nunavut) suggest there is a stable or increasing, sparsely distributed population of more than 3,000 animals (Dauphiné, 1989; NWT RWED, 2001). Wolverine pelts are highly valued by Inuit for their frost-resistant properties and continue to demand high prices relative to many other furbearers (Thorpe *et al.*, 2001; Appendix F-5 of the DEIS).

Wolverines are found in the Project area along the proposed road and port sites (Mulders, 2000; Appendices D-7 and F-5 of the DEIS). Wolverine and evidence of wolverine presence were detected during aerial and ground surveys of the Project area in 2001 and 2002. Six wolverines were observed, and six wolverine tracks were encountered along the proposed road in both years. Because of the wolverine's relatively small size, they are probably difficult to detect from the air, except when the ground is snow-covered. Therefore, more wolverines may have been present, but were not seen during aerial surveys.

Traditional Knowledge indicates that wolverines use the Project area extensively (Appendix F-5 of the DEIS). The southern end of the proposed road near Contwoyto Lake, including the Contwoyto Camp site, is an important area for wolverines because of the presence of caribou, a main prey item. Inuit hunting of wolverines is concentrated in this area. Wolverines are also known to use the southern end of Bathurst Inlet (Appendix F-5 of the DEIS). Natal denning areas are described around Contwoyto Lake, near the proposed Contwoyto Camp site.

Data from wolverine harvests indicate that Bathurst Inlet, which includes the proposed port site, is one of the main sites for wolverine hunting in the West Kitikmeot (Mulders, 2000). Hunting locations were identified around Contwoyto Lake, near the Contwoyto Camp site (Mulders, 2000). Data indicate that wolverines are relatively abundant in these areas.

7.1.2 Biology and Life Requisites

Habitat suitability for wolverine is based on their seasonal life requisites and habitat preference (Table 7.1-1). Based on Traditional Knowledge, observations of wolverine, and a literature research, the critical seasons for wolverine survival within the study area were identified as late winter/denning and growing/kit rearing.

Wolverines mate in the summer but implantation of the fertilized egg is delayed. The fertilized egg does not implant into the wall of the uterus until sometime between November and March. The active period of gestation, or pregnancy, lasts 30 to 40 days following implantation. Birth occurs between February and May.

Table 7.1-1
Seasonal Life Requisites of Wolverine

Season	Date[1]	Life Requisite	Habitat Preference
Late Winter/ Denning	April – May	Living and Reproducing	Boulder fields, heath tundra
Growing/ Kit Rearing	June – September	Living	Eskers, boulder fields
Autumn	September - October	Living	Riparian shrub, boulder fields, bedrock
Early Winter	October – January	Living	See locations of caribou

[1]**Magoun and Copeland (1998).**

7.1.3 Habitat Requirements and Diet

7.1.3.1 Overview

Food availability is the fundamental factor influencing movement patterns and home range selection by wolverines, although the habitat use patterns of adult males are also influenced by breeding activities (Banci, 1994). During the winter, wolverine distribution is determined by ungulate distribution because wolverines rely on the availability of ungulate carrion (Banci, 1987). Wolverine productivity, then, is closely tied to the status of caribou and wolf populations (Dauphiné, 1989; Mulder, 1999). Key habitats for wolverines in the central Canadian Arctic

include boulder fields, riparian tall shrub, and fractured bedrock sites (AXYS Environmental Consulting Ltd. and Penner and Associates Ltd., 1998).

Wolverines are both scavengers and predators; they feed opportunistically on a wide variety of prey items and carrion throughout the year. In general, the wolverine is not limited to specific habitats, and survives periods of food scarcity by feeding on cached food items. In the winter, caribou carrion is the primary food source; however, carrion from muskox and other animals is also consumed (Magoun, 1987; Mulders, 2000). Because of the dependence of wolverines on caribou carrion, their ecology is closely tied to the ecology of caribou and the Arctic wolf. In fact, wolverine densities appear to be highest where caribou are abundant and where wolf predation on caribou is high (Kessel *et al.*, 2002; Rescan, 2007). Relatively high quality habitat for wolverine occurs in sedge and tussock habitats, and eskers provide important foraging habitat (Mulders, 2000).

Wolverines feed primarily on caribou, but also feed on rodents, hare and young muskox. Wolverine densities appear to be highest where caribou are abundant and where wolf predation on caribou is high, such as to create scavenging opportunities for wolverines (COSEWIC, 2003). During the winter, wolverines rely heavily on scavenged and cached food (Magoun, 1987; Mulders, 2000; Thorpe *et al.*, 2001). Wolverine feed primarily on caribou carrion, although muskox carrion and cached Arctic ground squirrels are also important. Habitat modelling indicates that wolverine occurrence is correlated with sedge communities, heath rock and rock associations (Johnson *et al.*, 2005).

7.1.3.2 Late Winter/Natal Denning

One specific habitat type required by wolverines is denning habitat used by the female to give birth and raise her kits. Most dens that have been found are in tundra regions and consist of a complex of snow tunnels associated with boulders or rocks. The configuration of the rocks results in natural cavities under the snow, which form dens for the wolverine. Most dens that have been found are in the tundra consist of a complex of snow tunnels that have formed naturally around rock configurations (CWS, 2007).

Females give birth to kits in the winter after breeding in the summer, which is a result of delayed implantation. Denning sites are located away from wolverine predators such as grizzly bears, wolves and other wolverines, and are in sites that maintain a deep insulating layer of snow throughout the denning period (Magoun and Copeland, 1998). This snow layer also makes it more difficult for predators to reach wolverine kits in the den. Reproductive denning sites must also be in close proximity to kit rearing habitat, where prey items such as small mammals and birds are prevalent (Whitman *et al.*, 1986). Den sites are often used by wolverines for multiple consecutive years (Lee and Niptanatiak, 1996).

7.1.3.3 Growing/Kit Rearing

Wolverines give birth between February and May. Wolverine kits grow quickly compared to the young of other mammals. This rapid rate of growth continues after the mother stops nursing her kits when they are nine or ten weeks of age. Kits reach adult size by seven months of age.

According to Magoun (1987), the summer diet of wolverines is more varied than their winter diet and contains more freshly killed prey. As the movements of family groups are restricted, food must be found in a smaller area. Female wolverine with young rely on small mammals, such as ground squirrels, which are the main prey taken at this time. Studies show that the survival of young wolverines was significantly higher in years when small mammal populations were also high (Pulliainen, 1968). Wolverines also prey on birds, Arctic hares, young ungulates and small mammals such as lemmings and voles (Pulliainen, 1968; Magoun, 1987; Landa *et al.*, 1997; Mulders, 2000). Plant material such as berries is consumed to some extent while caribou carrion from wolf and grizzly bear kills, or from natural mortality, contributes significantly to the diet (Magoun, 1987; Mulders, 2000). Wolverines hide excess food by burying it or stashing it in rock crevices.

7.2 Results and Discussion

For wolverine, habitat suitability was assessed for late winter/denning, growing/kit rearing and early winter seasons, as large home ranges of diverse ecosystem types preclude a more refined characterization of wolverine habitat. The life requisites assigned to late winter/denning were *Living* and *Reproducing*, while growing/kit rearing and early winter seasons were assessed only for *Living*.

The majority of the habitat during the late winter/denning season within both study areas was assessed as moderate quality (Table 7.2-1, Figure 7.2-1). However, during the growing/kit rearing season, the majority of the habitat was of low quality (Figure 7.2-2). For all seasons, there is a higher proportion of high quality habitat within the LSA than within the RSA. The low quality habitat is proportionally higher in the LSA than in the RSA during the growing/kit rearing season. The low quality habitat is proportionally lower, however, in the LSA than in the RSA during the early winter season, and is roughly proportional during the late winter/denning season.

Table 7.2-1
Area and Proportion of High, Moderate, Low and Nil-rated Habitat within the LSA and RSA for Wolverine

Suitability Rating	Area in LSA (ha)	Percent of LSA	Area in RSA (ha)	Percent of RSA
Late Winter/Denning				
High	482	1.80	6,018	0.4
Moderate	22,700	85.87	1271243	84.57
Low	2,195	8.30	50,195	3
Nil	1,061	4.03	174229	12.03
Growing/Kit Rearing				
High	459	1.80	2,328	0.20
Moderate	5,472	20.57	586,357	38.80
Low	19,446	73.60	738,771	48.97
Nil	1,061	4.03	174,229	12.03

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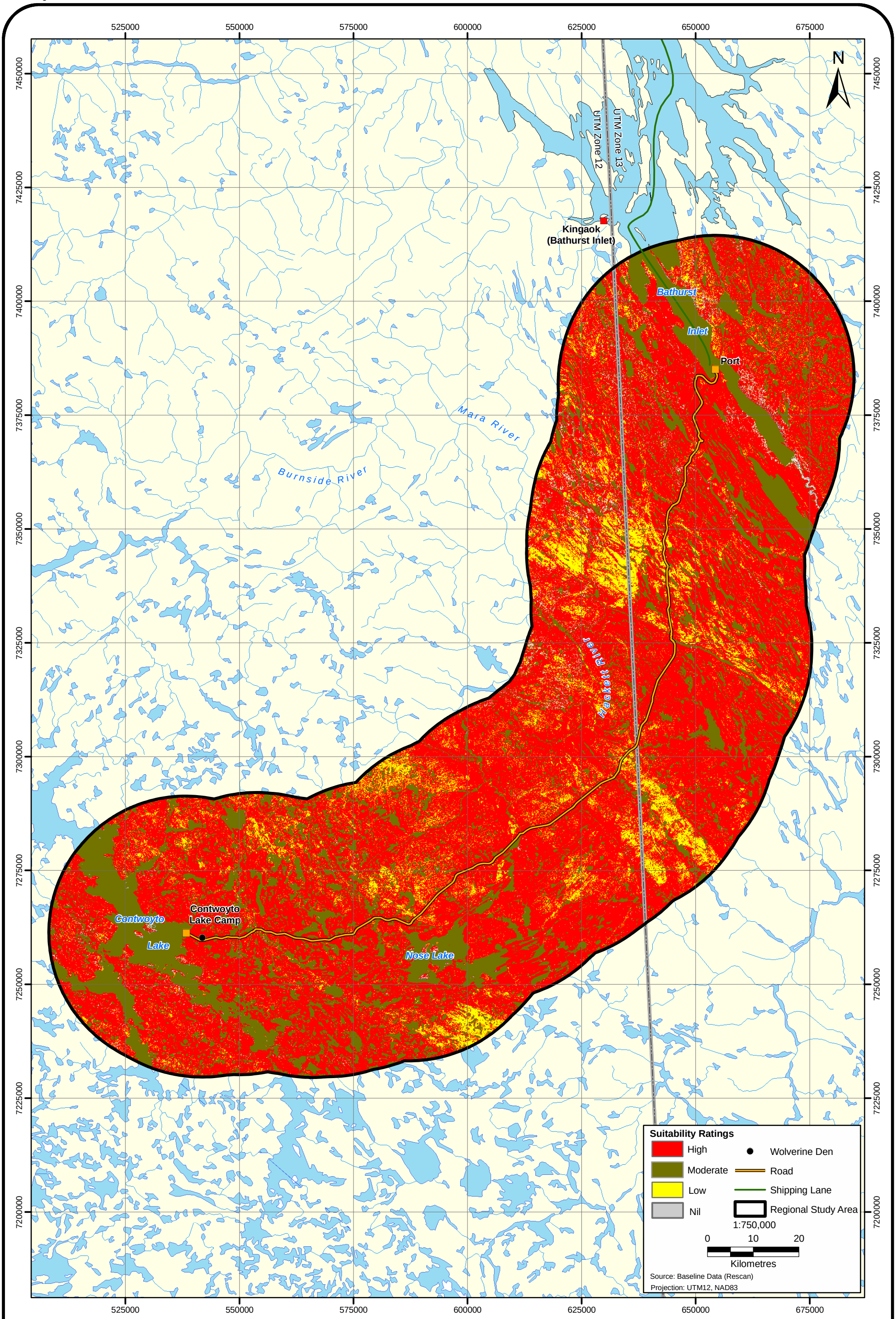

Suitable Habitat for Wolverine during the Late Winter / Denning Season

the Bathurst Inlet Port and Road Project

FIGURE 7.2-1

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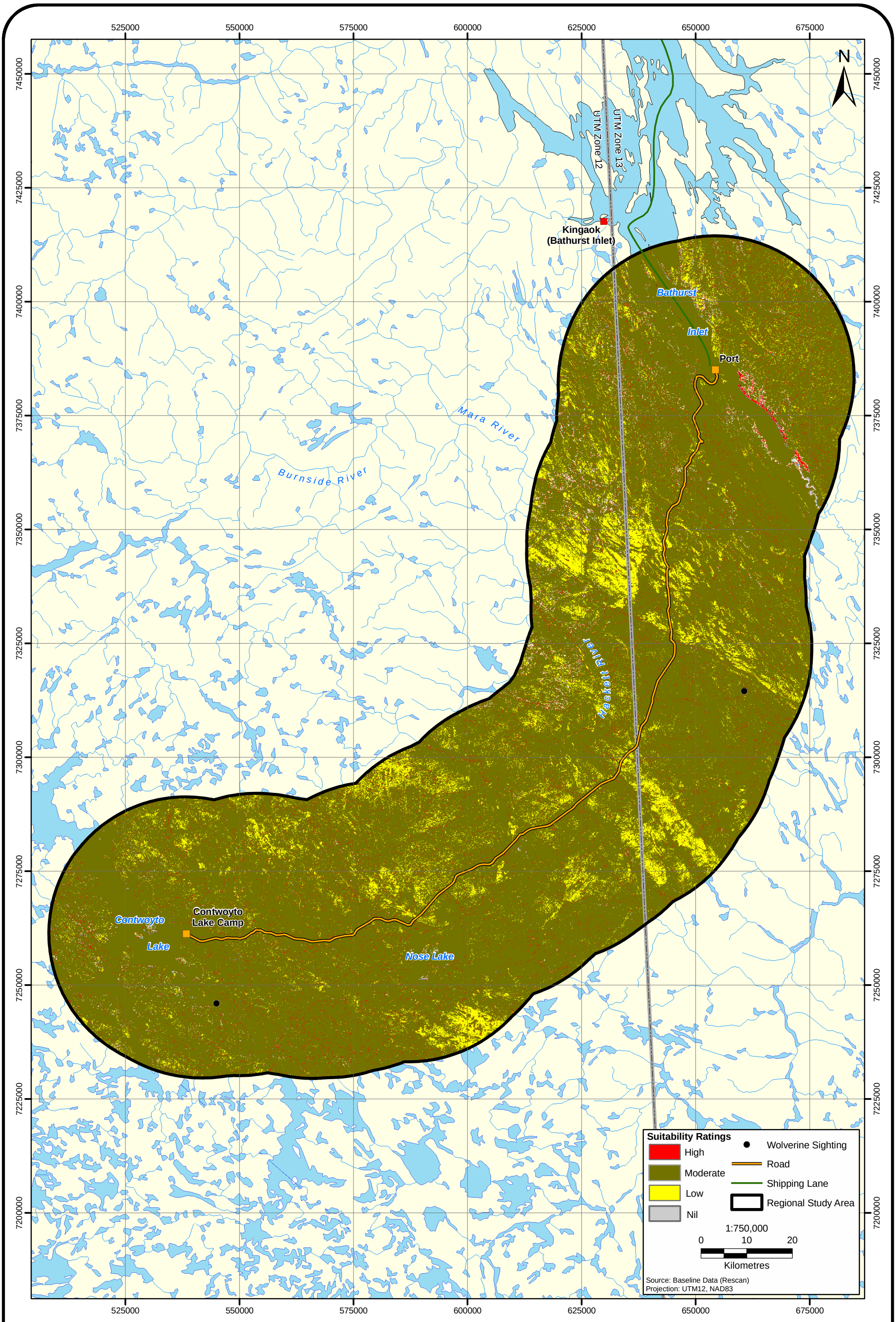

the Bathurst Inlet Port and Road Project

Suitable Habitat for Wolverine during the Growing / Kit Rearing Season

FIGURE 7.2-2

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Given the link between wolverine and caribou (*i.e.*, predator and prey), wolverine habitat suitability in the RSA is ranked according to caribou abundance: moderate in spring and winter, low in summer and high in autumn. The lower coverage of potentially important wolverine habitat (*e.g.*, Lichen Rock) in the study areas reduces wolverine habitat suitability in these study areas to low to moderate in winter and spring, very low in summer and moderate in fall.

The home range of an adult wolverine extends from less than 100 km^2 for females to over 1,000 km^2 for males. The size of the home range varies depending on the availability of food and how it is distributed across the landscape; the more food there is, the smaller the home range is likely to be.

7.2.1 Denning Ecology

Wolverines use dens for reproduction, resting, or as congregation sites for females and their weaned kits. Denning occurs from February through April (Magoun and Copeland, 1998). Wolverines have specific habitat requirements for den sites and often use dens for consecutive years (Lee and Niptanatiak, 1996). In winter, wolverines use snow dens or burrows dug in snow for resting. Winter resting dens are used by males and females and should not be confused with natal dens (Appendix F-5 of the DEIS).

Reproductive dens are found in rocky outcrops or snowdrifts, which must maintain a deep insulating layer of snow throughout the denning period (*e.g.*, a snow tunnel within a boulder field terminating in a crevice) (Magoun and Copeland, 1998; Appendix F-5 of the DEIS). Reproductive dens may be classified as either natal or maternal. Natal dens are used during parturition, while maternal dens are used subsequent to the natal den and before weaning (Magoun and Copeland, 1998). Denning sites are located away from predators such as grizzly bears, wolves and other wolverines. Proximity to kit-rearing habitat is also an important factor in den site selection (Magoun and Copeland, 1998).

The availability of natal den sites does not appear to be limiting for wolverines in the West Kitikmeot region (Mulders, 2000). However, maternal den sites may be limiting as they must be located near eskers or riparian areas where small prey (*e.g.*, small mammals and birds) are available for growing kits.

The sensitive period for wolverines is primarily during denning when disturbance to dens by humans often results in females abandoning their kits, or moving them to an alternate denning location which increases their exposure to predators (Magoun and Copeland, 1998; Heinemeyer *et al.*, 2001). Furthermore, the energy requirements of kits are especially high during this time (Wilson, 1982) due to a rapid growth rate (kits reach full adult size by seven months), and interruption of their development could hamper their survival and reproduction. A general threat to wolverines is their large home range size, which increases their interactions with hunters and trappers; males and transient yearlings are at the greatest risk since they travel longer distances than females.

8. MIGRATORY BIRDS

8. Migratory Birds

8.1 Introduction

8.1.1 Overview

Migratory birds in the Project area have been grouped to identify general population trends, habitat associations and sensitive periods during the breeding season. Raptors and waterfowl are addressed in Chapters 9 through 11, while the remaining migratory birds (*i.e.*, small passerines, shorebirds and gulls), are addressed below.

Birds are respected in Inuit culture (Appendix F-5 of the DEIS), and species such as ducks, geese and cranes are an important food source for the Inuit when caribou are not available (Thorpe *et al.*, 2001; Appendix F-5 of the DEIS). The Inuit stress the importance of conserving significant bird habitat in the Draft West Kitikmeot Land Use Plan (NPC, 2005; Appendix F-5 of the DEIS). Several bird species observed in the Project area are listed as sensitive in Nunavut (CESCC, 2005), meaning that there is concern in the long-term for these species due to declines. These species include the American golden plover, American tree sparrow, golden eagle, Harris's sparrow, semipalmated sandpiper, short-eared owl and white-crowned sparrow. Finally, the relatively high abundance of birds enables the statistical detection of changes in diversity and abundance in disturbed compared to undisturbed habitats and between pre- and post-disturbance phases over time.

8.1.2 Ecology

The majority of breeding birds within the Kitikmeot region are migratory, and winter in areas extending from the treeline to the southern tip of South America. This diverse group includes small passerines (*i.e.*, sparrows, warblers, longspurs and redpolls), shorebirds (*i.e.*, sandpipers, plovers, phalaropes and cranes), seabirds (*i.e.*, jaegers and terns), raptors (*i.e.*, falcons, hawks, eagles and owls) and waterfowl (*i.e.*, ducks, geese, swans, loons and grebes). Three species, the gyrfalcon, ptarmigan and raven, are resident in the region, but make short local migrations depending on weather (Holder and Montgomerie, 1993; Clum and Cade, 1994; Hannon *et al.*, 1998; Boarman and Heinrich, 1999; Appendix F-5 of the DEIS).

8.1.3 Habitat Associations and Community Structure

Baseline studies of birds in the LSA were conducted during the 2007 breeding season (Appendix D-10 of the DEIS). A cluster analysis of collected data revealed three main bird community assemblages associated with three main habitat features:

- **Community 1:** A unique community assemblage of birds was found in heath tundra and boulder field habitats, which are characterized by dry and low heterogeneous habitat structure. Common redpoll, Lapland longspurs, horned larks, rock ptarmigan, American pipit and Harris' sparrow were highest in abundance in these habitats.
- **Community 2:** A second unique community assemblage of birds was found in birch seep and riparian shrub habitats, which were characterized by the presence of shrubs and significant vertical vegetation structure. This second bird community was composed of a

higher proportion of shrub-nesting species in these areas. Common redpoll, hoary redpoll, American tree sparrow, white-crowned sparrow and savannah sparrow occurred in both riparian shrub and birch seep habitats, and were all generally in higher abundance in these habitats compared to other habitats.

- **Community 3:** A third unique community assemblage of birds was found in grassy, sedge habitat. This third bird community in sedge habitats was composed largely of wetland species, including savannah sparrow, Canada goose, least sandpiper, northern pintail, semipalmated plover and stilt sandpiper.

Since these communities were already defined statistically, habitat mapping simply focused on locations and amount of habitat that provided suitable habitat for each unique community.

8.2 Results and Discussion

8.2.1 Diversity Comparisons between Habitats

Diversity indices indicated a wide range of diversity values among habitat types represented along the proposed road (Appendix D-10 of the DEIS). The highest diversity values were observed in riparian shrub and birch seep habitats. Beach habitats, found along the shoreline at Bathurst Inlet, hosted the third highest species diversity followed by heath tundra, sedge, rocky outcrop, avens, boulder field and esker complexes.

Riparian habitats also had high equitability values, meaning that the relative abundance of birds belonging to different species was well-balanced. The low equitability value for boulder fields and lichen rock communities, on the other hand, indicated a disproportionately high abundance of few primary species, and low numbers of individuals of other species that contributed to the diversity value. The highest equitability value was observed in the esker complex, meaning that this community, although low in diversity, has a well balanced proportional abundance of species (Appendix D-10 of the DEIS).

The amounts of suitable habitat varied for each community, but were consistent between spring/nesting and summer/brood rearing seasons (Table 8.2-1, Figures 8.2-1, 8.2-2 and 8.2-3).

Table 8.2-1
Area and Proportion of Associated and Non-associated Habitat within the LSA and RSA for Migratory Birds

Suitability Rating	Area in LSA (ha)	Percent of LSA	Area in RSA (ha)	Percent of RSA
Heath Tundra Community (1) – Spring/Nesting and Summer/Fledging				
Community 1 Habitat	19,446	73.6	738,771	48.97
Non-Community 1 Habitat	6,992	26.4	762,914	51.03
Riparian Shrub Community (Amstrup) – Spring/Nesting and Summer/Fledging				
Community 2 Habitat	490	1.86	338,424	22
Non-Community 2 Habitat	25,948	98.14	1,163,261	77.6
Sedge Community (3) – Spring/Nesting and Summer/Fledging				
Community 3 Habitat	2,195	8.3	50,195	3
Non-Community 3 Habitat	24243	91.7	1451490	97

Section 1

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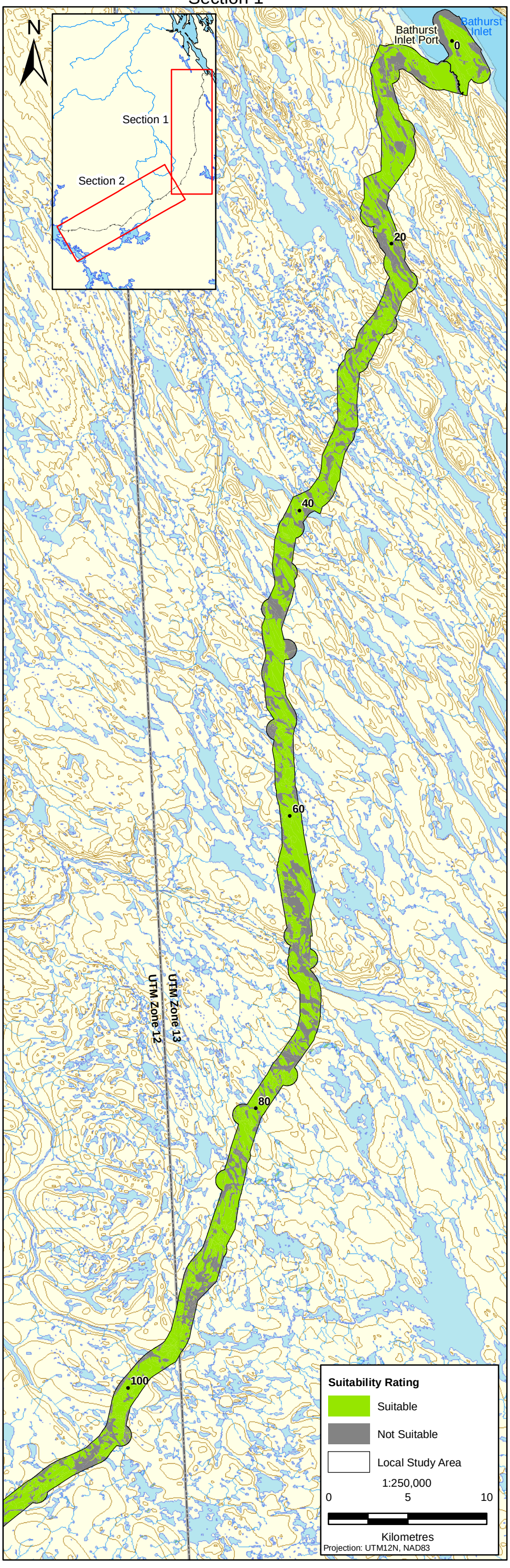

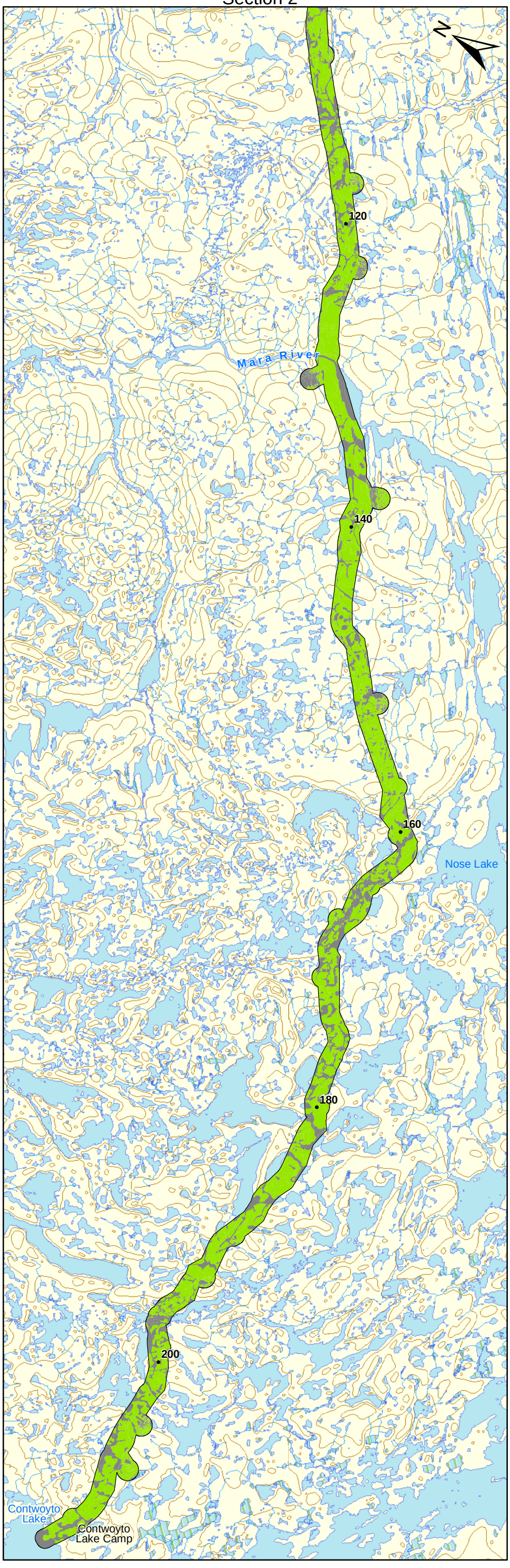

Associated Habitat for Migratory Birds - Community (1) during Spring / Nesting and Summer / Fledging Seasons

the Bathurst Inlet Port and Road Project

FIGURE 8.2-1

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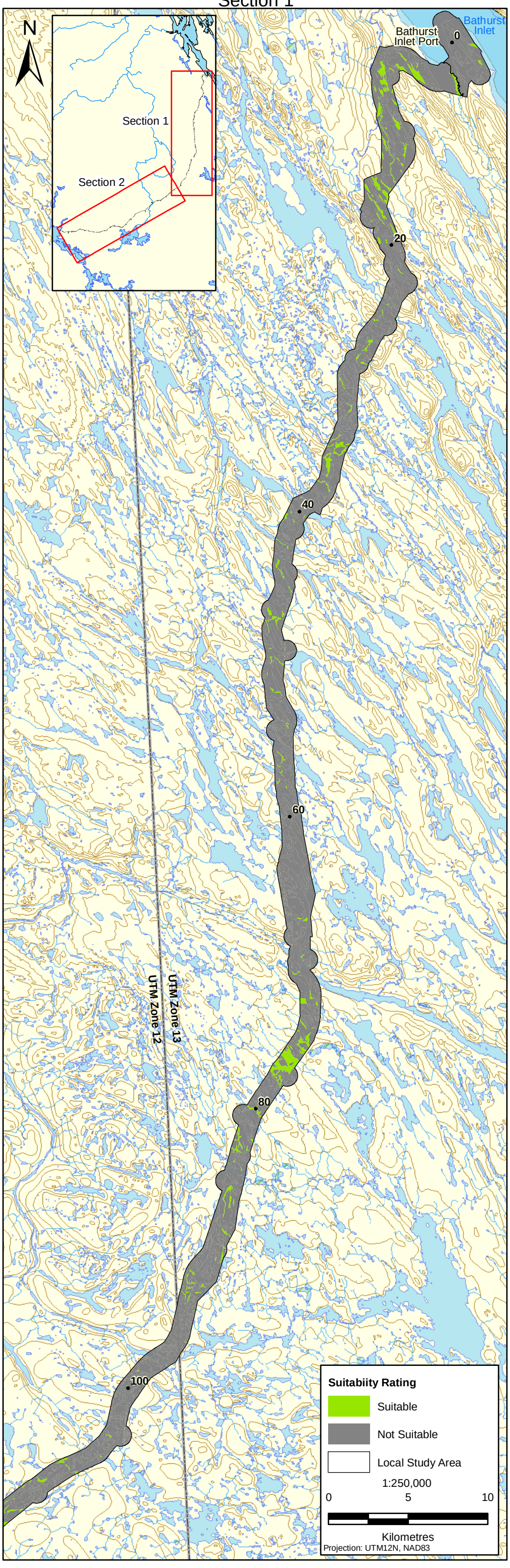

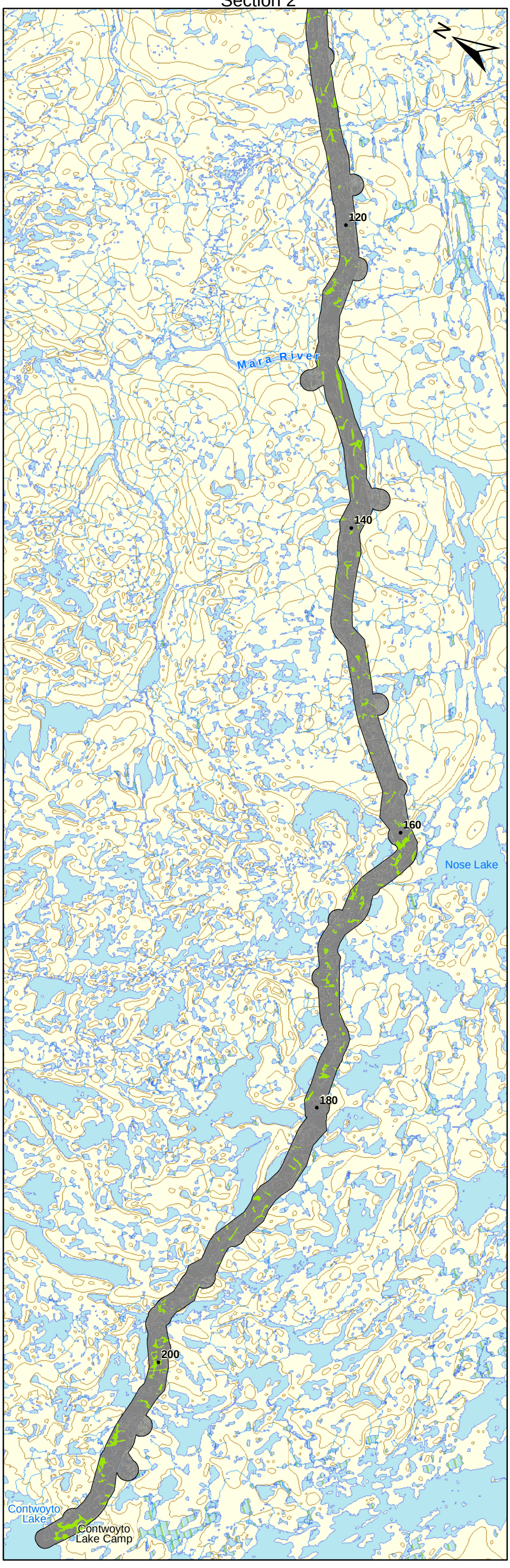

Associated Habitat for Migratory Birds - Community (2) during Spring / Nesting and Summer / Brood Rearing Seasons

FIGURE 8.2-2

the Bathurst Inlet Port and Road Project

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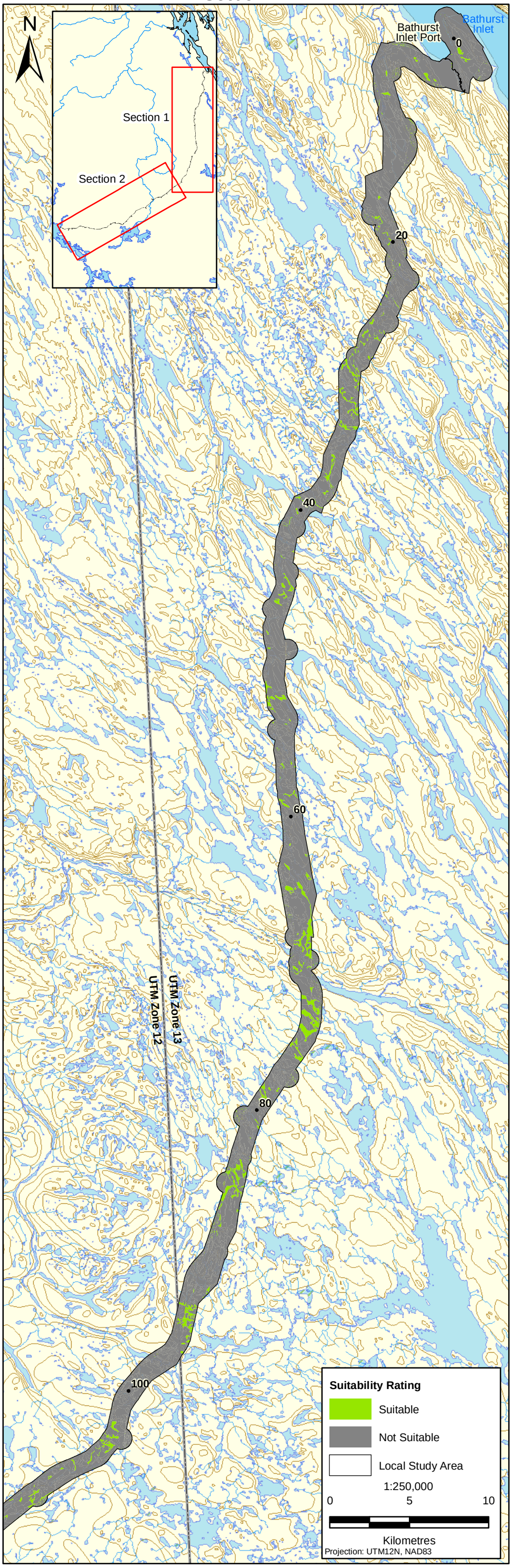

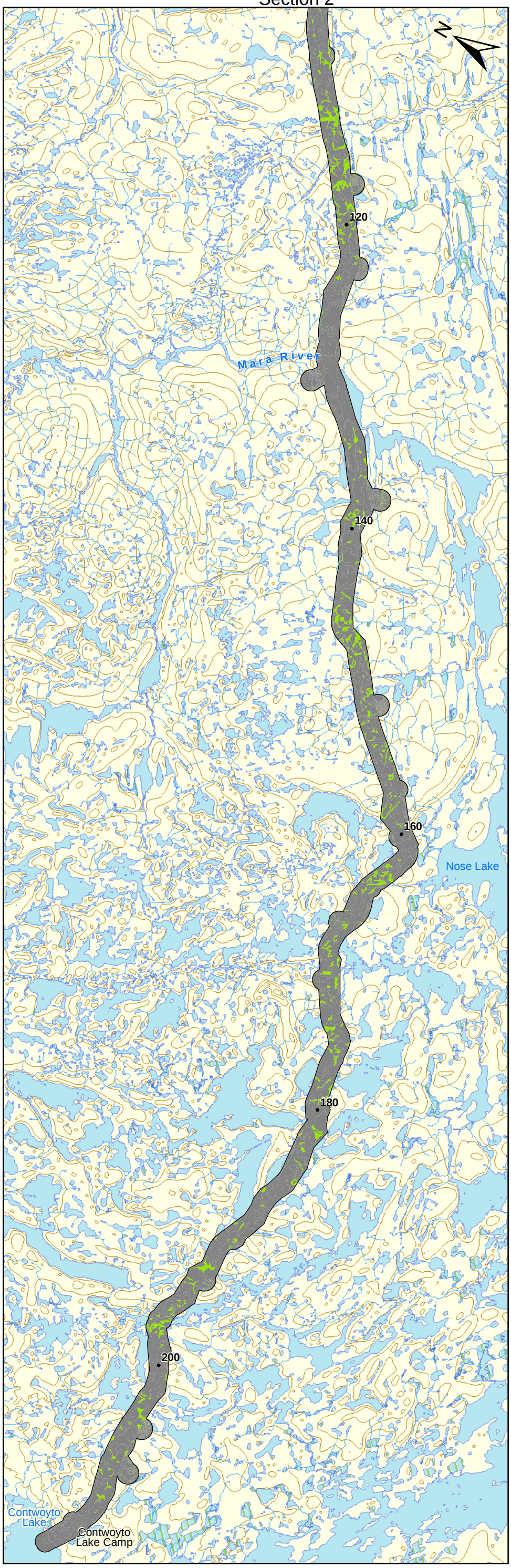

Associated Habitat for Migratory Birds - Community (3) during Spring / Nesting and Summer / Fledging Seasons

the Bathurst Inlet Port and Road Project

FIGURE 8.2-3

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9. CLIFF-NESTING RAPTORS

9. Cliff-nesting Raptors

9.1 Introduction

9.1.1 Overview

Many raptors are top predators and are often considered ideal 'indicator species' because their abundance and reproductive success reflect the health of their associated food chains. For example, declines in peregrine falcon and other raptor populations in the 1960s and 1970s signalled the negative ecological impacts of DDT and other persistent pesticides. Although common ravens are passerines, they are considered "functional raptors" because they compete with raptors for nesting sites on cliffs (Poole and Bromley, 1988) and feed on live prey and carrion (Boarman and Heinrich, 1999). Of the nine species of raptors potentially present in the RSA, six species form a guild that nest on steep cliff ledges (Poole and Bromley, 1988): golden eagle, bald eagle, gyrfalcon, peregrine falcon, rough-legged hawk and common raven. The Arctic provides raptors with critical breeding habitat and supports a large proportion of the breeding population of gyrfalcon, rough-legged hawk and peregrine falcon (*tundrius* subspecies). Bald eagles are accidental in the Project area, as the RSA is outside their established range.

The *tundrius* subspecies of the peregrine falcon (*Falco peregrinus tundrius*; the subspecies most likely to occur in the Project area) is listed by COSEWIC (2007) as a species of Special Concern under the Species at Risk Act. Peregrine falcons are globally threatened with extinction due to trade (CITES), and are ranked as G4 status by Natureserve, meaning that there is concern in the long-term for this species due to broad scale declines. Peregrine falcons, like all raptors, are highly respected in Inuit culture and were chosen as a valuable ecosystem component in other proximate Environmental Impact Assessments (Zinifex, 2007). The Draft WKLUP (2005) also prohibits the disturbance of nesting falcons during the breeding season. Finally, more data exist for the peregrine falcon than for other raptor species breeding in the North. The following section discusses the ecology of the tundra peregrine falcon and cliff-nesting raptors in general.

9.1.2 Ecology

Raptors are most sensitive to disturbances during the breeding period, which occurs from April through August in the Arctic (Poole and Bromley, 1988). Raptors are most likely to abandon nests from April through mid-July, when territories are being established and eggs are being laid and incubated (CWS, 2005a).

9.1.3 Habitat Requirements

In the central Arctic, the tundra peregrine falcon nests predominately on south facing cliffs and outcrops adjacent to or near bodies of water, most frequently on rocky cliffs along rivers or lakes (Plate 9.1-1). The availability of suitable cliffs for nesting is likely the most critical feature of its breeding habitat and the same cliffs can be occupied and used for decades by this species (Sinclair *et al.*, 2003). The second most important component of this species' breeding habitat in the Arctic is the proximity to wetlands and riparian areas where waterfowl and shorebirds, the main prey species of peregrine falcons, are common (Sinclair *et al.*, 2003). Data from the NWT and Nunavut Raptor Database indicate that peregrine falcon nests are concentrated along Bathurst Inlet and overlap the proposed port and road route (COSEWIC, 2007).

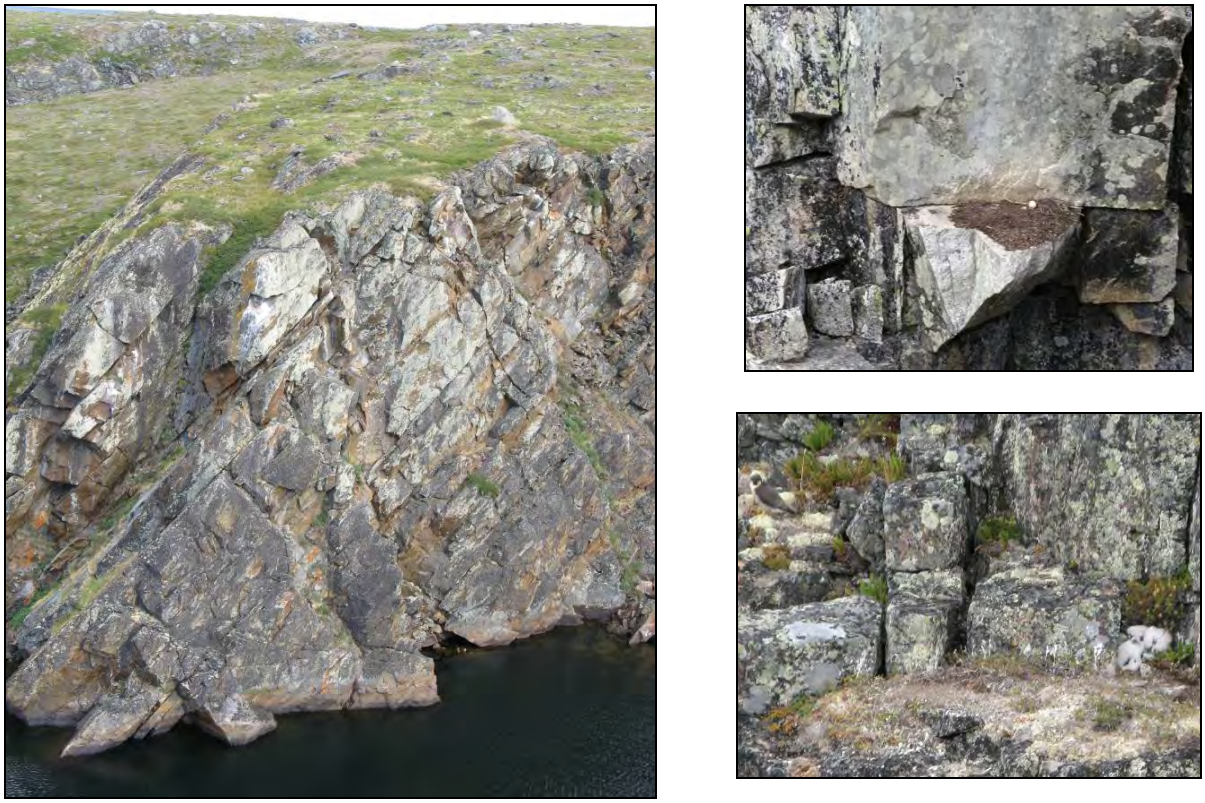

Plate 9.1-1. High quality habitat for peregrine falcons (left). Abandoned peregrine falcon egg (top right). Peregrine female with chicks (bottom right).

9.2 Results and Discussion

Five avian species have been found nesting on cliffs within the RSA. These species are: gyrfalcon, peregrine falcon, rough-legged hawk, common raven and Canada goose. Habitat suitability ratings for cliff-nesting birds were based on habitat quality ratings assigned to peregrine falcons, since suitable habitat for peregrine falcon will generally represent suitable habitat for other cliff-nesting raptor species as well. Habitat suitability was assessed for the spring/nesting and summer/fledgling seasons. The life requisites assigned to spring/nesting were *Living* and *Reproducing*, while the only life requisite assigned to summer/fledgling habitat was *Living*.

Due to the difficulty in distinguishing bedrock cliffs along water (preferential habitat for cliff-nesting raptors), suitable habitat was assumed to include areas within 1.6 km of known cliff nest sites, considering locations of all cliff-nesting raptors (Figure 9.2-1). This 1.6 km area was chosen because research suggests that most peregrine falcon activity (*e.g.*, perching, caching, defensive behaviour) occurs within 1 to 2 km of nest sites (Poole and Bromley, 1988; White *et al.*, 2002). At least one cliff nesting raptor was located on most suitable cliff faces, thus identifying areas of suitable habitat. This method may underestimate the amount of suitable habitat, as some cliffs that could support cliff-nesting raptors will be missed if no nests were found on the cliff face.

Section 1

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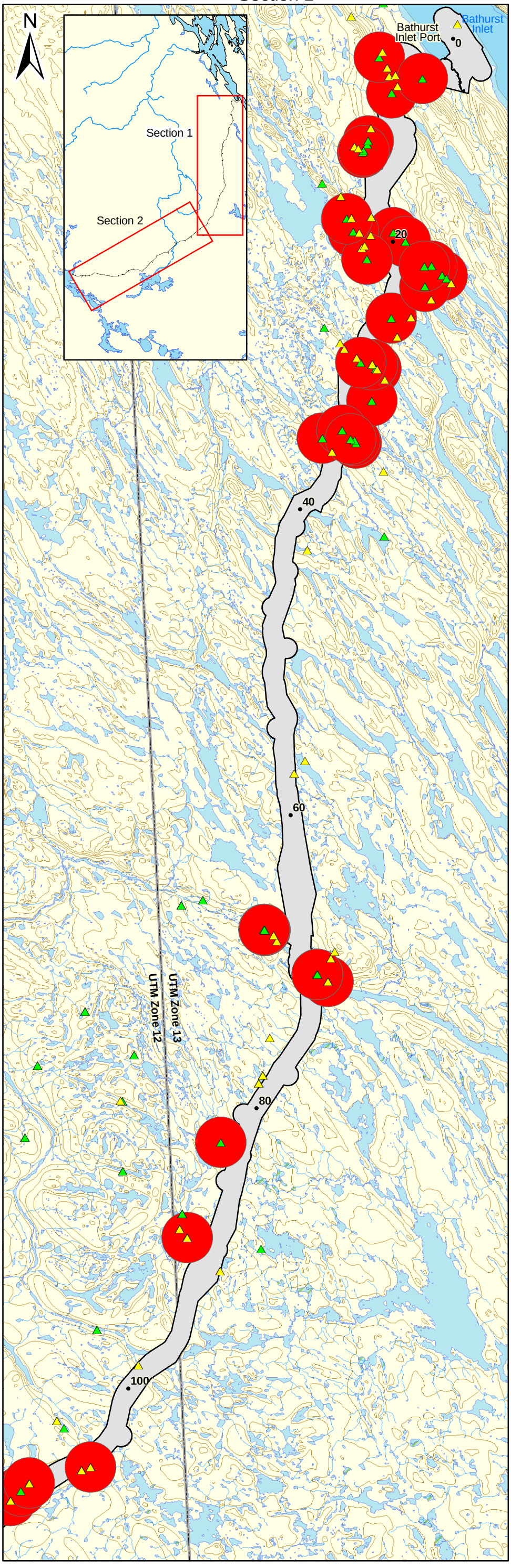

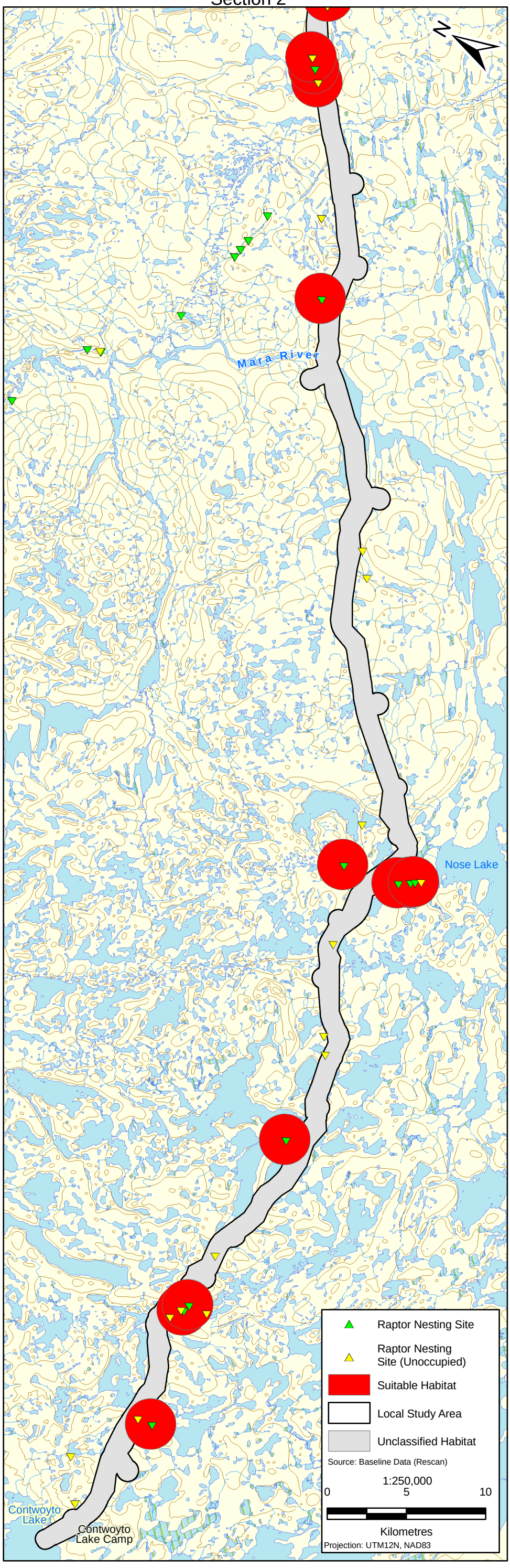

Suitable Habitat for Peregrine Falcons during Spring / Nesting and Summer / Fledging Seasons

the Bathurst Inlet Port and Road Project

FIGURE 9.2-1

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10. GROUND-NESTING RAPTORS

10. Ground-nesting Raptors

10.1 Introduction

10.1.1 Overview

Two ground-nesting raptor species inhabit the Arctic: short-eared owl (*Asio flammeus*) and snowy owl (*Bubo scandiaca*). The short-eared owl is found throughout the Eastern and Western hemispheres (Wiggins *et al.*, 2006). The snowy owl is found only in the northern hemisphere (Parmelee, 1992). Short-eared owls were incidentally observed during field surveys conducted in 2001 and 2002 (Appendix D-7 of the DEIS), as well as during point count surveys in 2007 (Appendix D-10 of the DEIS). No snowy owls were observed during baseline studies; therefore, habitat suitability ratings are given for short-eared owls.

The short-eared owl is classified as a species of special concern by COSEWIC in Canada due to a national trend of declining numbers and due to its sensitivity to human disturbance in its habitat (COSEWIC, 2007). In the NWT and Nunavut, the species is designated as sensitive (CESCC, 2005; Working Group on General Status of NWT Species, 2006). In the Arctic, populations of short-eared owls fluctuate in numbers, concomitant with populations of lemmings, which have a population cycle of high to low abundance every three to four years. Short-eared owls are ground-nesters: they need habitats with sufficient ground cover to hide their nests and with abundant food resources (mainly small mammals) (Alderfer, 2006).

10.1.2 Ecology

Short-eared owls (*Asio flammeus*) are a stocky bird of prey of the family Strigidae (order Strigiformes), about 40 cm long with a prominent facial disk. Female short-eared owls make a rudimentary nest on the ground by lining a scrape in the ground with a few leaves, feathers, or bits of grass (Wiggins *et al.*, 2006).

Short-eared owls are the most diurnal of owls; they may be seen at any time of day, but are especially active from late afternoon until dark, or at dawn. They also hunt at night, but also hunt during daylight hours more commonly during the winter or when they are feeding young. Most of their prey is mammalian, and up to 95% may be voles. Small birds, especially shorebirds are also taken as prey.

Courtship begins as early as April in Nunavut. The female incubates the eggs and is usually fed by the male. Clutch sizes are larger when food is abundant. The hatchlings leave the nest but stay in the immediate area to be fed by their parents. They begin to fly after 24 to 27 days, but are dependent on their parents for about seven weeks.

10.1.3 Habitat Requirements

10.1.3.1 Overview

Short-eared owls spend the winter in wide open grasslands, prairies, fields, salt marshes and estuaries south of the RSA. They migrate to Arctic tundra for the summer and breeding season.

Therefore, habitat suitability ratings were assessed for spring/nesting and summer/fledgling seasons.

10.1.3.2 Spring/Nesting

Preferred nesting habitat for short-eared owls are dense enough to conceal the nest, adjacent to open habitat used for hunting and are often located near water (Parmelee, 1992; Alderfer, 2006; Wiggins *et al.*, 2006). Females scrape out a bowl, lined with grasses and downy feathers from their breasts. Nests are concealed in dense vegetation, under low shrubs, reeds and grasses and are often located near water. Habitats chosen for nesting are dense, hummocky, dwarf shrub meadows (Parmelee, 1992).

Along Bathurst Inlet, short-eared owls hunt more birds and young gulls than those in the interior. Short-eared owls will often choose a breeding site that is adjacent to more open habitats used for hunting (Wiggins *et al.*, 2006).

10.1.3.3 Summer/Fledgling

Hatchlings leave the nest but stay in the immediate area to be fed by their parents. They begin to fly after 24 to 27 days, but are dependent on their parents for about seven weeks.

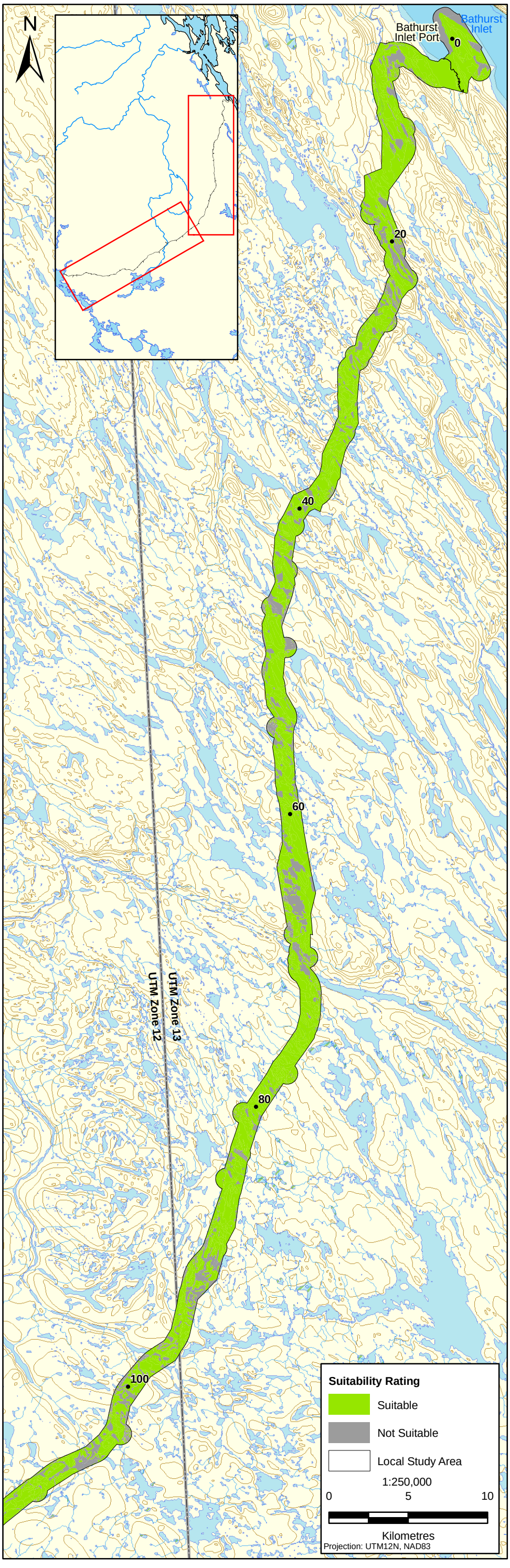
10.2 Results and Discussion

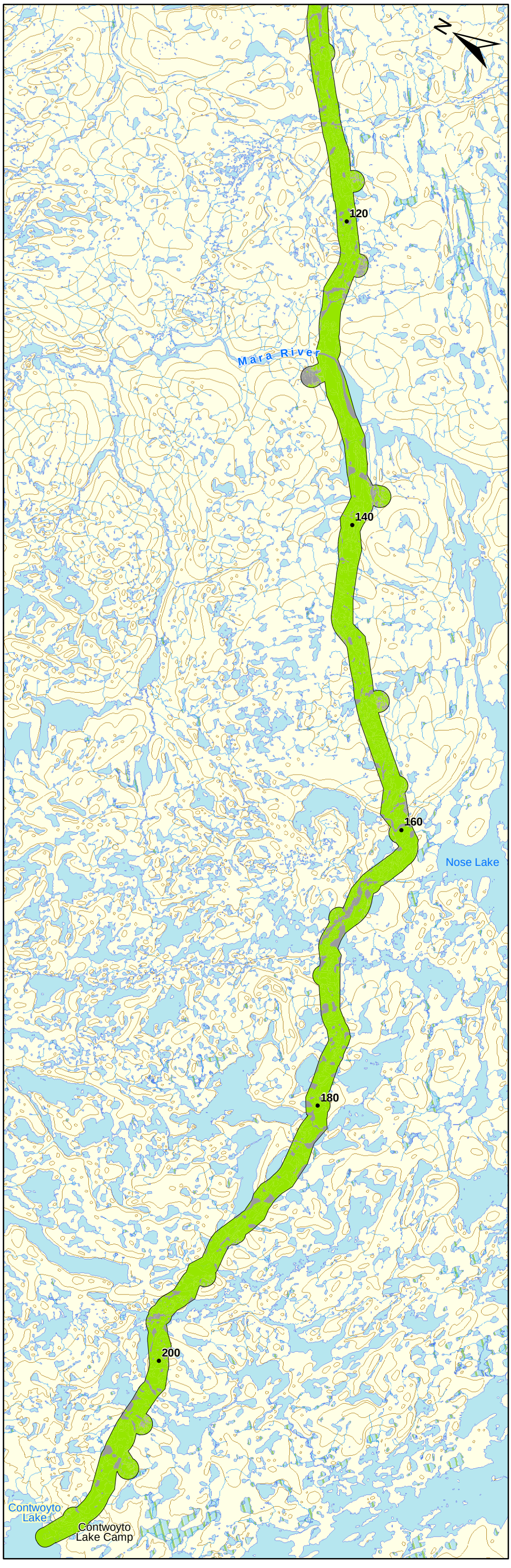
Only one species of ground-nesting raptor was found within the RSA: the short-eared owl. Habitat suitability for short-eared owls was assessed for the spring/nesting and summer/fledgling seasons. The life requisites assigned to spring/nesting were *Living* and *Reproducing*, while the only life requisite assigned to summer/fledgling habitat was *Living.*

The majority of the habitat during both seasons and within both study areas was assessed as usable habitat (Table 10.2-1, Figure 10.2-1). There is a greater proportion of not usable habitat within the RSA than within the LSA during both seasons.

Table 10.2-1
Area and Proportion of Suitable and Not Suitable Habitat within the LSA and RSA for Short-eared Owl

Suitability Rating	Area in LSA (ha)	Percent of LSA	Area in RSA (ha)	Percent of RSA
Short-eared Owl - Spring/Nesting and Summer/Fledging				
Suitable	24,497	92.70	1,129,718	75.00
Not Suitable	1,941	7.30	371,967	25.43





Suitable Habitat for Short-eared Owl during Spring / Nesting and Summer / Fledging Seasons

FIGURE 10.2-1

the Bathurst Inlet Port and Road Project

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11. WATERFOWL

11. Waterfowl

11.1 Introduction

11.1.1 Overview

Waterfowl are defined in this report as ducks, geese, swans, loons and grebes. Waterfowl breed in freshwater or marine habitats and feed on fish, invertebrates and/or plant material. The presence of waterfowl is an indicator of the availability of functional wetland habitat. Waterfowl are important food species for the Inuit (Thorpe *et al.*, 2001). The migratory nature of Arctic waterfowl affords special protection to species through the *Migratory Bird Convention Act* and the *Canada Wildlife Act* during the breeding season.

Fourteen waterfowl species were observed within the RSA (Appendix D-10 of the DEIS). The long-tailed duck (*Clangula hyemalis*) is a commonly observed species in the Arctic and may be sensitive to environmental impacts, such as oil spills. Further, numbers of long-tailed duck fluctuate in the Arctic. The Nunavut ranking system (CESCC, 2005) lists long-tailed ducks as secure and the NWT ranking system (Working Group on General Status of NWT Species, 2006) lists it as sensitive. Therefore, long-tailed ducks have been chosen for habitat mapping, as a proxy for waterfowl.

11.1.2 Ecology

Long-tailed ducks are migratory diving ducks that winter on salt water and breed in freshwater habitats. This species mainly preys on small fish, aquatic insects and invertebrates. Waterfowl arrive in the Arctic from mid to late May. Egg-laying and incubation generally occur from June to late July. Hatching occurs from late June to late August; fall migration occurs from August through September (Bellrose, 1976).

11.1.3 Habitat Requirements

11.1.3.1 Overview

Migration usually takes place close to shore, in the offshore following ice leads, or through inland regions if ice cover is extensive (Robertson and Savard, 2002). The long-tailed duck feeds primarily on animal matter such as aquatic insects, crustaceans and fish matter, although some plant matter is also taken (Robertson and Savard, 2002).

11.1.3.2 Spring/Nesting

Waterfowl arrive in the Arctic from mid to late May. Egg-laying and incubation generally occur from June to late July. Early in the breeding season, before lakes have thawed, females of some waterfowl species rely on endogenous fat reserves to lay and incubate eggs. Hatching occurs from late June to late August and young and adults generally leave for migration from August through September (Bellrose, 1976). During baseline studies, nests were observed in the Project area for Canada goose and long-tailed ducks in July 2001 and June 2007, respectively.

11.1.3.3 Summer/Brood Rearing

Breeding habitat for Arctic waterfowl typically consists of wetlands and lakes associated with sedge communities. Long-tailed duck generally nest within 50 m of water (Robertson and Savard, 2002). Nests are often located on small inland islands since these offer protection from most terrestrial predators. The depth of water preferred by breeding waterfowl varies by species. Long-tailed ducks (Robertson and Savard, 2002) and northern pintails (Austin and Miller, 1995) prefer shallow ponds for brood-rearing. Many species of waterfowl exhibit fidelity to specific nest sites and territories (philopatry) from year-to-year.

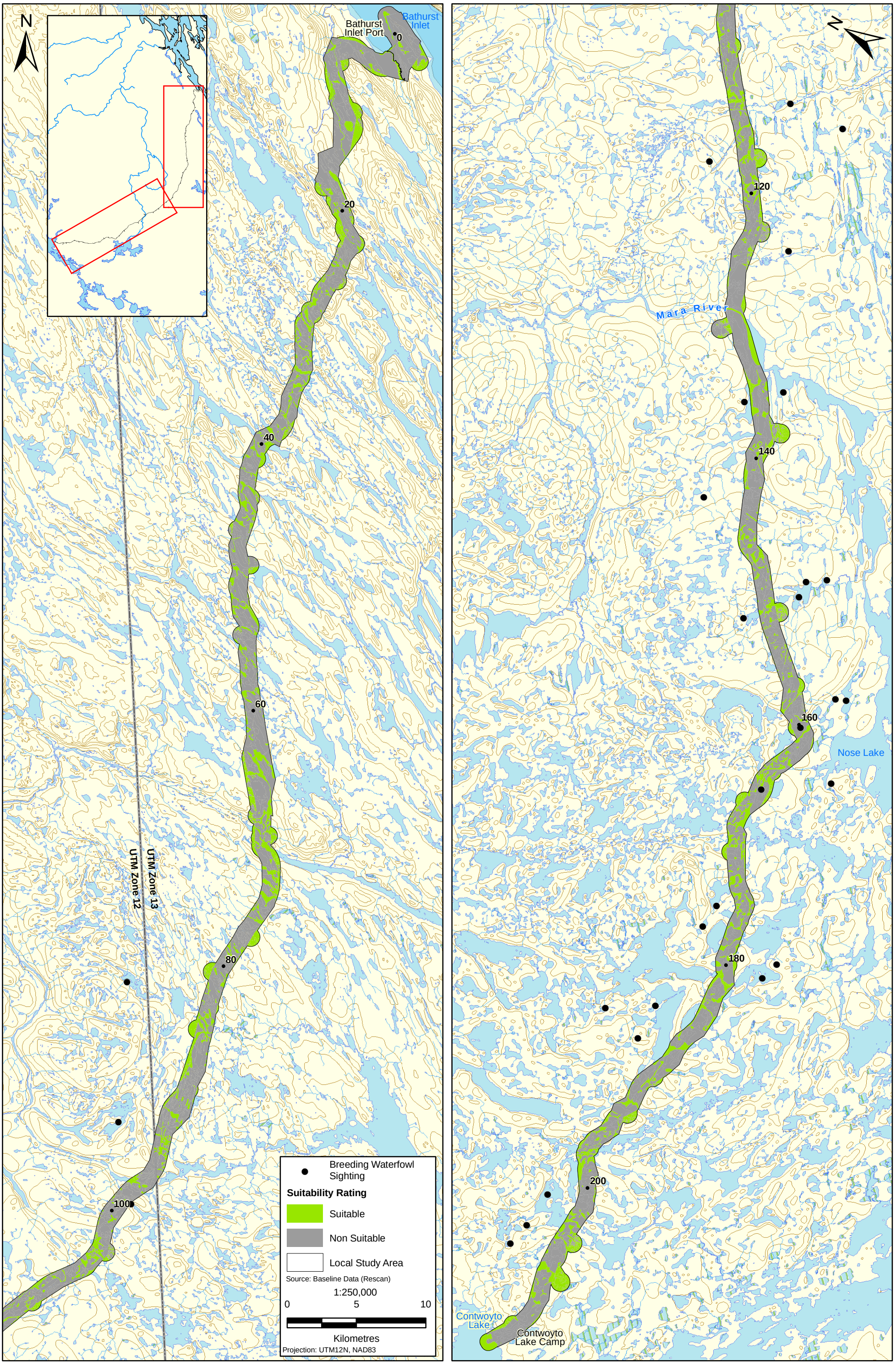
The long-tailed duck tends to nest in small colonies in tundra or tundra-like habitats in Arctic coastal and inland areas (Bellrose, 1976; Johnson and Herter, 1989). Nests are generally built close to the water's edge along ponds or lakes, or on islands; site selection may be influenced by predation pressure from foxes, jaegers, gulls and ravens (Bellrose, 1976; Johnson and Herter, 1989). Moulting habitats consist of deep, open lakes, and coastal lagoons (Robertson and Savard, 2002).

11.2 Results and Discussion

Results of the MAP indicate that large portions of the study area consist of wetlands (*e.g.*, sedge communities) and waterbodies that are associated with heath tundra communities (Table 11.2-1, Figure 11.2-1). Some of these wetlands, especially smaller waterbodies edged with emergent vegetation, are particularly suitable for long-tailed ducks.

Table 11.2-1
Area and Proportion of Suitable and Not Suitable Habitat within the LSA and RSA for Long-tailed Duck

Suitability Rating	Area in LSA (ha)	Percent of LSA	Area in RSA (ha)	Percent of RSA
Long-tailed Duck Spring/Nesting and Summer Brood Rearing				
Suitable	4,711	17.80	388,619	25.40
Not Suitable	21,727	82.20	1,113,066	74.60



Suitable Habitat for Waterfowl during the Spring / Nesting Season and Summer / Fledging Seasons

FIGURE 11.2-1

the Bathurst Inlet Port and Road Project

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12. CONCLUSION

12. Conclusion

The habitat suitability mapping exercise identified the locations and relative abundance of habitat types that are important to each wildlife VEC group in the LSA and the RSA associated with the proposed Project. The habitat suitability rating maps created allow for an estimate of seasonally important habitat that will be modified from the LSA and RSA, and the relative abundance of various habitat qualities in each. Essentially, the habitat suitability ratings present visual information on the locations and distribution of relatively high or low quality habitat for each selected species and season. Perhaps more importantly, the visual images produced allow for the examination of habitat that is potentially limiting in the LSA and RSA, the removal of which may impact wildlife.

The habitat suitability maps produced for the proposed Project identified three potentially limiting habitat features used by most VECs: esker complexes, riparian and birch communities and sedge wetlands. Heath tundra is also used to a great extent by many VECs, but does not appear to be a limiting habitat feature in the Project area. Results of the habitat suitability ratings exercise are presented in Table 12.1-1. In general, limited amounts of direct habitat loss will occur due to the proposed Project for most VECs, and where habitat will be lost, sufficient quantities appear to be present in adjacent areas associated with the larger RSA. Habitat loss that may have the greatest impact according to the maps produced includes the loss of high quality late winter/early spring habitat for muskox, spring and summer habitat for grizzly bears, spring/denning and summer/pup rearing for wolves, and growing/kit rearing habitat for wolverines.

The top rated habitats for all mammalian VECs were: eskers, sedge wetland, birch seep and riparian shrub. These habitats combined represent 10% of the LSA and 2% of the RSA. For most avian VECs, the top rated habitats for nesting and fledging seasons were those associated with standing or flowing water: riparian communities, waterbodies and wetlands. Cliff-nesting raptors and certain migratory birds were associated with cliffs adjacent to waterbodies and heath tundra communities, respectively.

The overall area of the Kitikmeot Region in Nunavut is 44,672,770 ha, of which, 3.36 % is situated in the RSA and 0.07 % is in the LSA.

Table 12.1-1
Summary Table of Habitat Preference by VEC and Season

VEC	Season	Preferred Habitat	Potentially Limiting	Figure Number
Caribou	Calving	open, flat tundra; cotton-grass and sedges	Yes	3.2-1
	Post-calving/Summer	eskers, lakes and lakeshores, riparian and sedge communities	Yes	3.2-2
	Winter	lichens	No	3.2-3
Muskox	Late Winter/Calving	sedge community, eskers, riparian shrub, heath tundra	Yes	4.2-1
	Rutting/Autumn	wetlands, riparian communities, valleys/lowlands	No	4.2-2
Grizzly Bear	Spring	eskers, saxifrage-blueberry, sedge and riparian communities	Yes	5.2-1
	Summer	eskers, saxifrage-blueberry, sedge and riparian communities	Yes	5.2-2
	Autumn	eskers, saxifrage-blueberry, sedge and riparian communities	No	5.2-3
	Winter	tundra, esker, heath boulder fields	No	5.2-4
Wolf	Spring/Denning	eskers	Yes	6.2-1
	Summer/Pup Rearing	eskers, riparian communities	Yes	6.2-2
Wolverine	Late Winter/Denning	boulder fields, heath tundra	No	7.2-1
	Growing/Kit Rearing	eskers, boulder fields	Yes	7.2-2
Migratory Birds				
Heath Community	Spring/Nesting and Summer/Fledging	heath tundra, boulder fields	No	8.2-1
Riparian Shrub Community	Spring/Nesting and Summer/Fledging	birch seep, riparian shrub communities	Yes	8.2-2
Sedge Community	Spring/Nesting and Summer/Fledging	sedge community	Yes	8.2-3
Cliff-nesting Raptor	Spring/Nesting and Summer/Fledging	bedrock cliffs adjacent to water	Yes	9.2-1
Ground-nesting Raptor	Spring/Nesting and Summer/Fledging	riparian shrub, birch seep, heath tundra, sedges	No	10.2-1
Waterfowl	Spring/Nesting	sedges, heath tundra, birch seep, riparian shrub, water	No	11.2-1
	Summer/Brood Rearing	riparian shrub, water, sedge community	Yes	11.2-2

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For an explanation of the abbreviations found throughout this reference list, please refer to the *Glossary, Acronyms and Abbreviations* section.

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APPENDIX 1
ECOLOGICAL LAND CLASSIFICATION UNITS WITHIN RSA

Appendix 1 – Ecological Land Classification Units within RSA

Bedrock Association: exposed bedrock with coverage in excess of 80%, supports very little vegetative cover. These areas are generally wind swept and moisture free. Crustose lichens are common, but vegetative coverage is highly variable and favours protected areas, crevices and depressions where growth can be initiated.

Birch Seep: dwarf birch is the dominant species; generally low-growing, but not prostrate; occurs on solifluction lobes and hummocks, but rarely on boulders; usually on gentle slopes where moisture seeps downslope on top of permafrost.

Boulder Association: boulder fields with a coverage in excess of 80%, including boulder outcrops, boulder streams and drainages, and glacial eratics. Boulders support a community of rock lichens, but little other plant growth.

Esker Complex: includes all communities occurring on esker landforms. Esker tops are usually sparsely vegetated; common species include three-toothed saxifrage and moss-campion with lesser amounts of crowberry and bearberry. Lee slopes support bands of dwarf birch and willow that may reach heights of 1 metre. Eskers provide significant topographic relief to a gently rolling tundra landscape. These linear structures of sand and gravel, formed by glacial rivers, can run for hundreds of kilometres and reach 30 metres in height. Eskers support a number of plant communities and are important habitat for wildlife. They are used as travel corridors by caribou, grizzly bears, wolves and other wildlife. The ice-free substrate of sand and gravel provides excellent den sites where digging is relatively easy.

Heath Tundra: the typical mesic tundra habitat; boulder and bedrock content is below 30%. The closed mat plant community grows on moderate to well drained soils and consists primarily of plants belonging to the heath family (*Ericaceae*). Low shrubs including dwarf birch, Arctic willow, northern Labrador tea, crowberry, cranberry, black and red bearberry, and blueberry are present, but herb and moss layers are not well developed.

Lichen Rock: mixture of crustose and fruticose lichens on rocks of various sizes; rocks about 80% covered with lichens on exposed surfaces; includes boulder fields, bedrock outcrops, cliff faces and ledges; lichens include map lichen, sunburst lichen, rock tripe and bloodspot lichen.

Riparian Complex: occurs in all active stream channels, usually with cobble or boulder substrate. The productive soil medium and constant availability of flowing water supports a tall shrub community. The herb layer is also well developed with bluejoint, dwarf raspberry, dwarf march-violet, and horsetail as common species.

Sedge Community: wetland complexes are typically wet sedge meadows, sedge fens and other areas of active seepage with non-tussock plant species. Sedge species such as *Carex aquatilis* and *C. bigelowii*, and cotton grass (*Eriophorum angustifolium*) are the dominant vegetation

types. Plant species occupy wet, low lying sites where standing water is present throughout much of the growing season. The substrate is usually organic or silty soils.

Unvegetated: includes exposed soil, gravel bars, beach materials, permanent snow and disturbance features, such as dens.

Water: includes deep and shallow water bodies, such as lakes, ponds, rivers and open water.

Additional Ecological Land Classification Units within LSA

Within Bedrock Association (RSA)

Avens Community: mountain avens is the dominant species; typically occurs on level, well-drained sites with gravelly to sandy soils; often occurs on exposed tops of ridges that are more stable than esker crests; includes various small sedges and grasses.

Within Esker Complex (RSA)

Saxifrage – Blueberry Community: patches of vegetation on xeric sites with thin or relatively unstable (wind blown) soil; mostly on the crests of eskers or drumlins; may include blueberry, prickly saxifrage, pussy-toes, bearberry, snow cinquefoil, dwarf fireweed and moss campion.

Within Water (RSA)

Lake: a naturally occurring static body of water greater than 2 metres deep; larger than 50 ha in size.

River: a large natural stream of water emptying into an ocean, lake or other body of water.

Pond: water bodies greater than 2 metres deep, but smaller than 50 ha in size.

Open Water: standing water bodies less than 2 metres deep.

Within Unvegetated (RSA)

Beach Material: Sorted sediments reworked by wave action; formed at the edge of fresh or saltwater bodies.

Disturbance Feature: area shows evidence of being significantly disturbed by animals, man or natural processes.

Gravel Bar: an elongated landform generated by waves and currents and usually running to the shore; composed of unconsolidated small rounded cobbles, pebbles, stones and sand.

Exposed Soil: unvegetated areas

Permanent Snow: occurs on south or southeast-facing slopes where deep snowbanks accumulate and remain into mid-summer; characterized by presence of least willow, grey mealy lichen, Labrador tea, and blueberry; in the northern part of the study area, pygmy buttercup, and in the southern part, bog laurel and mountain heather also occur.

APPENDIX 2
HABITAT RATINGS TABLES

Appendix 2
Habitat Ratings Tables

WATERFOWL Habitat	Spring/Nesting and Summer Brood Rearing
Heath Tundra	X
Birch Seep	X
Riparian Shrub	U
Lake	U
Pond	U
River	U
Open Water	U
Boulder Field	X
Lichen Rock	X
Bedrock Outcrop	X
Avens Community	X
Sedge Community	U
Esker	X
Saxifrage Blueberry	X
Gravel Bar	X
Exposed Soil	X
Beach Materials	U
Disturbance Feature	X
Permanent Snow	X

WATERFOWL Habitat	Spring/Nesting and Summer/Brood Rearing
Heath Tundra	X
Birch Seep	X
Riparian Shrub	U
Water	U
Boulder Field	X
Lichen Rock	X
Bedrock Outcrop	X
Sedge Community	U
Esker	X
Unvegetated	X

GROUND-NESTING RAPTORS - SHORT-EARED OWL Habitat	Spring/Nesting and Summer/Brood Rearing
Heath Tundra	U
Birch Seep	U
Riparian Shrub	U
Lake	U
Pond	U
River	U
Open Water	U
Boulder Field	X
Lichen Rock	X
Bedrock Outcrop	X
Avens Community	X
Sedge Community	U
Esker	U

H = High **N = Nil** **A = Associated** **(continued)**
M = Moderate **U = Suitable** **NA = Not Associated**
L = Low **X = Not Suitable**

Appendix 2
Habitat Ratings Tables (continued)

GROUND-NESTING RAPTORS - SHORT-EARED OWL	
Habitat	**Spring/Nesting and Summer/Brood Rearing**
Saxifrage Blueberry	U
Gravel Bar	X
Exposed Soil	X
Beach Materials	U
Disturbance Feature	X
Permanent Snow	X

GROUND-NESTING RAPTORS - SHORT-EARED OWL		
Sub-Habitat	**Spring/Nesting**	**Summer/Brood Rearing**
Heath Tundra	U	U
Birch Seep	U	U
Riparian Shrub	U	U
Water	U	U
Boulder Field	X	X
Lichen	X	X
Bedrock Outcrop	X	X
Sedge Community	X	X
Esker Complex	U	U
Unvegetated	U	U

MIGRATORY BIRDS - SEDGE COMMUNITY		
Habitat	**Spring/Nesting**	**Summer/Brood Rearing**
Heath Tundra	NA	NA
Birch Seep	NA	NA
Riparian Shrub	NA	NA
Lake	NA	NA
Pond	NA	NA
River	NA	NA
Open Water	NA	NA
Boulder Field	NA	NA
Lichen Rock	NA	NA
Bedrock Outcrop	NA	NA
Avens Community	NA	NA
Sedge Community	A	A
Esker	NA	NA
Saxifrage Blueberry	NA	NA
Gravel Bar	NA	NA
Exposed Soil	NA	NA
Beach Materials	NA	NA
Disturbance Feature	NA	NA
Permanent Snow	NA	NA

MIGRATORY BIRDS - SEDGE COMMUNITY		
Habitat	**Spring/Nesting**	**Summer/Brood Rearing**
Heath Tundra	NA	NA
Birch Seep	NA	NA
Riparian Shrub	NA	NA
Water	NA	NA
Boulder Field	NA	NA

H = High **N = Nil** **A = Associated** **(continued)**

M = Moderate **U = Suitable** **NA = Not Associated**

L = Low **X = Not Suitable**

Appendix 2
Habitat Ratings Tables (continued)

MIGRATORY BIRDS - SEDGE COMMUNITY

Habitat	Spring/Nesting	Summer/Brood Rearing
Lichen Rock	NA	NA
Bedrock Outcrop	NA	NA
Sedge Community	A	A
Esker	NA	NA
Unvegetated	NA	NA

MIGRATORY BIRDS - HEATH TUNDRA COMMUNITY

Habitat	Spring/Nesting	Summer/Brood Rearing
Heath Tundra	A	A
Birch Seep	A	A
Riparian Shrub	NA	NA
Lake	NA	NA
Pond	NA	NA
River	NA	NA
Open Water	NA	NA
Boulder Field	NA	NA
Lichen Rock	NA	NA
Bedrock Outcrop	NA	NA
Avens Community	NA	NA
Sedge Community	NA	NA
Esker	NA	NA
Saxifrage Blueberry	NA	NA
Gravel Bar	NA	NA
Exposed Soil	NA	NA
Beach Materials	NA	NA
Disturbance Feature	NA	NA
Permanent Snow	NA	NA
Heath Tundra	A	A
Birch Seep	A	A
Riparian Shrub	NA	NA
Water	NA	NA
Boulder Field	NA	NA
Lichen Rock	NA	NA
Bedrock Outcrop	NA	NA
Sedge Community	NA	NA
Esker	NA	NA
Unvegetated	NA	NA

MIGRATORY BIRDS - RIPARIAN SHRUB COMMUNITY

Habitat	Spring/Nesting	Summer/Brood Rearing
Heath Tundra	NA	NA
Birch Seep	NA	NA
Riparian Shrub	A	A
Lake	NA	NA
Pond	NA	NA
River	A	A
Open Water	NA	NA
Boulder Field	NA	NA
Lichen Rock	NA	NA

H = High **N = Nil** **A = Associated** **(continued)**
M = Moderate **U = Suitable** **NA = Not Associated**
L = Low **X = Not Suitable**

Appendix 2
Habitat Ratings Tables (continued)

MIGRATORY BIRDS - RIPARIAN SHRUB COMMUNITY

Habitat	Spring/Nesting	Summer/Brood Rearing
Bedrock Outcrop	NA	NA
Avens Community	NA	NA
Sedge Community	NA	NA
Esker	NA	NA
Saxifrage Blueberry	NA	NA
Gravel Bar	NA	NA
Exposed Soil	NA	NA
Beach Materials	NA	NA
Disturbance Feature	NA	NA
Permanent Snow	NA	NA

MIGRATORY BIRDS - RIPARIAN SHRUB COMMUNITY

Habitat	Spring/Nesting	Summer/Brood Rearing
Heath Tundra	NA	NA
Birch Seep	NA	NA
Riparian Shrub	A	A
Lake	NA	NA
Boulder Field	NA	NA
Lichen Rock	NA	NA
Bedrock Outcrop	NA	NA
Sedge Community	NA	NA
Esker	NA	NA
Unvegetated	NA	NA

WOLVERINE

Habitat	Late Winter/Den	Growing/Kit Rearing	Early Winter
Heath Tundra	M	L	M
Birch Seep	M	L	M
Riparian Shrub	M	M	M
Lake	M	M	M
Pond	M	M	M
River	M	M	M
Open Water	M	M	M
Boulder Field	M	M	M
Lichen Rock	H	M	M
Bedrock Outcrop	N	N	N
Avens Community	N	N	N
Sedge Community	L	M	M
Esker	M	H	H
Saxifrage Blueberry	M	H	H
Gravel Bar	N	N	N
Exposed Soil	N	N	N
Beach Materials	N	N	N
Disturbance Feature	N	N	N
Permanent Snow	N	N	N

***Water habitat = mod: most lakes are relatively small and shores of water bodies = excellent habitat.**

(continued)

H = High **N = Nil** **A = Associated**

M = Moderate **U = Suitable** **NA = Not Associated**

L = Low **X = Not Suitable**

Appendix 2
Habitat Ratings Tables (continued)

WOLVERINE Habitat	Late Winter/Den	Growing/Kit Rearing
Heath Tundra	H	M
Birch Seep	H	H
Riparian Shrub	H	H
Water	M	M
Boulder Field	H	M
Lichen Rock	M	M
Bedrock Outcrop	L	L
Sedge Community	M	M
Esker	M	H
Unvegetated	N	N

WOLF Habitat	Growing/Den	Summer/Pup Rearing	Winter
Heath Tundra	M	M	M
Birch Seep	H	M	M
Riparian Shrub	M	H	L
Lake	M	M	M
Pond	M	M	M
River	M	M	M
Open Water	M	M	M
Boulder Field	N	N	N
Lichen Rock	H	L	H
Bedrock Outcrop	M	M	M
Avens Community	M	M	M
Sedge Community	M	M	M
Esker	H	H	H
Saxifrage Blueberry	H	M	M
Gravel Bar	N	N	N
Exposed Soil	N	N	N
Beach Materials	N	N	N
Disturbance Feature	N	N	N
Permanent Snow	N	N	N

WOLF Habitat	Growing/Den	Summer/Pup Rearing
Heath Tundra	M	M
Birch Seep	H	M
Riparian Shrub	M	H
Water	M	M
Boulder Field	L	L
Lichen Rock	H	L
Bedrock Outcrop	M	M
Sedge Community	M	M
Esker	H	H
Unvegetated	N	N

***Water habitat = mod: most lakes are relatively small and shores of water bodies = excellent habitat.**

H = High **N = Nil** **A = Associated**

M = Moderate **U = Suitable** **NA = Not Associated**

L = Low **X = Not Suitable**

(continued)

Appendix 2
Habitat Ratings Tables (continued)

MUSKOX Habitat	Late Wi/Early Sp	Rutting/Fall
Heath Tundra	M	H
Birch Seep	H	H
Riparian Shrub	M	H
Lake	M	M
Pond	M	M
River	M	M
Open Water	M	M
Boulder Field	L	L
Lichen Rock	H	M
Bedrock Outcrop	L	L
Avens Community	M	L
Sedge Community	H	H
Esker	H	M
Saxifrage Blueberry	H	M
Gravel Bar	N	N
Exposed Soil	N	N
Beach Materials	N	N
Disturbance Feature	N	N
Permanent Snow	N	N

MUSKOX Habitat	Late Wi/Early Sp	Rutting/Fall
Heath Tundra	M	H
Birch Seep	H	H
Riparian Shrub	M	H
Water	M	M
Boulder Field	L	L
Lichen Rock	H	M
Bedrock Outcrop	L	L
Sedge Community	H	H
Esker	H	M
Unvegetated	N	N

CARIBOU Habitat	Calving	Post-Calving/Summer	Winter
Heath Tundra	M	M	H
Birch Seep	H	H	L
Riparian Shrub	H	H	L
Lake	M	L	L
Pond	M	H	L
River	M	M	L
Open Water	L	L	L
Boulder Field	L	L	M
Lichen Rock	H	L	H
Bedrock Outcrop	L	L	L
Avens Community	L	M	H
Sedge Community	M	H	L
Esker	L	H	H
Saxifrage Blueberry	L	H	H

H = High **N = Nil** **A = Associated**

M = Moderate **U = Suitable** **NA = Not Associated**

L = Low **X = Not Suitable**

(continued)

Appendix 2
Habitat Ratings Tables (continued)

CARIBOU Habitat	Calving	Post-Calving/Summer	Winter
Gravel Bar	N	N	N
Exposed Soil	N	N	N
Beach Materials	N	N	N
Disturbance Feature	N	N	N
Permanent Snow	L	M	N

CARIBOU Habitat	Calving	Post-Calving/Summer	Winter
Heath Tundra	M	M	H
Birch Seep	H	H	L
Riparian Shrub	H	H	L
Water	M	H	L
Boulder Field	L	L	M
Lichen Rock	H	L	H
Bedrock Outcrop	L	L	L
Sedge Community	M	H	L
Esker	L	H	H
Unvegetated	L	L	L

GRIZZLY BEAR Habitat	Spring	Summer	Autumn	Winter
Heath Tundra	M	M	H	H
Birch Seep	L	H	M	L
Riparian Shrub	M	H	H	L
Lake	L	N	N	N
Pond	M	L	L	N
River	H	M	L	N
Open Water	L	N	N	N
Boulder Field	L	N	N	M
Lichen Rock	H	N	H	M
Bedrock Outcrop	N	N	N	N
Avens Community	M	L	L	N
Sedge Community	M	H	M	L
Esker	H	H	H	H
Saxifrage Blueberry	H	M	H	N
Gravel Bar	N	N	N	L
Exposed Soil	N	N	N	L
Beach Materials	N	N	N	L
Disturbance Feature	N	N	N	M
Permanent Snow	N	N	N	N
Heath Tundra	M	M	H	H
Birch Seep	H	H	M	L
Riparian Shrub	H	H	H	L
Water	L	M	L	N
Boulder Field	L	L	L	M
Lichen Rock	H	L	H	M
Bedrock Outcrop	L	L	L	N
Sedge Community	M	H	M	L
Esker	H	H	H	H
Unvegetated	N	L	N	M

H = High **N = Nil** **A = Associated**
M = Moderate **U = Suitable** **NA = Not Associated**
L = Low **X = Not Suitable**

Appendix D-9
Caribou and Muskox Baseline Study

Author: **Rescan Environmental Services Ltd.**
Date: **October 2007**

the BATHURST INLET PORT AND ROAD PROJECT

Bathurst Inlet Port and Road Project

Nunavut, Canada

Bathurst Inlet Port and Road Caribou and Muskox Baseline Study

Prepared by:

Rescan™ Environmental Services Ltd.
Vancouver, British Columbia, Canada

October 2007

EXECUTIVE SUMMARY

Executive Summary

This report presents the results of aerial surveys conducted during five trips from the middle of May to the middle of September, 2007, corresponding to the spring migration, peak of calving, post calving, summer, and fall migration periods of the Bathurst, Ahiak and Dolphin and Union caribou herds (*Rangifer tarandus*). The goals of the 2007 caribou and muskox (*Ovibos moschatus*) baseline work were to:

1. observe the caribou population in the Bathurst Inlet Port and Road (BIPR) study area during spring migration, calving, post calving, summer and fall migration seasons;
2. observe the muskox population in the study area during the same period; and
3. record incidental observations of other wildlife species.

Caribou were sighted in the BIPR study area during all surveys at low densities except during the third survey flight (July 12 to 14), corresponding to the post-calving period. During this flight, 1,662 caribou were observed, composed of a dispersed nursery group. During the first flight in May (May 16 to 19), which corresponds to spring migration, 540 caribou were observed in 20 groups. Lower numbers of caribou (13 to 36 individuals) were observed during the rest of the survey flights. A total of 152 muskoxen were observed during surveys, comprised of 133 adults and 19 calves/juveniles. Incidental wildlife observations included three terrestrial mammals; wolf (*Canis lupus*), grizzly bear (*Ursus arctos horribilis*) and red fox (*Vulpes vulpes*), five birds: tundra swan (*Cygnus columbianus*), short-eared owl (*Asio flammeus*), rough-legged hawk (*Buteo lagopus*), Canada goose (*Branta canadensis*) and sandhill crane (*Grus canadensis*) and one marine mammal (seal spp.).

Caribou is a keystone species in the Arctic both biologically and culturally. Not only are caribou a main prey item of grizzly bears, wolves, wolverines (*Gulo gulo*) and other carnivores, they also influence the tundra landscape, such as the composition of plant communities and seasonal distribution of predators. Caribou, and caribou hunting, are also central to Inuit culture, identity, recreation, and kinship. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) has designated the Dolphin and Union herd as a sub-population of Special Concern due to high harvests without recent population estimates. Two species observed incidentally are listed by COSEWIC as species of Special Concern, the grizzly bear and the short-eared owl.

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ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations

BIPR	Bathurst Inlet Port and Road
CESCC	Canadian Endangered Species Conservation Council
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CWS	Canadian Wildlife Service
DEIS	Draft Environmental Impact Statement
GNWT ENR	Government of the Northwest Territories Department of Environment and Natural Resources
GPS	global positioning system
NPC	Nunavut Planning Commission
NWT	Northwest Territories
the Project	the Bathurst Inlet Port and Road Project
the proponent	Bathurst Inlet Port and Road Project Joint Venture
Rescan	Rescan Environmental Services Ltd.
RSA	Regional Study Area
SARA	Species at Risk Act (Canada)
TAH	total annual harvest
UNEP	United Nations Environment Programme
WKRLUP	West Kitikmeot Regional Land Use Plan

1. INTRODUCTION

1. Introduction

The Bathurst Inlet Port and Road (BIPR) Project (the Project) includes a proposed 211 km all-weather road to be developed in the Kitikmeot region of Nunavut. The proposed road will extend southward from a future port site at Bathurst Inlet to Contwoyto Lake. In order to determine the vulnerability of caribou and muskoxen to habitat changes resulting from the road construction and operation, baseline information on these herds using habitats associated with the road alignment is required.

Inuit and wildlife biologists in Nunavut have identified caribou as a keystone species in the Arctic. Caribou, along with muskoxen, provide food and income for Inuit, support carnivore populations, and alter vegetation communities over a vast area. Grizzly bear, wolves and wolverine have also been identified as culturally and biologically important species in the Kitikmeot region of Nunavut and each of these species rely on caribou and muskoxen for large proportions of their diet (Thorpe *et al.*, 2001).

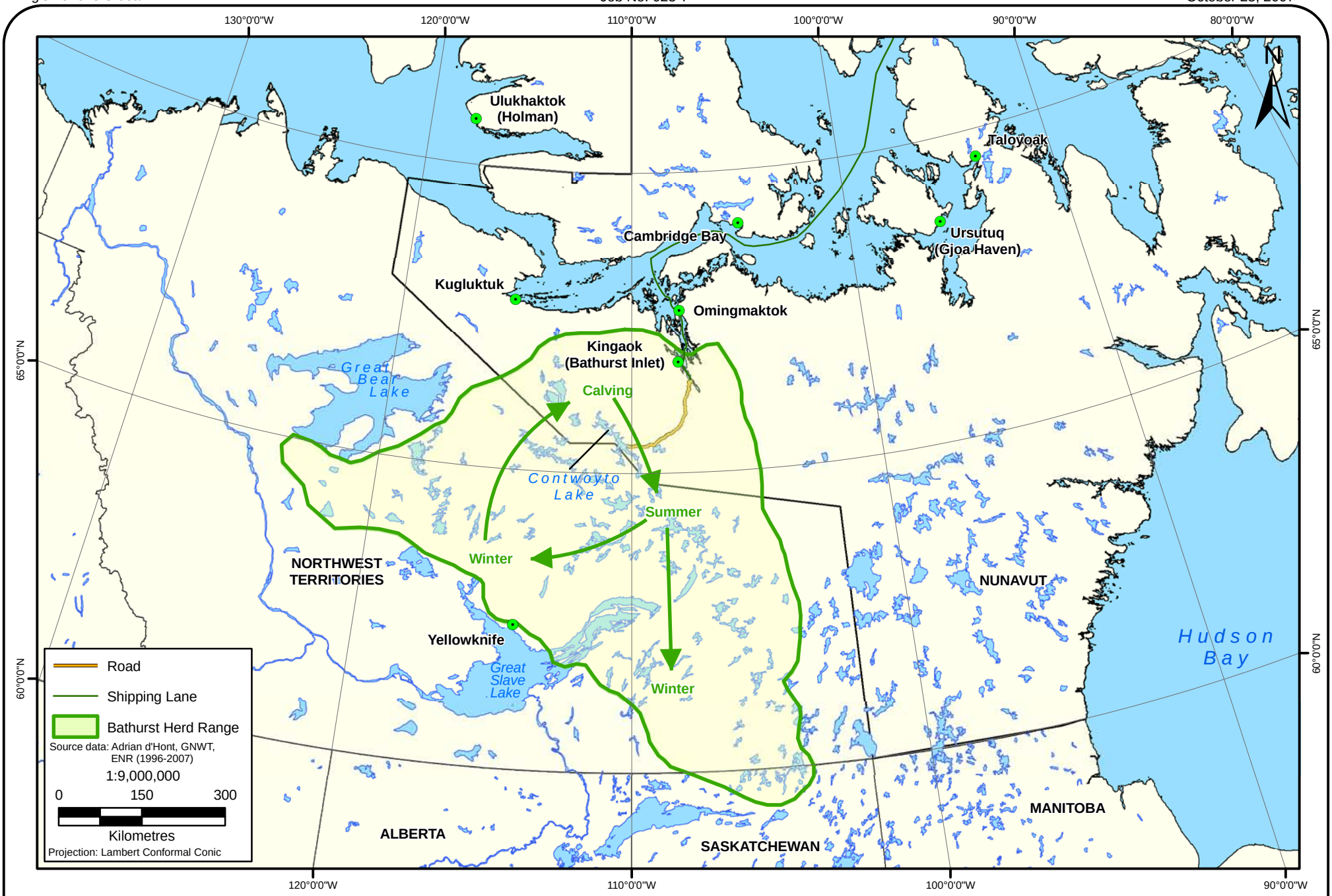
Three caribou herds have been recorded in the vicinity of the road: the Bathurst, Ahiak, and Dolphin and Union herds (Figures 1-1, 1-2, 1-3). Aerial surveys were undertaken in 2001 and 2002 to assess the seasonal distribution and abundance of caribou and muskox in the study area and to record incidental sightings of other large mammals (Appendix D-7 of the DEIS). In 2007, a second series of aerial surveys were conducted during key periods of the year for these animals. A data-sharing agreement between Dundee Precious Metals Inc. and Sabina Silver Corp. resulted in a larger area being surveyed for the road route during 2007 which included the area surrounding the proposed road route, and Hackett River (Sabina) and Back River (Dundee) sites. This baseline document reports the results of the 2007 aerial surveys.

1.1 Objectives

The objectives of this baseline study were to identify the abundance and distribution of caribou within the study area during key periods, including: spring migration, calving, post calving, summer, and fall migration.

The specific objectives were to:

- observe the caribou population in the study area during spring migration, calving, post calving, summer, and fall migration seasons;
- observe the muskox population in the study area during the same period; and
- record incidental observations of other large mammals such as grizzly bear, wolf, wolverine, fox, and moose (*Alces alces*).



the BATHURST INLET PORT AND ROAD PROJECT

Seasonal Range of Bathurst Caribou from 1996-2007 Satellite Collar Data

FIGURE 1-1

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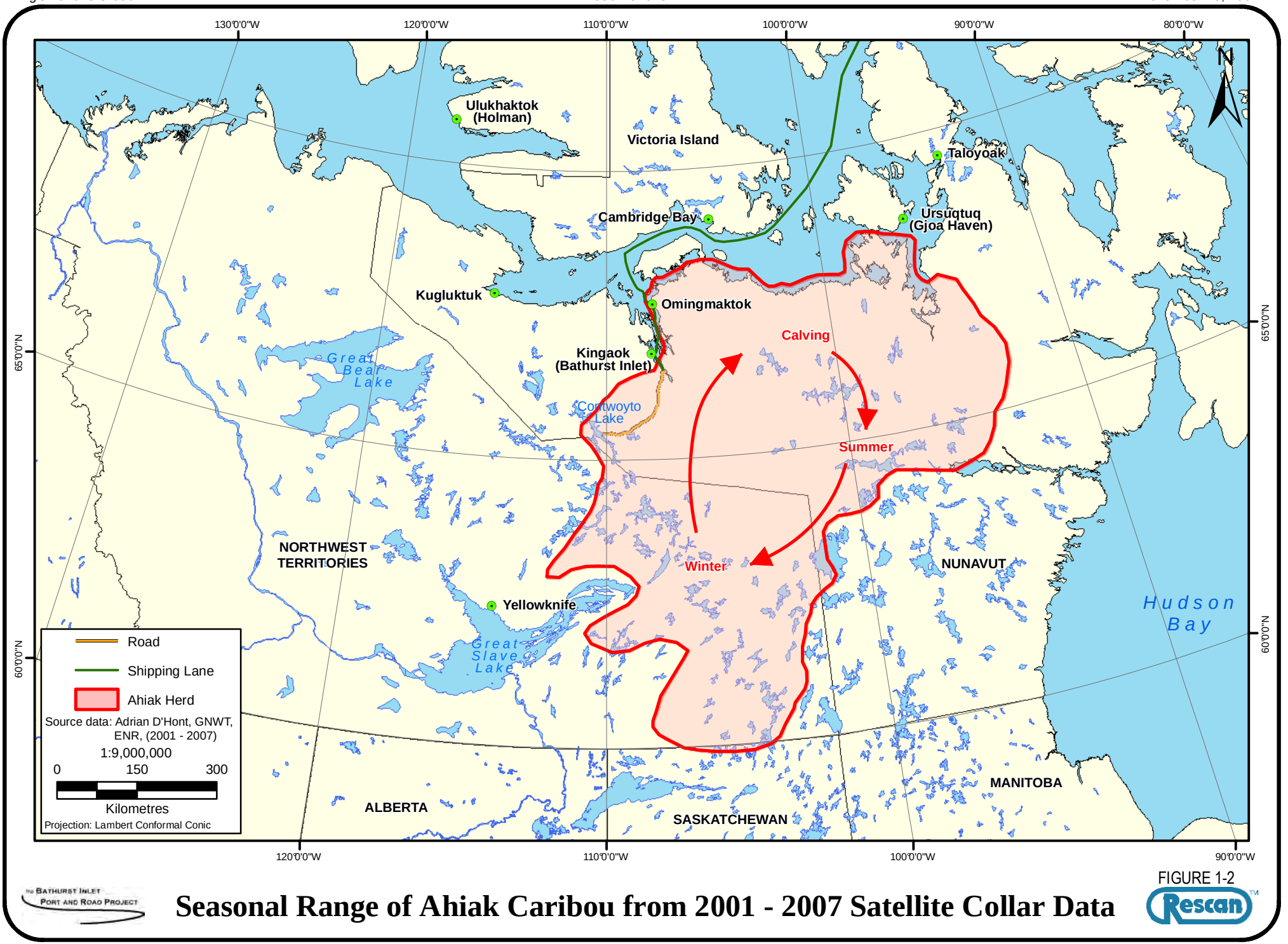
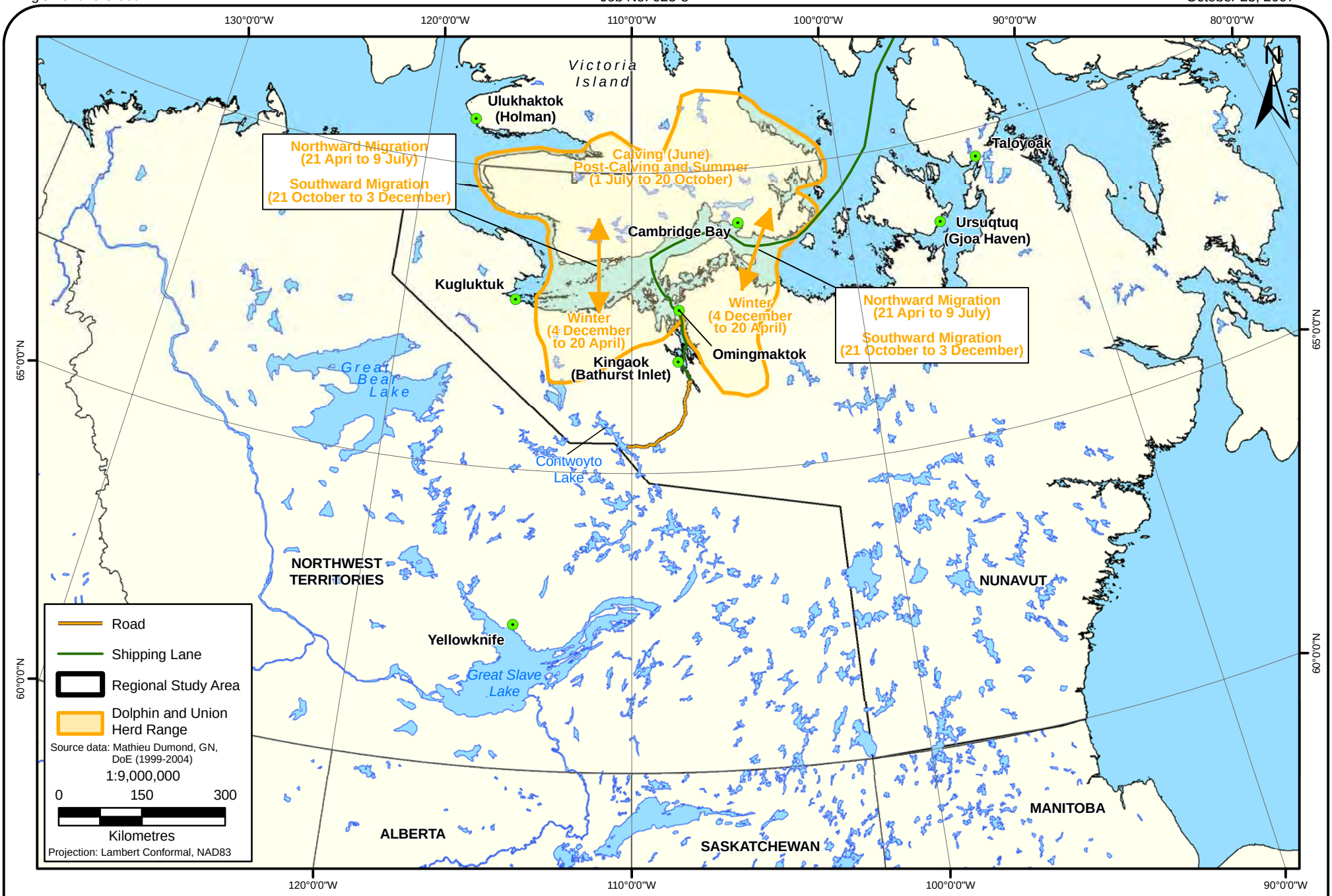


FIGURE 1-2

Seasonal Range of Ahiak Caribou from 2001 - 2007 Satellite Collar Data



Seasonal Range of Dolphin and Union Caribou from 1999-2004 Satellite Collar Data

the Bathurst Inlet Port and Road Project

FIGURE 1-3

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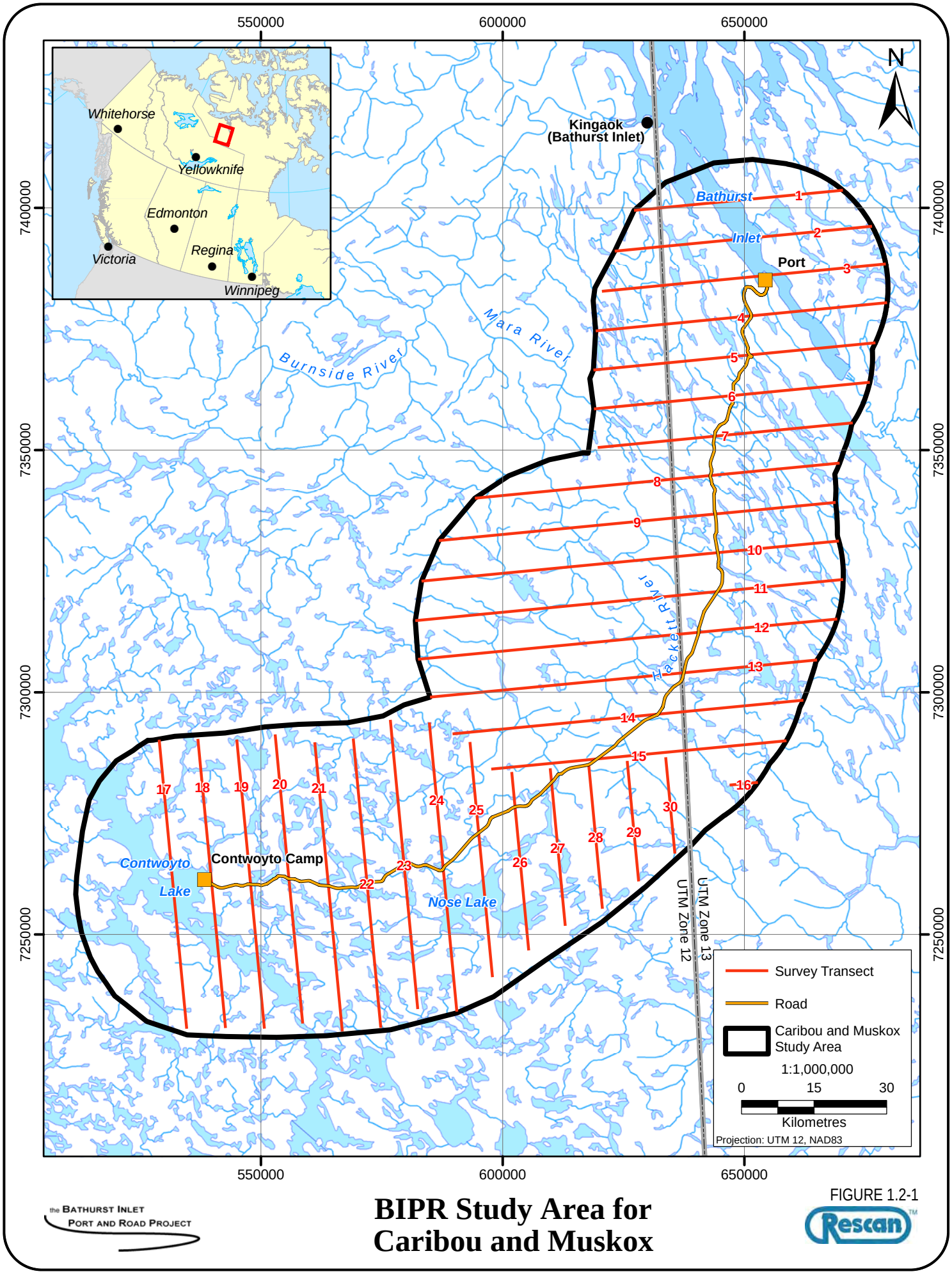
1.2 Study Area

In May 2007, Dundee Precious Metals Inc. and Sabina Silver Corp. entered in a data-sharing agreement for large mammal surveys for the Hackett River, Back River, and BIPR projects. The resulting caribou and muskox Regional Study Area (RSA) extends an average of 30 km from the road and port facility and covers an area of 1,476 km^2. The RSA also includes some areas to the west of the road route around the Hackett River Project (Sabina) (Figure 1.2-1).

Aerial surveys within the RSA included 30 transects with a total area of 184.5 km^2 or 12.5% of the RSA. Transects were arranged east-west for the Hackett and Back River survey areas (the northern two-thirds of the RSA) and north-south transects for the southern portion of the study area (Figure 1.2-1).



the Bathurst Inlet Port and Road Project

BIPR Study Area for Caribou and Muskox

FIGURE 1.2-1

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2. METHODS

2. Methods

2.1 Aerial Surveys

Five surveys were flown during the spring, summer, and fall of 2007 (Table 2.1-1). Surveys were scheduled to correspond with spring migration, peak of calving, post calving, summer and fall migration periods for caribou. The May and June surveys occurred in the Back River and Hackett River study areas (Transects 1 to 16 in Figure 1.2-1; Table 2.1-1) which covered the northern two-thirds of the road. The July and September surveys covered the entire study area (Transects 1 to 30) with some exceptions due to bad weather in September (Table 2.1-1).

Table 2.1-1
Survey Dates and Transects Flown, Aircraft and Observers

Survey	Date	Transects Flown	Aircraft Type
1	May 16 to 19	1 to 16	Cessna 185
2	June 11 and 12	1 to 16	Turbo Beaver
3	July 12 to 14	1 to 30	Cessna 185
4	July 29 to 30	1 to 30	Cessna 185
5	September 7 to 9 and 11 to 13	1 to 6 and 17 to 20	Cessna 185

Aerial surveys were conducted using standard census techniques for large mammals. Survey lines were parallel and spaced 8 km apart. The aircraft followed predetermined survey lines using an onboard Garmin global positioning system (GPS) at an elevation of 400 feet (122 m) and speed of approximately 150 km/hr.

The width of the survey transect was 500 m on either side of the airplane. Each observer calibrated this distance before the survey by having the airplane fly over two markers at an elevation of 400 feet. The markers were spaced 500 m apart and the observers noted the angle of the outside marker against calibration markers that were placed on the wing struts.

During survey flights, observers noted the sexes and numbers of caribou observed and the approximate distance that the animals were from the aircraft in 100 m increments. When large groups were observed, the airplane circled the group in order to achieve a more accurate count. Each observer counted the caribou independently and counts of each observer were averaged. Caribou were classified as bulls, cows, young and nursery groups were identified (Appendix 1). Muskoxen were classified as either adults or calves. The location and habitat for each observation were also recorded (Appendix 1). All animals observed off-transect during ferry flights were also recorded.

Survey conditions were noted for each survey flight, including the aircraft type, pilot, observers, snow cover, air temperature, wind speed, visibility, and survey time.

Incidental observations were also recorded for a variety of wildlife and birds which can be identified from aircraft (Appendix 2).

3. RESULTS

3. Results

3.1 Caribou

Five caribou surveys were conducted in 2007 during May, June, early July, late July, and September. These surveys correspond with the spring migration, calving, post calving, summer, and fall migration periods for Bathurst and Ahiak caribou (Russel, 1998; Gunn *et al.*, 2002; Johnson *et al.*, 2005). Caribou from the Bathurst and Ahiak herds were observed in the study area with a peak in caribou numbers during the post-calving period (early July). Caribou were classified as Bathurst or Ahiak animals based on field observations of colour—Bathurst caribou are typically lighter than Ahiak caribou—and by plotting the distribution of satellite collared animals for the 5 days before and after the survey flight in 2007.

The first survey was conducted on May 16 to 19, 2007, during the spring caribou migration period. Five hundred and forty caribou were observed in 20 groups, of which nine were groups of females (Figure 3.1-1, Table 3.1-1). The distribution of collared Bathurst and Ahiak caribou in the area five days before and after the survey suggests that the observed animals were from either the Bathurst or Ahiak herd (Figure 3.1-2). However, observations in the field suggest that observed animals were from the Ahiak herd. Observed caribou were light in colour and similar to the lighter Ahiak caribou than the darker coloured Bathurst herd (K. Poole, *Personal Communication*).

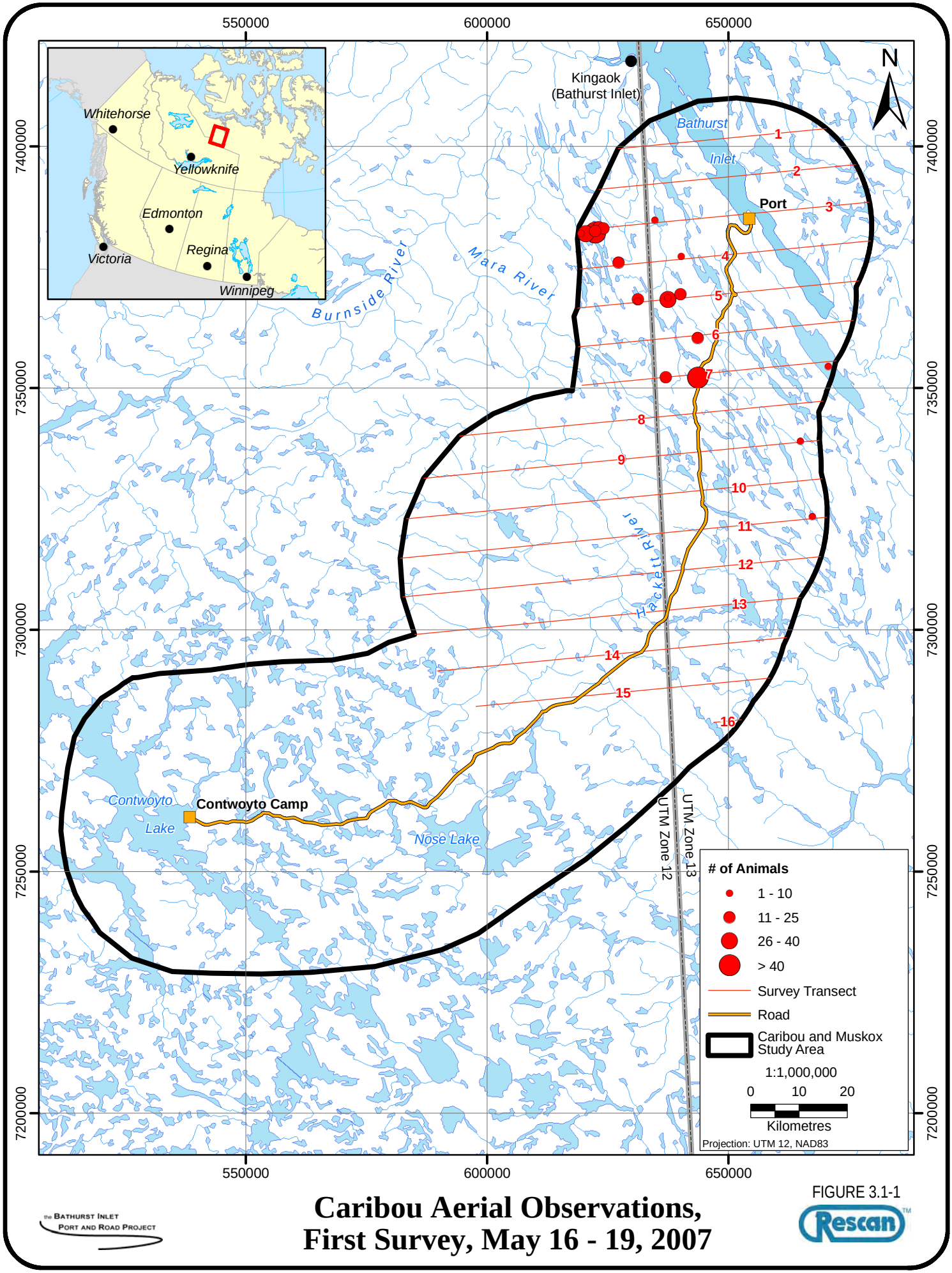
Table 3.1-1
Results of Caribou Aerial Surveys, 2007

Survey Timing	Transects	Bulls	Cows	Calves and Juveniles	Unknown	Total on Transect	Proportion Suspected B/A[1]
May 16 to 19	1 to 20	7	146	0	386	540	0/100
June 11 and 12	1 to 20	7	6	0	0	13	100/0
July 12 and 14	1 to 30	0	0	0	1662	1662	100/0
July 29 to 30	1 to 30	9	4	0	1	14	100/0
September 7 to 9 and 11 to 13	1 to 6 and 21 to 24	0	5	3	28	36	100/0

[1]**Proportion of caribou observed determined to be Bathurst (B) or Ahiak (A) based on colouration and locations within the survey area compared to collared caribou locations.**

The second survey was conducted on June 11 and 12, 2007, during the peak of calving period. Few caribou were observed (13 caribou in 2 groups) on the western edge of the study area (Figure 3.1-3). The Bathurst calving ground is typically between Hood and James Rivers to the north-west of the study area. Satellite collared animals from the Bathurst herd were located in the identified calving area in the five days before and after the aerial survey during 2007 (Figure 3.1-4). These data suggest that the caribou observed during the survey were Bathurst caribou on the edge of the calving ground for this herd.

The third survey was conducted from July 12 to 14, 2007, during the post-calving period; 1,662 caribou were observed composed of a single, large, dispersed nursery group (Figure 3.1-5).



Caribou Aerial Observations, First Survey, May 16 - 19, 2007

FIGURE 3.1-1

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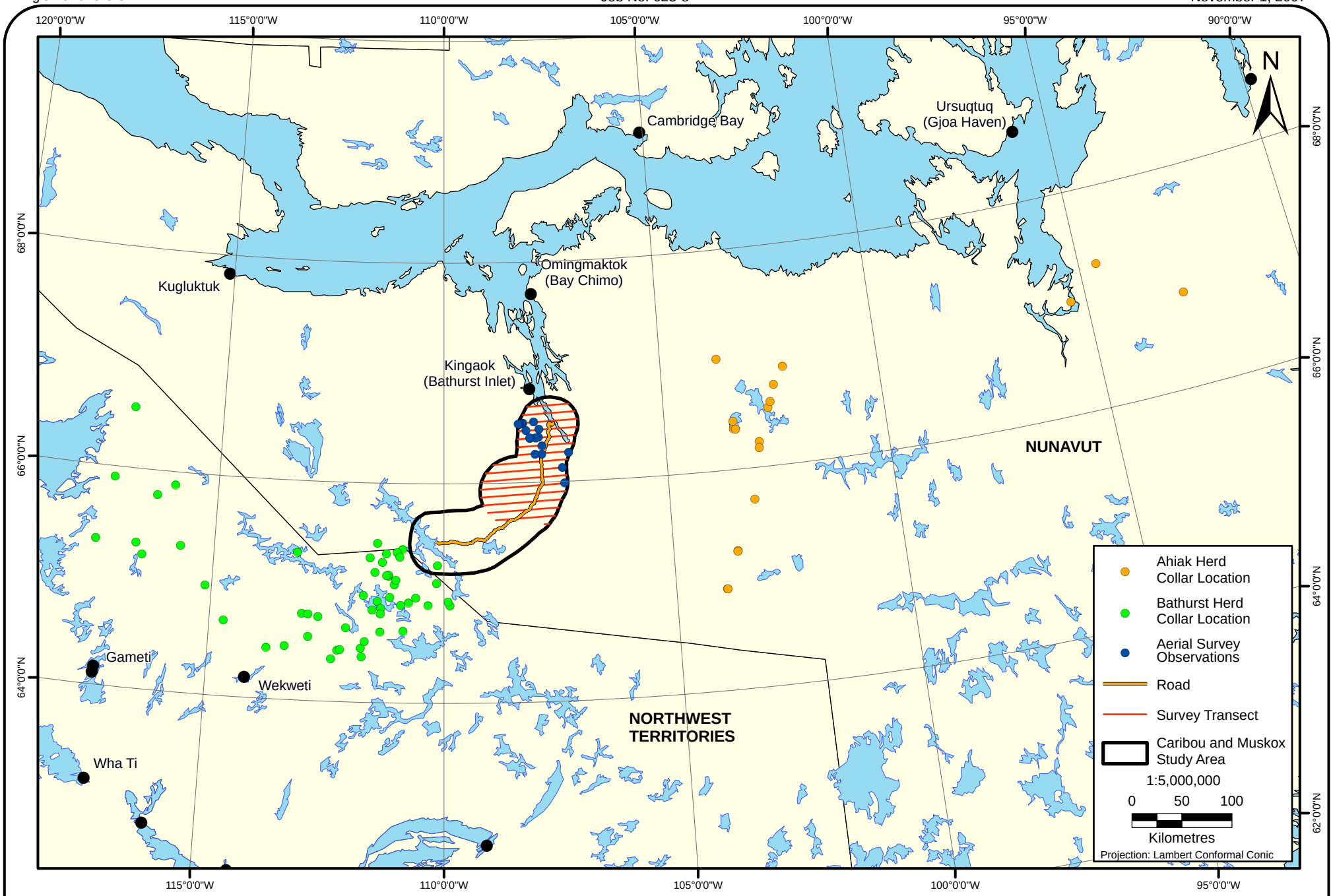

Locations of Collared Bathurst and Ahiak Caribou, May 11-24 2007

the Bathurst Inlet Port and Road Project

FIGURE 3.1-2

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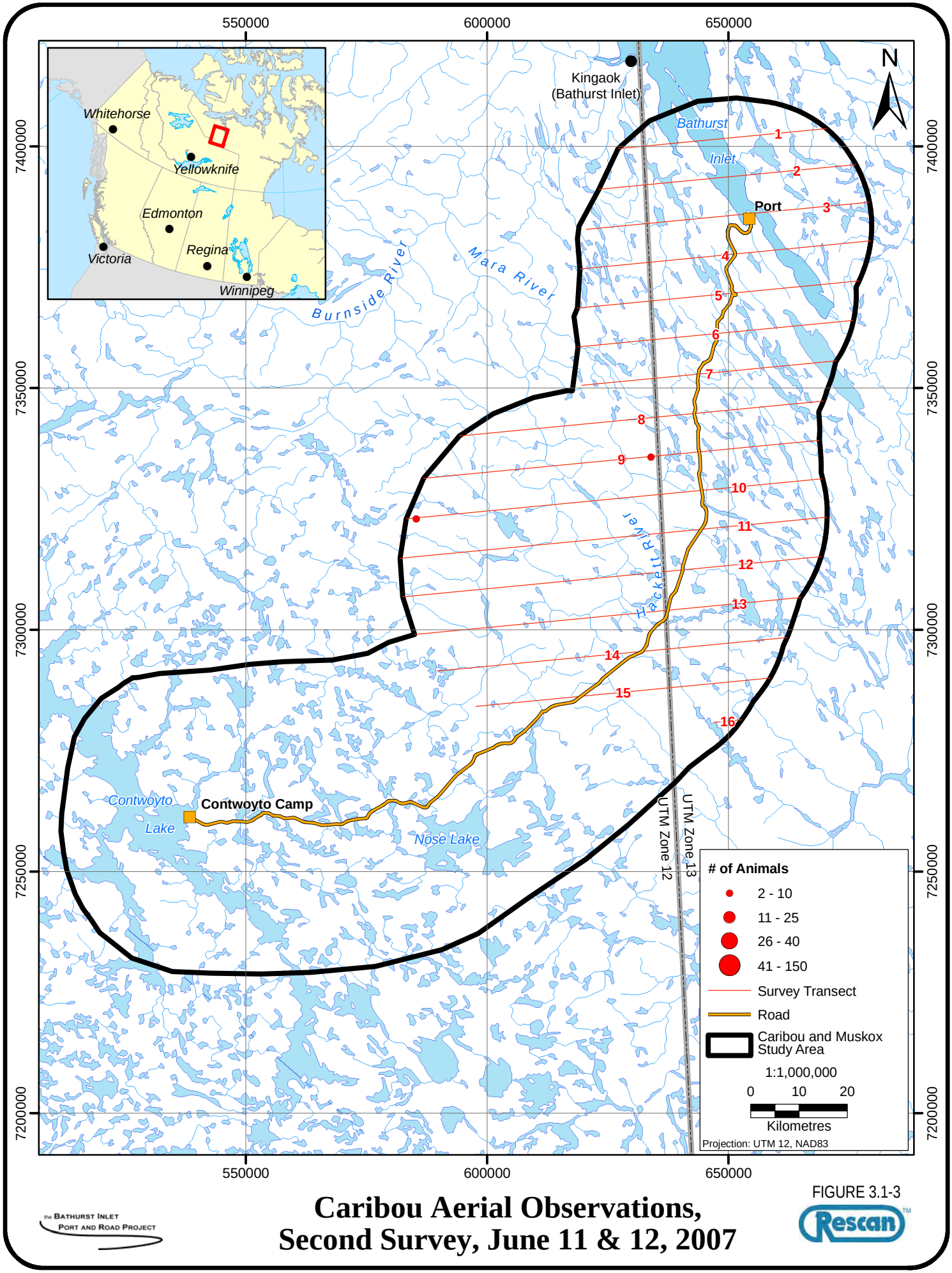

FIGURE 3.1-3

Caribou Aerial Observations, Second Survey, June 11 & 12, 2007

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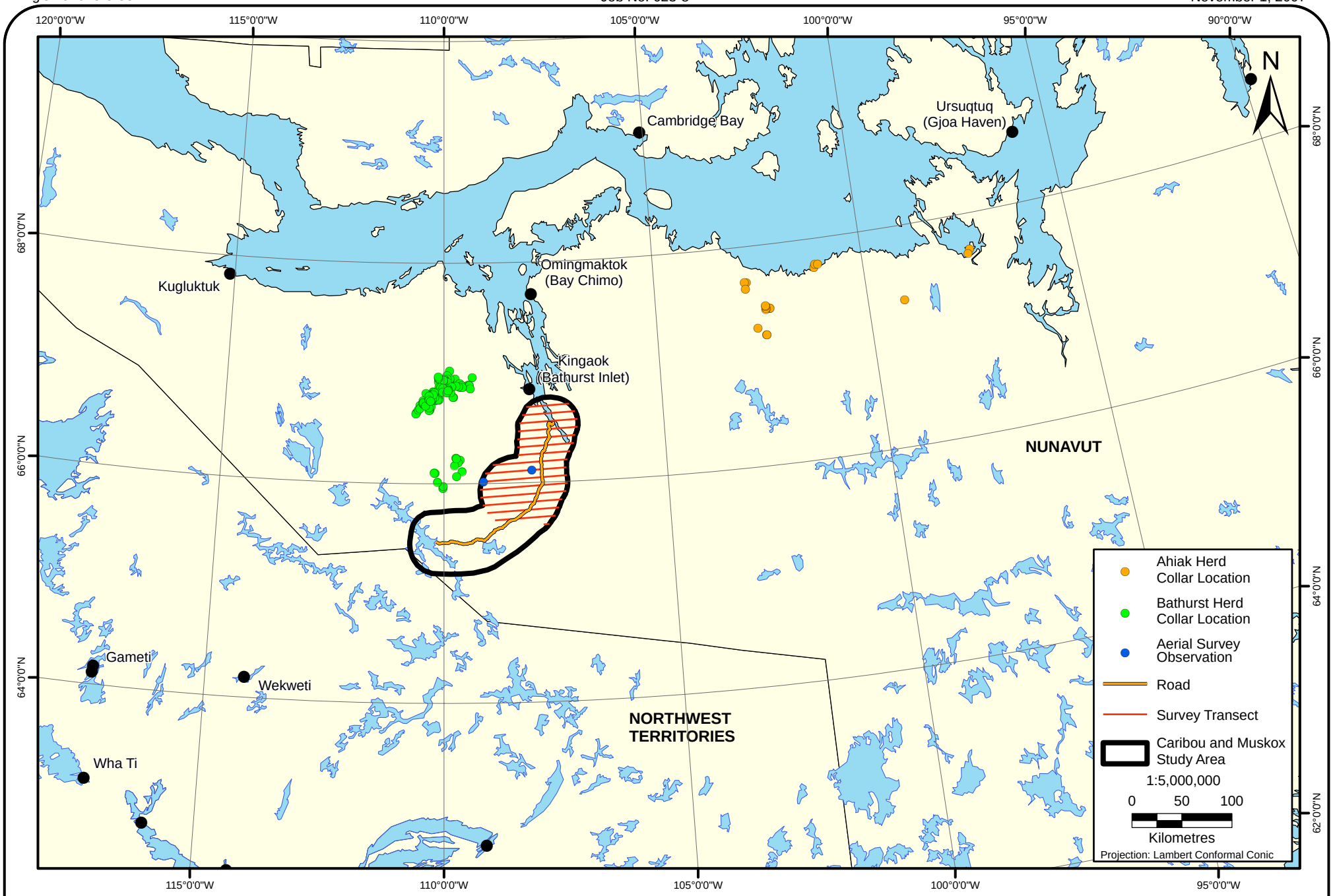

Locations of Collared Bathurst and Ahiak Caribou, June 7-17, 2007

the Bathurst Inlet Port and Road Project

FIGURE 3.1-4

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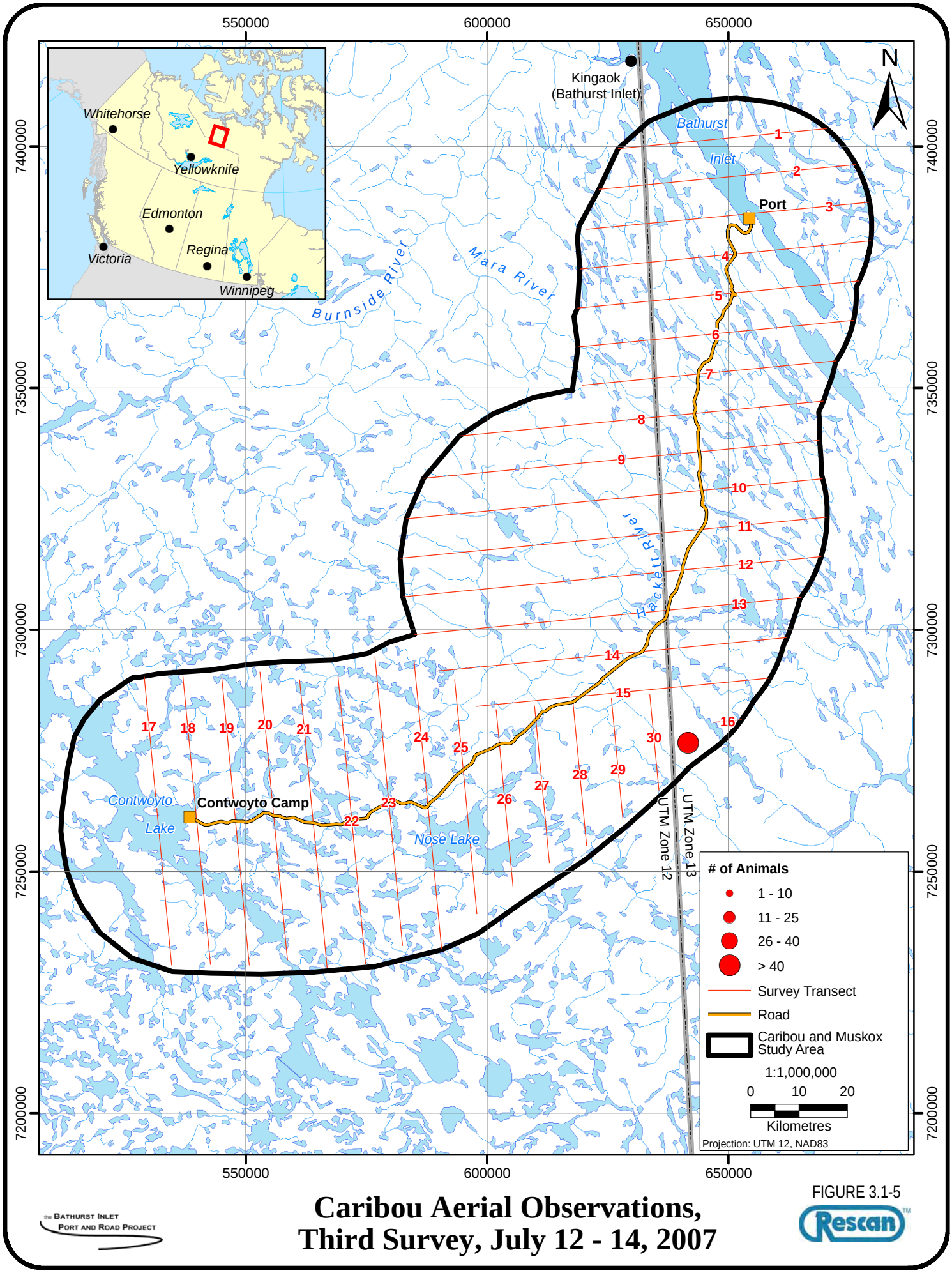

FIGURE 3.1-5

Caribou Aerial Observations, Third Survey, July 12 - 14, 2007

the Bathurst Inlet Port and Road Project

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Collared caribou from the Bathurst herd five days before and after the aerial survey moved out of the calving ground and south-east across the RSA (Figure 3.1-6). During the same period, Ahiak caribou were located to the northeast of the study area during the post calving period. Hence the observed caribou were likely Bathurst herd caribou.

The fourth survey was conducted on July 29 to 30, 2007, during the summer period for caribou. Fourteen caribou were observed as separate, dispersed individuals, none of which were nursery groups (Figure 3.1-7). Collared caribou from both the Bathurst and Ahiak herds occurred near the study area during July 23-31 (Figure 3.1-8) suggesting that the observed caribou could be from either herd. However, the observed animals were dark in colour, suggesting that the observed caribou were from the Bathurst herd.

The fifth survey was conducted on September 7-13, 2007, during the late summer period for caribou. However, poor weather restricted the survey to 10 of the 30 transects along the BIPR road. Thirty-six caribou were observed in two groups, both of which were nursery groups (Figure 3.1-9). Animals were dark in colour suggesting that they were Bathurst herd animals, but collar data suggests that caribou from both Bathurst and Ahiak herds are present in the RSA during the fall migration period (Figure 3.1-10). As satellite collar data were not yet available for September 2007 at the time or report writing, data from September 2006 was used instead.

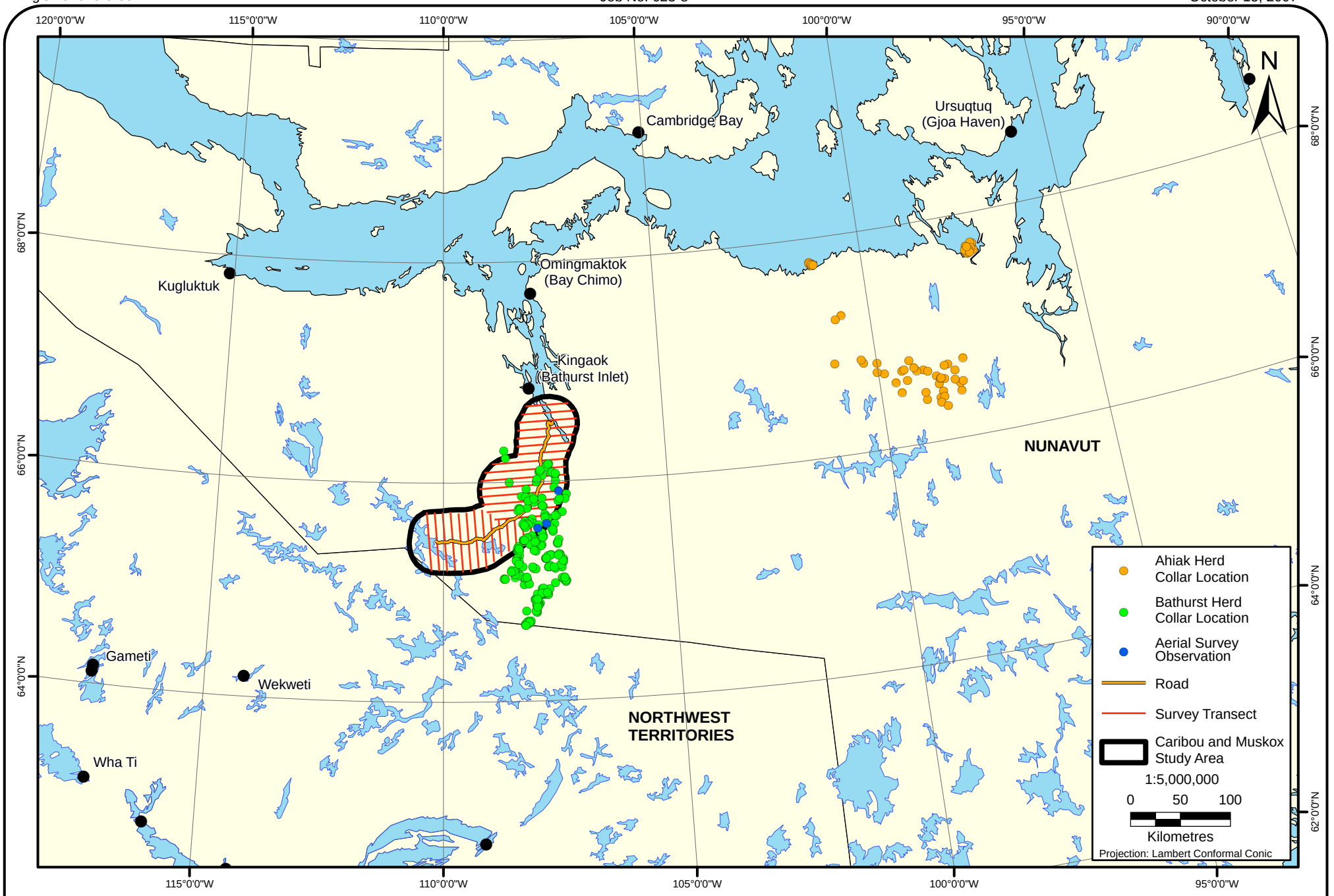
3.2 Muskox

Observations of muskox were also recorded during the caribou surveys. When muskox were observed, group size and location was noted along with the number of adult and juveniles within each group. A total of 152 muskox were observed in the study area, comprised of 133 adults and 19 calves/juveniles (Figure 3.2-1, Table 3.2-1). A small group of muskox were observed in multiple surveys at the northern end of the study area and a larger group of *ca*. 15 individuals were observed in the centre of the survey area. In contrast to caribou, muskox occupy a relatively small home range of approximately 70 km^2 during the year (Reynolds, 1998). Those groups observed on more than one survey may represent resident herds in the study area.

Three groups of muskox were observed in the southern RSA during the fourth aerial survey. The third and fourth surveys were the only complete surveys of the southern RSA (transects 17-30).

Table 3.2-1
Observations of Muskox during Caribou Aerial Surveys, 2007

Survey Timing	Transects	Adults	Calves and Juveniles	Total on Transect
May	1 to 16	37	6	43
June	1 to 16	5	0	5
Early July	1 to 30	16	1	17
Late July	1 to 30	75	12	87
September	1 to 6 and 21 to 24 (572.4 km^2)	0	0	0



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Locations of Collared Bathurst and Ahiak Caribou, July 8-19

FIGURE 3.1-6

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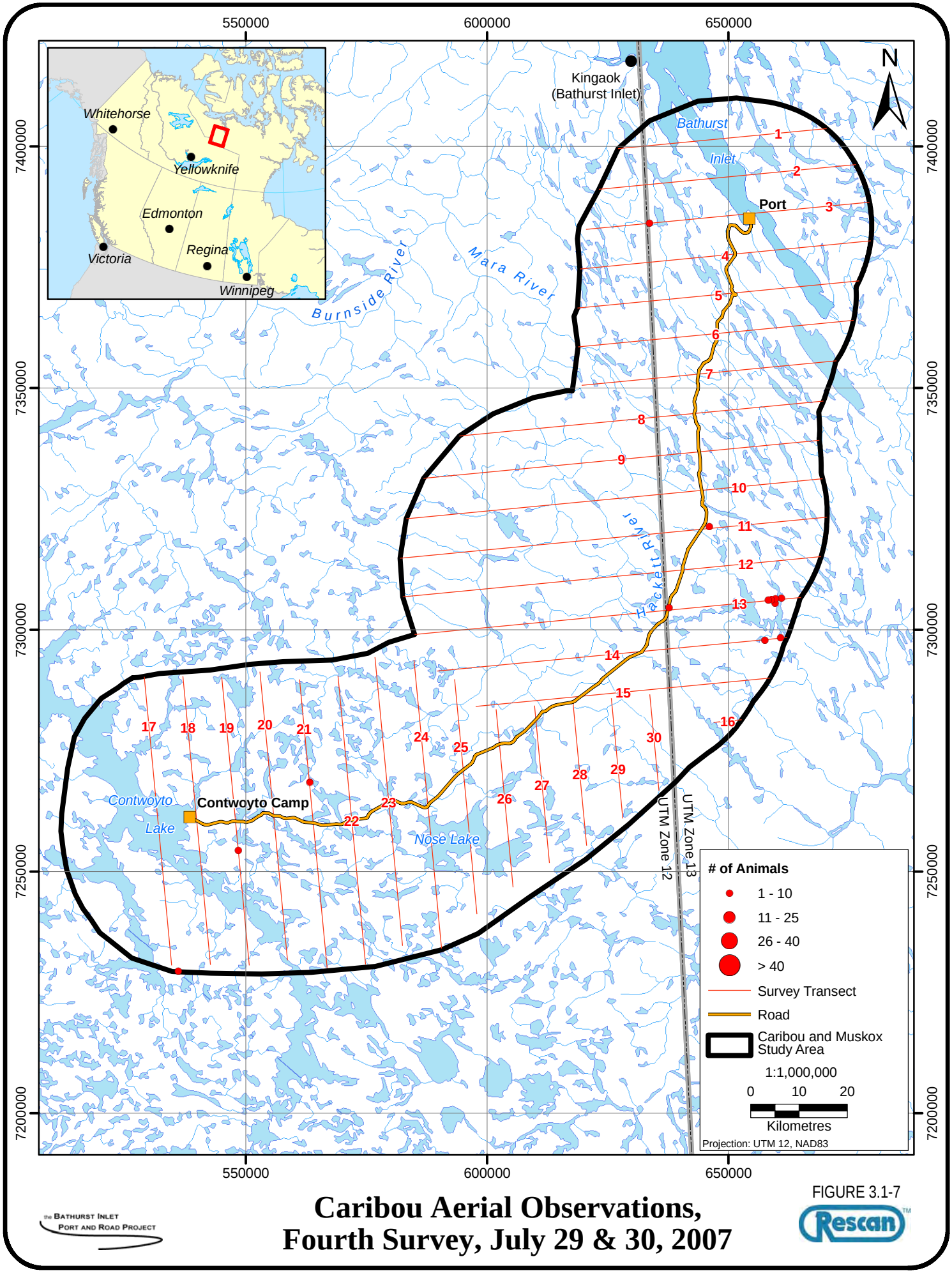

Caribou Aerial Observations, Fourth Survey, July 29 & 30, 2007

FIGURE 3.1-7

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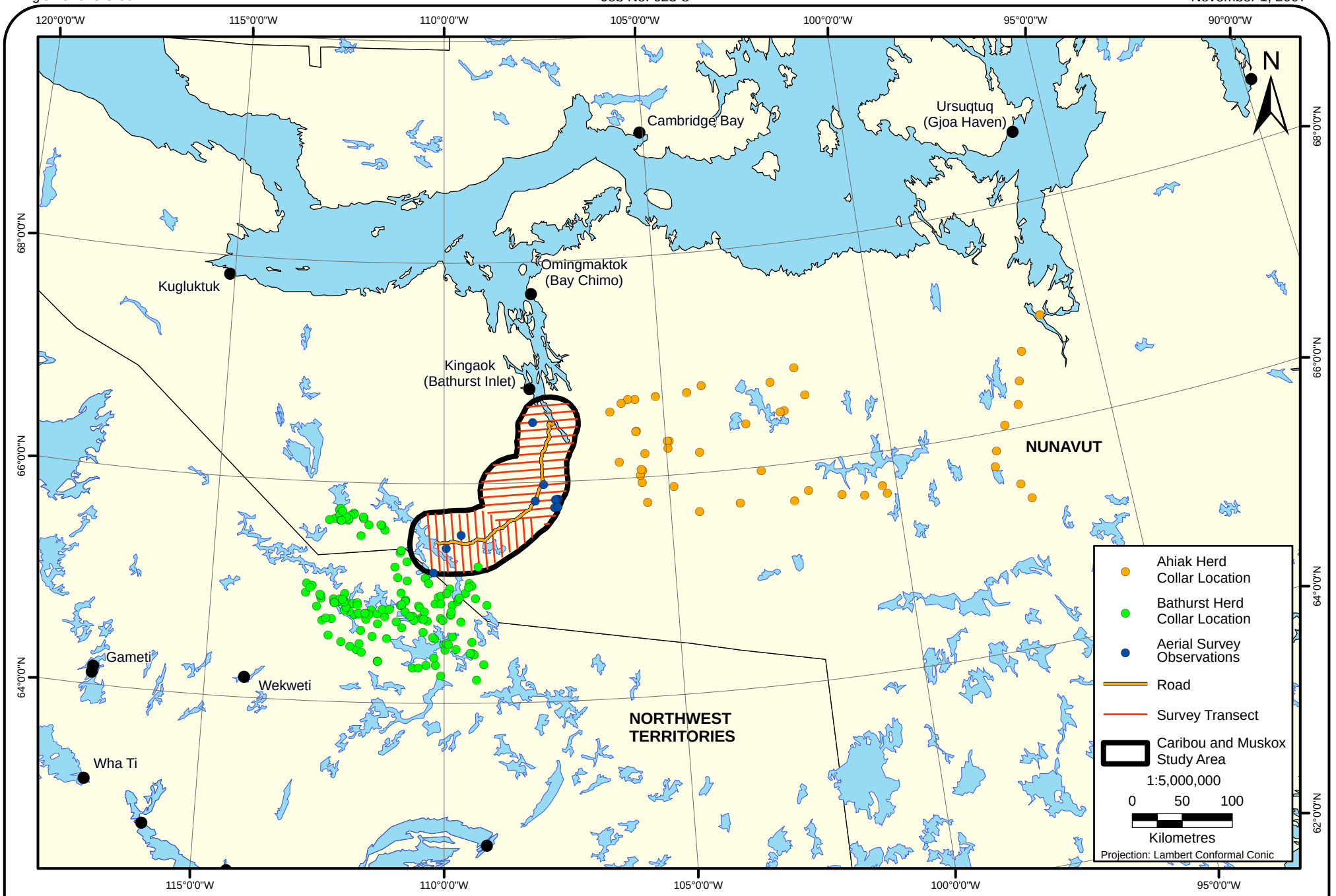

Locations of Collared Bathurst and Ahiak Caribou, July 23-31, 2007

the Bathurst Inlet Port and Road Project

FIGURE 3.1-8

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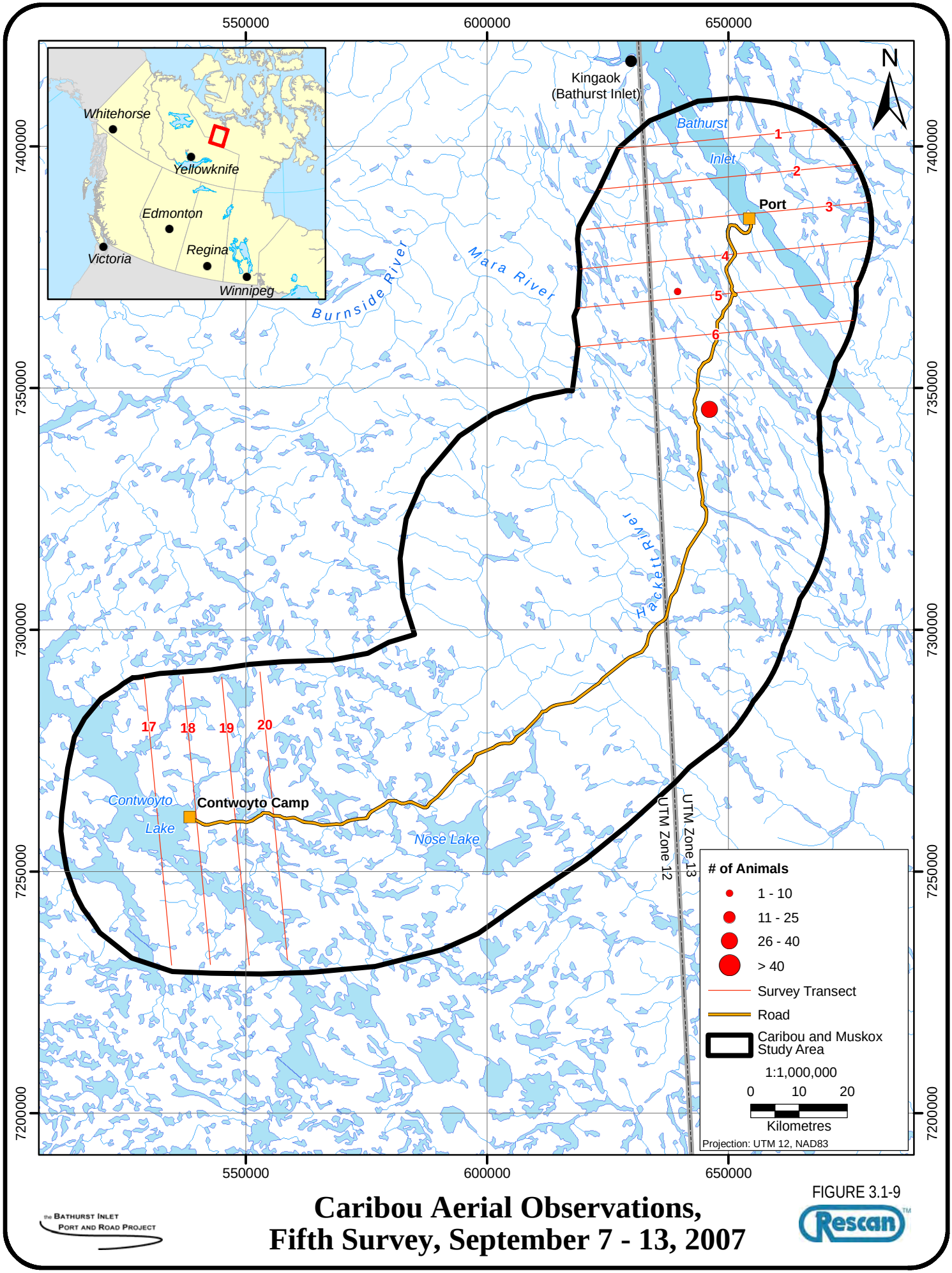

Caribou Aerial Observations, Fifth Survey, September 7 - 13, 2007

FIGURE 3.1-9

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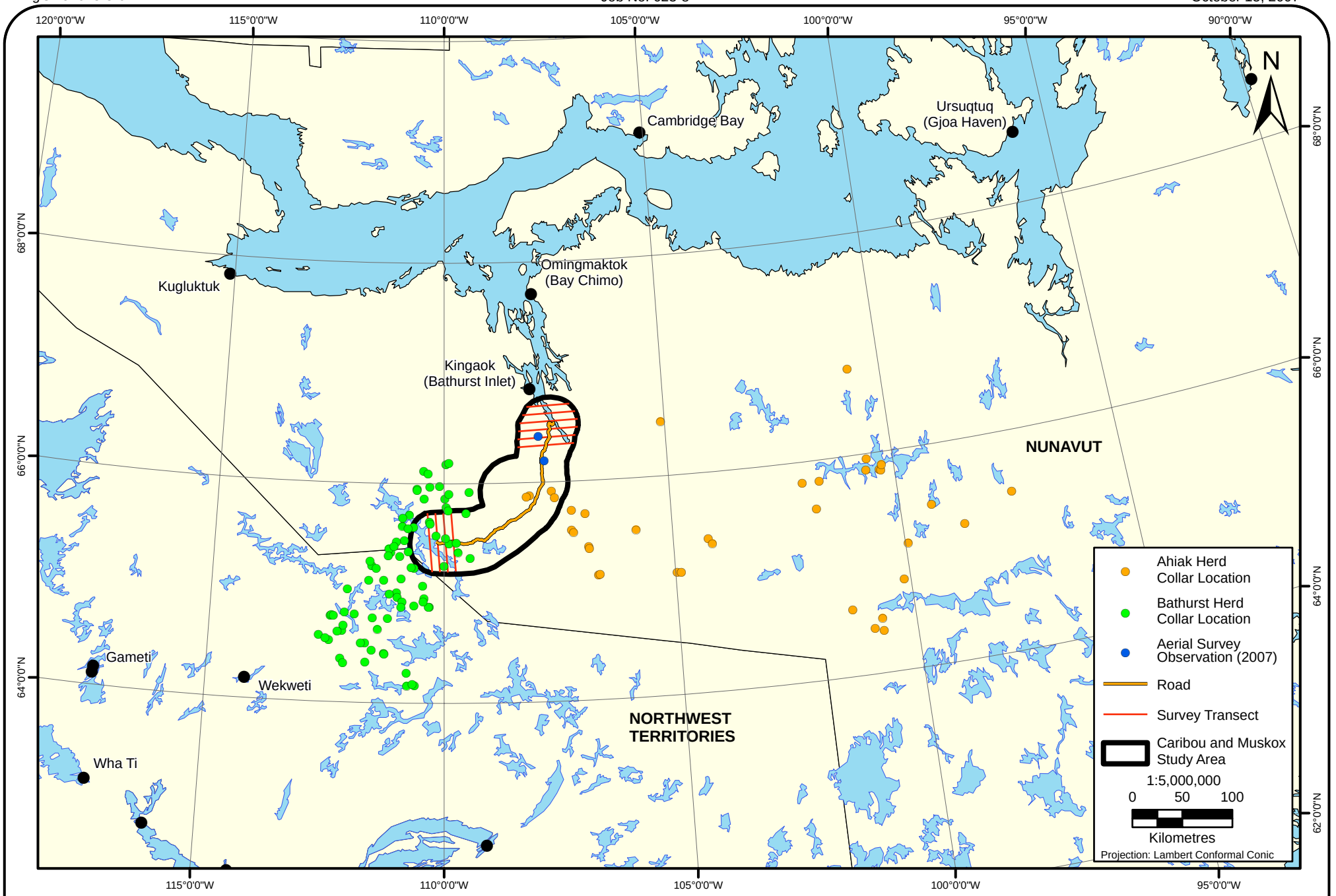

Locations of Collared Bathurst and Ahiak Caribou, September 3-30, 2006

the Bathurst Inlet Port and Road Project

FIGURE 3.1-10

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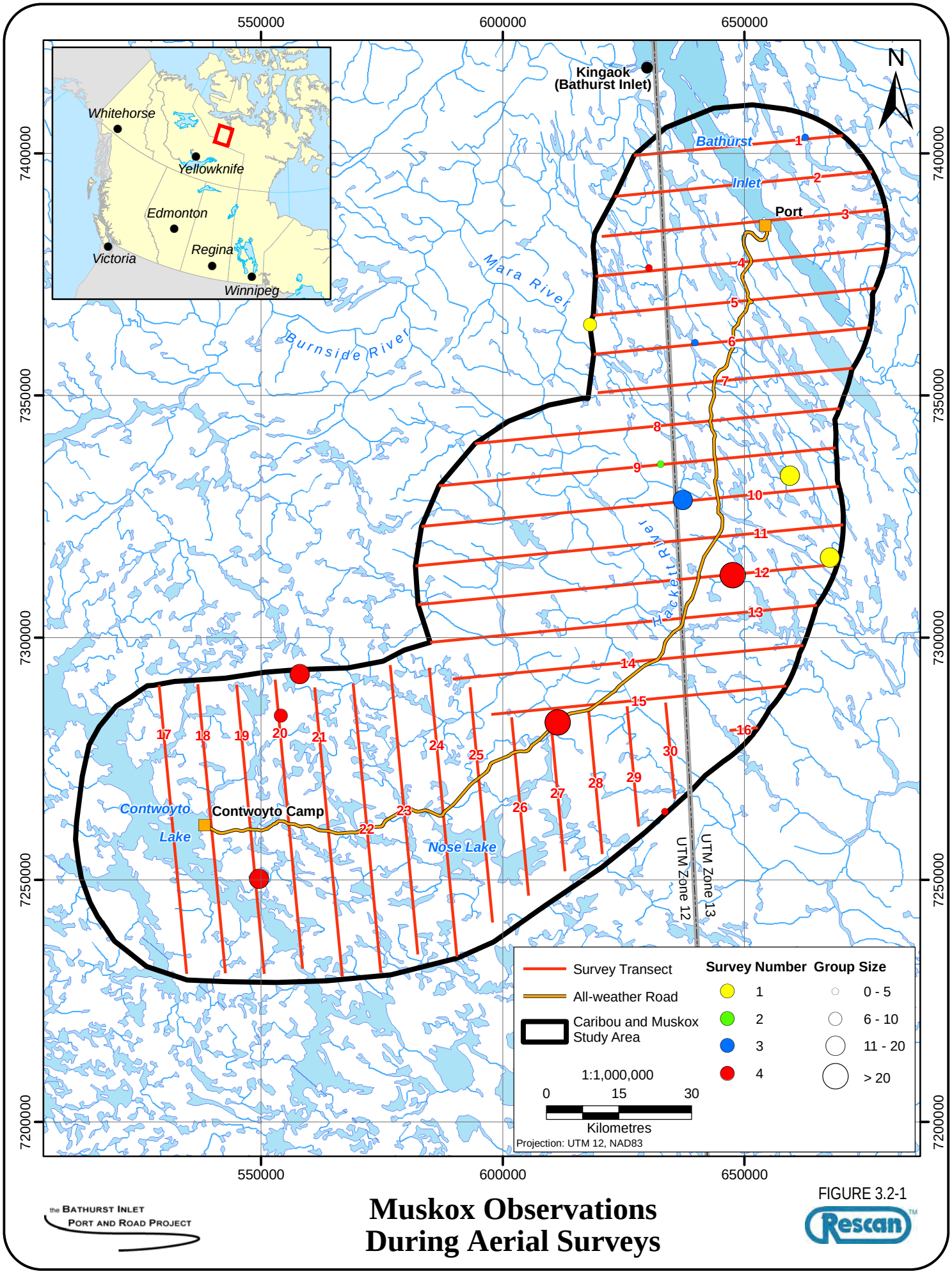

Muskox Observations During Aerial Surveys

FIGURE 3.2-1

the Bathurst Inlet Port and Road Project

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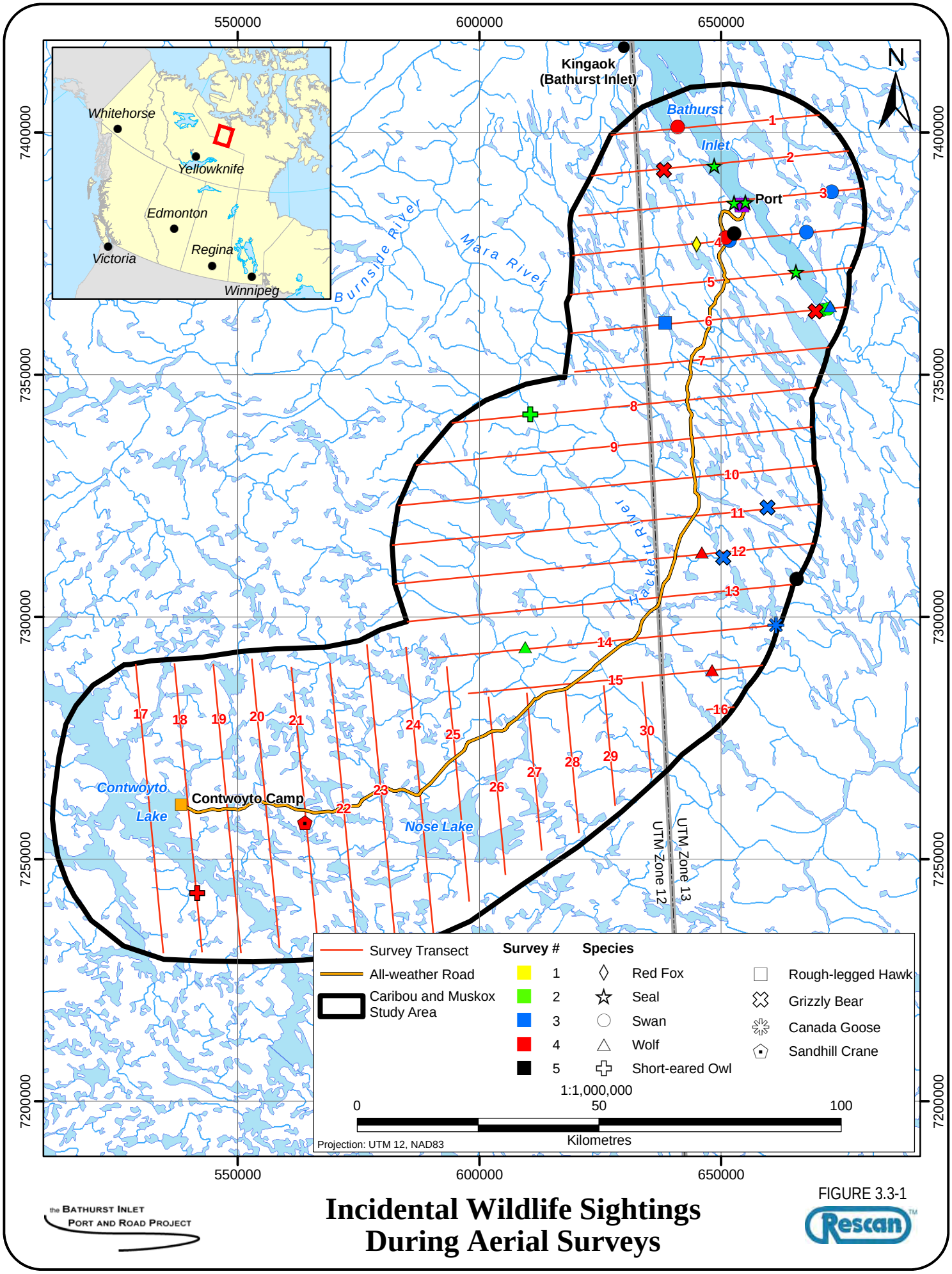
3.3 Incidental Wildlife Observations

Incidental observations of nine species of wildlife were made during caribou aerial surveys (Figure 3.3-1, Table 3.3-1). These included three terrestrial mammals (wolf, grizzly bear and red fox), five birds (swans, short-eared owl, rough-legged hawk, Canada goose and sandhill crane) and one marine mammal (seal).

Table 3.3-1
Incidental Wildlife Observations

Survey	Species	Number
1	Red Fox	1
2	Seal	3
2	Seal	1
2	Seal	1
2	Seal	2
2	Swan	2
2	Swan	5
2	Short-eared Owl	1
2	Wolf	2
3	Grizzly Bear	1
3	Canada geese	50
3	Grizzly Bear	3
3	Swan	2
3	Swan	1
3	Swan	2
3	Rough Legged Hawk	6
3	Wolf	3
4	Swan	2
4	Grizzly Bear	1
4	Swan	2
4	Grizzly Bear	1
4	Wolf	1
4	Wolf	1
4	Short-eared Owl	1
4	Sandhilll Crane	2
5	Swan	2
5	Swan	2



the Bathurst Inlet Port and Road Project

Incidental Wildlife Sightings During Aerial Surveys

FIGURE 3.3-1

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4. DISCUSSION

4. Discussion

4.1 Caribou Herds and the Caribou and Muskox Regional Study Area

Three caribou herds occur in the area of the RSA; the Bathurst, Ahiak, and Dolphin and Union herds (Figures 1-1, 1-2, 1-3). Each of these caribou herds migrate between winter ranges, calving areas, and summer areas. Caribou vary in their response to disturbances based on the time of year and age of calves. The following sections describe the migration routes of each herd, the distribution of caribou relative to the RSA, and the life stage of caribou during periods when each herd may interact with the RSA.

Satellite collar data indicate that the Bathurst and Ahiak caribou occur in the RSA at certain periods of the year. Dolphin and Union Caribou occur to the north of the RSA, but will be discussed in the context of their yearly migration across the areas which may be used for shipping.

The caribou yearly cycle can be divided into six periods: winter, spring migration, calving, post calving, summer and fall migration. These periods vary between herds (Table 4.1-1) and are defined by movement rates for migrations vs. winter and summer ranges (Johnson *et al.*, 2005). The peak of calving (the day when 50% of the caribou have calved) and the weaning of calves defines the calving period and post-calving period respectively; post-calving extends for 5 weeks after the end of the calving period (Russel *et al.*, 2002).

Table 4.1-1
Life Cycle Stage Dates for Bathurst and Ahiak Caribou

Life Cycle Stage	Bathurst	Ahiak
Spring Migration	April 15 to June 4	April 15 to June 4
Calving	June 5 to June 15	June 5 to June 20
Post-Calving	June 16 to July 20	June 21 to July 15
Summer	July 21 to August 31	July 26 to August 31
Fall Migration	September 1 to October 31	September 1 to October 31
Winter	November 1 to April 14	November 1 to April 14

4.1.1 Bathurst Caribou

The Bathurst caribou population has declined from 472,000 ± 72,900 animals in 1986 (Heard and Williams, 1991) to 186,005 ± 40,146 animals in 2003 (Gunn, 2005). These estimates are based on calving ground surveys of breeding females and they suggest an average annual decline of 5% per year since 1986 (Boulanger *et al.*, 2004; Gunn, 2005). 2006 survey results suggest that the decline is continuing at 5% per annum with a herd size estimated at 128,000 ± 27,300 (R. Case, GNWT ENR, *personal communication*). Annual monitoring of calf survival indicates that mean winter calf survival and calf-cow ratios for the Bathurst herd have declined by almost

50% from 2001 to 2004 compared with the 1985 to 1996 period (Gunn *et al.*, 2005). Caribou abundance is thought to fluctuate with a periodicity of between 40 and 70 years (Gunn, 2003). While the decline in the Bathurst caribou numbers may be a consequence of natural population cycles, the current low numbers make the population vulnerable to human harvest, disturbance, weather and other factors (R. Case, GNWT ENR, *Personal Communication*).

The seasonal distribution of Bathurst caribou is estimated from a survey on cows fitted with satellite collars, which was conducted between 1996 and 2007. Between 10 and 29 animals were included in the survey each year (Gunn *et al.*, 2002). This herd winters south of the treeline in the Northwest Territories and northern Saskatchewan (Figure 1-1). During the spring, Bathurst caribou migrate north and pass through the southern end of the RSA on their way to the calving grounds in the northern tundra, near Bathurst Inlet (Figure 1-1). In recent years, cows have calved northeast of Contwoyto Lake, between the Hood and Burnside Rivers (Sutherland and Gunn, 1996; Gunn and D'Hont, 2002; Gunn *et al.*, 2002). Cows return to the same general area to calve every year. However, the calving ground shifts over longer timeframes. The calving ground has gradually shifted from the western side of Bathurst Inlet (in the 1950s) to the eastern side (1960s to mid-1980s) and in recent years has shifted back to the western side (Sutherland and Gunn, 1996; Thorpe *et al.*, 2001; Gunn and D'Hont, 2002). Cows disperse to the southeast during the post-calving and summer seasons and pass through the RSA (Figure 1-1) (Gunn *et al.*, 2002; Gunn and D'Hont, 2002). After several months, they begin the fall migration south towards the Taiga, and some animals cross the RSA in the process (Figure 1-1) (Rescan, 2007a; Rescan, 2007c).

The Bathurst caribou herd are found in the RSA during five stages of their lifecycle: spring migration, calving, post-calving, summer and fall migration (Figure 1-1) (Thorpe *et al.*, 2001; Gunn and D'Hont, 2002; Appendix F-6 of the DEIS; Russel *et al.*, 2002). Caribou are most sensitive to population-level impacts during calving and post-calving when calves are most susceptible to predation and disturbance (Russell *et al.*, 2002). Calving and post-calving areas are designated as important habitat for caribou in the West Kitikmeot Regional Land Use Plan (WKRLUP) (NPC, 2005).

4.1.2 Ahiak Caribou

The Ahiak herd has increased from between 40,000 and 60,000 animals in 1986 to roughly 200,000 animals in 1996, based on aerial calving area surveys along the Queen Maud Gulf (Gunn *et al.*, 2000). The current population trend is unknown.

The winter range of the Ahiak herd overlaps that of the Bathurst and Beverly herds (Figures 1-1 and 1-2) and extends from Bathurst Inlet south to the area east of Great Slave Lake and the Saskatchewan border (Figure 1-2). In some years, Ahiak caribou are found along the southern portion of the RSA, as in 2007. During the spring migration, Ahiak caribou migrate north from their wintering grounds to calving grounds along the Queen Maud Gulf (Figure 1-2) on the east side of Bathurst Inlet, in the Queen Maud Gulf Migratory Bird Sanctuary (Figure 1-2) (Gunn *et al.*, 2000; Gunn and D'Hont, 2002; Appendix F-6 of the DEIS; Adrian D'Hont, Government of Northwest Territories, unpublished data). In recent years, the calving grounds of the Ahiak herd have overlapped the traditional (but not current) calving grounds of the Bathurst herd on the east

side of Bathurst Inlet (Gunn *et al.*, 2000; Gunn and D'Hont, 2002; Appendix F-6 of the DEIS). During the post-calving period, Ahiak cows disperse south and southwest (Figure 1-2). The western edge of the post-calving and summer ranges overlaps the RSA. Unlike Bathurst cows, Ahiak cows do not depart immediately from the calving area; therefore there is some overlap in areas used for calving and post-calving (Gunn *et al.*, 2000; Gunn and D'Hont, 2002). During the fall, Ahiak caribou migrate south towards the Thelon Game Sanctuary, located on the NWT/Nunavut border east of Great Slave Lake, where the rut occurs (Figure 1-2) (Gunn *et al.*, 2000). One collared caribou was recorded in the RSA, suggesting that caribou from this herd also use the RSA during the fall migration. After rutting, Ahiak caribou disperse northwest or south for the winter (Figures 1-2) (Gunn *et al.*, 2000).

4.1.3 Dolphin and Union Caribou

Dolphin and Union caribou winter on the Nunavut mainland near the Dolphin and Union Strait and Kent Peninsula to the east and west of Bathurst Inlet (Figure 1-3). This herd migrates across the sea ice (Figure 1-3) to its calving grounds on Victoria Island (Figure 1-3). During migration, the herd requires ice thick enough to support their weight as they cross the Dolphin and Union Strait, Coronation Gulf, and Dease Strait. The Dolphin and Union caribou herd crosses the BIPR shipping route in Dease Strait during the spring and fall migrations. Inuit knowledge suggests that Dolphin and Union caribou may be found in the vicinity of the proposed road (Appendix F-6 of the DEIS) but satellite collar data indicates that these animals are not found within the BIPR RSA (Adrian D'Hont, Government of Northwest Territories, *unpublished data*).

In the early 1900s, the Dolphin and Union caribou herd was estimated at 100,000 animals (COSEWIC, 2004). Overhunting is reported to have caused a population crash between 1900 and 1920 to the point where caribou were not observed migrating between Victoria Island and the mainland (Gunn, 2005). In the late 1980s and early 1990s, the Dolphin and Union herd had recovered to the point where they resumed their historic migrations between Victoria Island and the mainland (Gunn *et al.*, 1997). Approximately 7,200 Dolphin and Union caribou were counted prior to migration in spring 1993 (Gunn *et al.*, 1997). In 1997, the Dolphin and Union herd was estimated at 28,000 ± 3,350 animals (Nishi and Gunn, 2004), which is approximately one third of its historic size. The herd is thought to be increasing (COSEWIC, 2004; Appendix F-6 of the DEIS) although population trends are tentative.

Dolphin and Union caribou conduct their spring migration from April 21 to June 29, and fall migration from October 22 to December 9 (Adrian D'Hont, Government of Northwest Territories, *unpublished data*). Shipping for the BIPR Project is expected to occur between mid July and the end of October. Caribou cannot cross south to the mainland until ice has formed, and cannot cross north to Victoria Island once the sea ice has melted. Ice-breaking in Dease Strait has the potential to disrupt caribou migrations or cause caribou die-offs (COSEWIC, 2004).

Dolphin and Union caribou have recently been recognized as a genetically distinct population from the Peary caribou and barrenground caribou (COSEWIC, 2004). COSEWIC has designated the Dolphin and Union herd as a sub-population of Special Concern due to high harvests without recent population estimates (COSEWIC, 2004). COSEWIC highlights potential

threats to this herd due to climate warming and shipping activity across the herd's migration route (COSEWIC, 2004). Climate warming may shorten the amount of time caribou have to cross between the mainland and Victoria Island during the spring and fall migrations, since this movement is dependent on ice formation. COSEWIC states that shipping and icebreaking make Dolphin and Union caribou "vulnerable to die-offs similar to those that have affected Peary caribou" (COSEWIC, 2004). The draft WKRLUP also expresses concern for caribou at ice crossings between Victoria Island and the mainland, and stipulates that shipping "may not take place outside the normal open water season between July 1 and October 15" (Conformity Requirement 6.2, NPC, 2005). The herd is pending addition to Schedule 1 of Species at Risk Act (Canada) (SARA).

4.2 Muskox and the RSA

Muskox are distributed across most of the Kitikmeot region of Nunavut (Gunn and Adamczewski, 2003), including the RSA (Appendices D-7 and F-6 of the DEIS). Muskox are the only other large ungulate aside from caribou that occupy the barren-grounds. Unlike caribou, muskox do not migrate long distances.

Muskox in Nunavut and the NWT were estimated at 140,000 animals in 1997 (Fournier and Gunn, 1998). Nineteen thousand of these animals were from mainland populations, while the remainder were from populations inhabiting the Canadian Arctic Islands. The Inuit have also remarked on the expansion in distribution and numbers of muskox since the 1960s (Appendix F-6 of the DEIS). Muskox are presently designated as Secure in Nunavut (CESCC, 2005). Muskox are recovering from near extinction in the early 1900s due to overhunting. Although the population has been increasing over the last thirty years, recent declines have occurred on the mainland (Dumond, 2006b).

The number of muskox between northeast Contwoyto Lake and southwestern Bathurst Inlet was estimated at 3,400 ± 460 animals during a 1986 systematic strip transect survey (Gunn, 1990). Although the proportion of calves relative to total muskox was low (12.0%), it is consistent with counts from other northern mainland muskox populations (10% and 15%) (Gunn and Case, 1984; Gunn and Fournier, 2000).

Muskox in the RSA are from the MX/14 (central mainland) population, which lies within the MX14 and MX19 wildlife management zones (Dumond, 2006b). In August 2005, a thorough survey of the area between Coppermine River and Bathurst Inlet was conducted (Dumond, 2006a). During this survey, 55 muskox were estimated for a 16,302 km^2 area that overlapped the BIPR RSA. The proportion of calves to total muskox was estimated at 9.0%. Muskox in and around the BIPR RSA were clustered near Contwoyto Lake and along the northern half of the proposed road. Although the abundance of muskoxen in the Kitikmeot has been increasing over the past 3 decades (Fournier and Gunn, 1998), mainland populations have experienced recent declines and calf production has been low (Dumond, 2006b).

The Government of Nunavut Department of Environment (GN DOE, 2005) recommends a total annual harvest (TAH) of 4% for the MX14 muskox population, meaning that a maximum of 240 muskox from this population may be harvested annually (Dumond, 2006a). On the West

Kitikmeot mainland, Bathurst Inlet harvests of muskox for subsistence or sport hunts are between 20 and 30 animals annually (M. Dumond, *personal communication*). Kugluktuk harvests of muskox are between 35 and 50 animals annually. Harvest statistics from Bathurst Inlet and Kugluktuk include muskox hunts near Contwoyto Lake and Pellat Lake.

Muskox are a particularly sensitive species to disturbance during the calving season (late March through May), disturbance to herds that culminate in stampeding behaviour can cause calves to be trampled or abandoned (Gunn, 1984).

4.3 Incidental Wildlife Observations

Three mammal species observed in the RSA are listed by international (NatureServe), national (Committee on the Status of Endangered Wildlife in Canada [COSEWIC]), or local (Nunavut) bodies; red fox, grey wolf and grizzly bear. Grey wolf and red fox are considered secure internationally and in Nunavut (Table 4.3-1).

Grizzly bear is listed as "apparently secure" at the international level (NatureServe ranking G4), nationally as special concern meaning they "may become a threatened or endangered species because of a combination of biological characteristics and identified threats" (COSEWIC, 2004). Locally, the grizzly bear is secure.

Table 4.3-1
Status Rankings of the Species Observed in the BIPR RSA

Common Name	Scientific Name	NatureServe	COSEWIC Status	Nunavut Ranking
Red Fox	*Vulpes vulpes*	G5	Not listed	secure
Grey Wolf	*Canis lupus*	G4	Not at risk	secure
Grizzly Bear	*Ursus arctos*	G4	Special concern	sensitive

NatureServe Rank:
G4: Apparently Secure - Uncommon but not rare; some cause for long-term concern due to declines or other factors.
G5: Secure - Common; widespread, and abundant.
COSEWIC Status:
Special Concern - A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Nunavut Rank:
Sensitive - Species that are not believed to be at risk of immediate extirpation or extinction but may require special attention or protection to prevent them from becoming at risk.
Secure - Species that are not believed to belong in the categories Extirpated, Extinct, At Risk, May Be At Risk, Sensitive.

The status and trends of bird populations are discussed in Appendix D-10 of the DEIS (Songbird and Shorebird Baseline Study).

4.4 Likely Future Conditions

Bathurst caribou are designated as Secure in Nunavut (CESCC, 2005); however, the population has been declining over the past two decades. Although the decline appears to be part of the natural population cycle for Bathurst caribou, these animals are currently sensitive to changing conditions such as those from development and climate change.

It is uncertain how environmental change in the form of climate warming will affect Bathurst caribou populations. Climate warming results in a longer growing season, which could benefit caribou by increasing the availability of forage during the summer (Brotton and Wall, 1997; Thorpe *et al.*, 2001). However, a study by Mörschel and Klein (1997) demonstrated that caribou decreased foraging and increased energy-expenditure in response to warm weather and insect activity. Environmental change is also thought to result in sporadic freeze-thaw cycles, which could result in vegetation being inaccessible under crusts of ice (Thorpe *et al.*, 2001). The future of Bathurst caribou is uncertain given their long-term population decline and the uncertain effects of climate change. The potential effects of the project on Bathurst caribou will be difficult to assess because of the variable nature of their calving ground. While the calving ground is today outside the RSA, the calving ground was historically on the east side of Bathurst inlet and may move again.

The Ahiak herd has increased in size in recent years but the future population trajectory is uncertain. Changes to snow cover and ice thickness may also have major impacts on the Ahiak herd, which migrate long distances over ice and snow. Overall, little knowledge exists on the Ahiak caribou and their likely future condition is uncertain, especially in the face of climate change.

The Dolphin and Union caribou herd appears to be increasing. However, climate change is likely to result in altered timing of freeze-up and break-up of sea ice. Caribou deaths may increase if caribou attempt to cross thin sea ice between Victoria Island and the mainland (COSEWIC, 2004). The Dolphin and Union herd could potentially be impacted by shipping if it occurs outside the open water season (between July 1 and October 15) (NPC, 2005).

Muskox may benefit from an increase in vegetation due a longer growing season (Thorpe *et al.*, 2001; UNEP, 2007). However, climate change may also increase the northward spread of diseases which could negatively impact muskox populations (Dumond, 2006b).

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An explanation of the acronyms used throughout this reference list can be found in the *Acronyms and Abbreviations* section.

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APPENDIX 1
CARIBOU AERIAL SURVEY OBSERVATIONS, 2007

Appendix 1
Caribou Aerial Survey Observations, 2007

Survey	Date	Transect[1]	Easting[2]	Northing	Distance from the Plane (m)	Direction	Side	Nursery	Bulls	Cows	Calves	Unknown	Total	Habitat	Notes
1	May 18, 2007	3	368446	7384517	450	N	R		0	0		6	6		Heading S
1	May 18, 2007	3	356722	7384256	0		R	Y	0	24		0	24		
1	May 18, 2007	0	357653	7383925	0		R	Y	0	15		0	15		Under aircraft
1	May 18, 2007	3	355909	7383528	450	S	L	Y	0	11		0	11		
1	May 18, 2007	0	355909	7383178	800	S	L		0	0		150	150		
1	May 18, 2007	0	353906	7383141	900	S	L		0	0		40	40		
1	May 18, 2007	0	352930	7383348	200	E	R	N	7	0		0	7		
1	May 18, 2007	0	360090	7376597	600	N	L		0	0		16	16		
1	May 18, 2007	4	373172	7376586	450	N	L		0	0		10	10		
1	May 18, 2007	0	372230	7368845	800	N	R		0	0		17	17		
1	May 18, 2007	5	369544	7367971	50	N	R	Y	0	38		0	38		
1	May 18, 2007	5	369544	7368271	350	N	L	Y	0	8		0	8		
1	May 18, 2007	5	363355	7368248	250	N	R	Y	0	7		0	7		
1	May 18, 2007	0	363355	7368598	600	N	R		0	0		20	20		
1	May 18, 2007	6	374978	7359506	450	S	R	Y	0	15		0	15		
1	May 18, 2007	6	401354	7350994	1,000	S	L		0	0		5	5	Ice	
1	May 18, 2007	0	374148	7351277	700	S	L		0	0		120	120		
1	May 18, 2007	7	367591	7351981	50	S	L	Y	0	20		0	20		
1	May 18, 2007	9	394116	7336131	150	N	R	Y	0	8		0	8		
1	May 18, 2007	11	395104	7320414	450	N	R		0	0		2	2		
2	June 11, 2007	9	362940	7335806	250	S	L	N	7	0		0	7	Ht-b	
2	June 11, 2007	10	313310	7327823	250	S	R	N	0	6		0	6		1 hard antler, 5 antlerless
3	July 12, 2007	0	364928	7276327	1,600	W	R	Y	0	0		1,660	1,660		
3	July 12, 2007	0	374116	7279843	1	N	L		0	0		0	1		
3	July 14, 2007	0	388727	7312148	100	E	R		0	0		1	1		
4	July 29, 2007	3	367290	7384073	150	N	R	N	1	0		0	1		
4	July 30, 2007	11	373624	7320366	350	N	R	N	1	0		0	1		
4	July 30, 2007	13	387139	7304224	250	N	R	N	2	0		0	2		
4	July 30, 2007	0	385663	7303329	700	S	L	N	1	0		0	1		
4	July 30, 2007	13	385901	7304169	150	N	R	N	1	0		0	1	SW	
4	July 30, 2007	13	385012	7304095	50	N	R	N	0	1		0	1	HT	
4	July 30, 2007	13	384355	7304092	150	N	R	N	0	1		0	1	HT	
4	July 30, 2007	0	363712	7304500	550	N	R	N	1	0		0	1		
4	July 30, 2007	14	382841	7295878	50	S	R	N	0	1		0	1	SW	
4	July 30, 2007	14	386147	7296174	150	N	L	N	1	0		0	1		
4	July 31, 2007	0	255269	7239377	800	NW	L		0	0		1	1	SW	
4	July 31, 2007	3	269989	7263027	50	W	R	N	1	0		0	1	Mud Pond	
4	July 31, 2007	5	286149	7275626	150	E	L	N	0	1		0	1	Esker	
5	September 7, 2007	5	371710	7369466	300	S	L	Y	0	5	3	0	16		
5	September 11, 2007	8	375949	7344472	200	S	R	Y	0	0		0	0		

[1]0 = off transect.

[2]UTM Zone 13.

APPENDIX 2
MUSKOX AERIAL SURVEY OBSERVATIONS, 2007

Appendix 2
Muskox Aerial Survey Observations, 2007

Survey	Date	Transect[1]	Easting[2]	Northing	Distance from the Plane (m)	Direction	Side	Adult	Calves	Total	Habitat
1	May 18, 2007	0	349881	7366169	100	E	L	6	0	6	
1	May 18, 2007	0	388037	7331177	300	S	L	15	3	18	
1	May 18, 2007	0	394663	7313533	600	S	L	16	3	19	
2	June 11, 2007	9	361675	7336130	150	N	R	5	0	5	
3	July 13, 2007	10	365472	7328366	250	S	L	14	1	15	
3	July 13, 2007	1	397919	7400381	250	N	R	1	0	1	
3	July 13, 2007	6	371159	7360468	300	N	L	1	0	1	
4	July 29, 2007	0	363156	7376639	600	N	L	1	0	1	
4	July 30, 2007	12	374271	7311833	150	S	R	18	4	22	HT
4	July 31, 2007	0	335357	7285043	0		R	32	2	34	HT
4	July 31, 2007	0	270772	7258736	700	E	L	9	2	11	HT
4	July 31, 2007	0	278524	7291880	600	E	R	5	2	7	HT-b
4	July 31, 2007	0	283197	7300135	300	NE	L	10	2	12	HT
4	July 31, 2007	0	355725	7264636	50	SW	L	1	0	1	HT

[1]0 = off transect.

[2]UTM Zone 13.

APPENDIX 3
INCIDENTAL AERIAL SURVEY OBSERVATIONS, 2007

Appendix 3
Incidental Aerial Survey Observations, 2007

Survey	Date	Transect[1]	Easting[2]	Northing	Distance from the Plane (m)	Direction	Side	Adult	Calves	Habitat	Notes
1	May 18, 2007	4	377778	7375834	150	S	Red Fox	R	1		
2	June 11, 2007	2	382975	7391648	350	S	Seal	R	3	Ice	On Bathurst Inlet ice
2	June 11, 2007	3	388640	7383596	450	S	Seal	L	1	Ice	On Bathurst Inlet ice
2	June 11, 2007	3	386328	7383698	250	S	Seal	L	1	Ice	On Bathurst Inlet ice
2	June 11, 2007	5	397713	7368217	250	N	Seal	R	2	Ice	On Bathurst Inlet ice
2	June 11, 2007	6	402388	7359803	250	S	Swan	R	2		
2	June 11, 2007	6	403596	7359873	150	S	Swan	R	5		
2	June 11, 2007	8	340200	7344200	0		Short-eared Owl	R	1		
2	June 12, 2007	14	334582	7296459	450	N	Wolf	L	2		1 white, 1 3/4 white with grey; on gl-fluvial area
3	July 12, 2007	0	377123	7310935	150	N	Grizzly Bear	L	1		dark brown
3	July 13, 2007	14	386622	7295983	0	S	Canada Geese	L	0		
3	July 13, 2007	11	387205	7320327	400	N	Grizzly Bear	L	1		blonde female with 2 dark brown cubs
3	July 13, 2007	3	406665	7383937	0	S	Swan	L	0		
3	July 13, 2007	4	384643	7375956	150	S	Swan	R	0		
3	July 13, 2007	4	400685	7376096	0	N	Swan	L	0		
3	July 13, 2007	6	369734	7360284	0	N	Rough-legged Hawk	L	0		
3	July 13, 2007	6	404088	7360438	300	N	Wolf	L	0		
4	July 29, 2007	0	376252	7400300	300	N	Swan	R	0		
4	July 29, 2007	2	372574	7391756	350	S	Grizzly Bear	R	1		
4	July 29, 2007	0	383899	7376631	750	N	Swan	L	0		
4	July 29, 2007	6	400969	7359720	150	S	Grizzly Bear	R	1	SW	
4	July 30, 2007	0	372758	7312429	550	N	Wolf	L	1		
4	July 30, 2007	15	372554	7288014	50	N	Wolf	R	1		White wolf
4	July 31, 2007	2	262144	7252324	150	E	Short-eared Owl	R	0		
4	July 31, 2007	5	285755	7264741	250	W	Sandhill Crane	R	2		
5	September 7, 2007	4	385750	7377347	200	S	Swan	L	2	Lake	
5	September 8, 2007	13	391827	7305073	200	S	Swan	L	2	Lake	

[1]0 = off transect.

[2]UTM Zone 13.

Appendix D-10
Songbird and Shorebird Baseline Study

Author: **Rescan Environmental Services Ltd.**
Date: **September 2007**

the BATHURST INLET PORT AND ROAD PROJECT

Bathurst Inlet Port and Road Project

Nunavut, Canada

BIPR Songbird and Shorebird Baseline Study

Prepared by:

Rescan™ Environmental Services Ltd.
Vancouver, British Columbia, Canada

September 2007

EXECUTIVE SUMMARY

Executive Summary

This report presents the results of terrestrial upland bird surveys conducted from 18 to 25 June, 2007 within the Bathurst Inlet Port Road (BIPR) Project Area. Variable range point counts were conducted along transects on the proposed road alignment, and one to three kilometres from the alignment for use as future controls. Transects were selected to cover different habitats in proportion to the availability of each habitat type. Waterfowl using Bathurst Inlet were recorded during an aerial survey of the Inlet at the northern terminus of the road on 25 June, 2007. Overall, a total of 46 one kilometre transects, representing 10 habitat types, were surveyed for birds. The goals of the 2007 baseline work were to:

1. determine the species present, the relative abundance of those species, and the reproductive phenology schedules of the main species;
2. identify habitats that support particularly high levels of avian biodiversity;
3. establish the number of distinct bird communities in the study area, and habitat features that delineate those communities, and
4. identify any species at risk that require special considerations under existing wildlife regulations or guidelines.

Forty-one species of birds were observed in association with the BIPR proposed road alignment. Only eight species of waterbirds were observed on the water in Bathurst Inlet. Nests with eggs were found for every main species group represented, demonstrating a high synchrony in reproductive timing across species. Habitats that contained vertical vegetative structure, such as riparian shrub and birch seep habitat, supported the highest avian diversity, while the lowest avian diversity was found in habitat with very low surface substrate heterogeneity or vegetative cover for ground nesting. Three main avian community groups were found using cluster analysis. The first avian community was characterized by ground nesting tundra species found in heath tundra and boulder field habitats that are characterized by low emergent plant cover with substrate heterogeneity created largely by boulders, hummocks, and prostrate vegetation. The second avian community was characterized by a high proportion of shrub nesting species found in habitat containing a high degree of vertical vegetation structure (*e.g.*, riparian shrub and birch seep habitat). Finally, a third community of birds was characterised by wetland species found in sedge habitats dominated by sedges and grasses on a moist substrate.

Of the species observed, only two are listed by COSEWIC as species of special concern under the Species at Risk Act (SARA): peregrine falcon (*Falco perigrinus tundrius*) and short-eared owl (*Asio flammeus*). Other species, including red-necked phalarope, semipalmated sandpiper, long-tailed duck, northern pintail, American golden plover, American pipit, and American tree sparrow were listed as sensitive under local NWT or Nunavut ranking categories.

In conclusion, the present report suggests the Project area has a relatively high species diversity that is maintained by a matrix of tundra, shrub, and grassy habitat features. The low abundance of riparian shrub and birch seep habitat relative to the number of species these habitats host,

make them particularly important habitats for species in the region. In contrast, habitat with particularly scant ground cover or wind exposed ridgelines hosted a low diversity of avian species. The presence of cliffs and river banks are also crucial habitat features for nesting of some of the species observed, including a listed species, the peregrine falcon.

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1. INTRODUCTION

1. Introduction

The Bathurst Inlet Port and Road Project (BIPR) includes a 211 km all-weather road proposed to be developed in the Kitikmeot region of Nunavut. The proposed road will extend southward from a future Port site at Bathurst Inlet to Contwoyto Lake. Baseline information on species using habitat along the BIPR alignment is required in order to determine the vulnerability of avifauna to habitat changes resulting from the road construction and operation.

Monitoring bird species is important throughout the planning, implementation, operation, and closure phases of a development project for a number of reasons. Identification of avian species in the proposed project development area is a necessary step in meeting the obligations of federal and territorial regulations for species protection. Further, avian species that migrate between countries receive protection under the federal Migratory Bird Convention Act. Some bird species, particularly raptors, are protected under the Wildlife Act, while species at risk are protected under the federal Species at Risk Act (SARA). Finally, the relatively high abundance of birds enables the statistical detection of changes in diversity and abundance in disturbed compared to undisturbed habitats, and between pre- and post-disturbance phases over time.

This report summarizes avian studies conducted in 2007 for the Bathurst Inlet Port and Road (BIPR) project. Surveys conducted in 2007 focused on terrestrial upland birds, shorebirds, and waterfowl in Bathurst Inlet, near the northern terminus of the road; however, data for all avian groups encountered were recorded during surveys. Surveys were designed to collect baseline information on species presence and abundance, reproductive timing, diversity, avian community structure and community habitat associations. The goals of collecting these data were to:

- Establish baseline information on species present in the area and reproductive phenology of breeding activity of main species in order to identify species and temporal periods that are sensitive to development;
- Compare species diversity and equitability (evenness) within the habitat types represented along the BIPR proposed road to determine habitat of high value for the maintenance of species diversity;
- Establish the number and composition of main bird community assemblages in the project area, and determine the habitat characteristics that best delineate different communities, and;
- Identify species of conservation concern in the area, such that appropriate conservation steps may be taken to meet statutory requirements under relevant wildlife acts and guidelines.

Aerial surveys for raptors and incidental surveys for waterfowl were previously conducted in 2001 and 2002 along the BIPR proposed road during baseline work. However, no systematic surveys were done in those years to identify and quantify terrestrial songbirds and shorebirds. Furthermore, aerial waterfowl surveys had not previously been conducted over Bathurst Inlet, which may be sensitive to development. Also, variable range point count (VRPC) transect surveys were conducted in 2007 along the BIPR proposed road, and aerial surveys were

conducted along Bathurst Inlet in order to document upland breeding birds, shorebirds, raptors, and waterfowl.

Baseline information will enable forecasting potential effects of habitat loss on bird communities in the area, and will help develop management strategies to minimize negative impacts of the road on bird species of conservation concern.

2. STUDY AREA

2. Study Area

The proposed road route traverses 211 km in the Kitikmeot Region of Nunavut, Canada. The proposed road will extend southward from a future Port site at Bathurst Inlet to Contwoyto Lake (Figure 2-1). The study area focused on in the present report consisted of habitat within 500 m of either side of the proposed road, as well as habitat along the Bathurst Inlet shoreline. The dominant habitat types within the study area include heath tundra; however 10 major habitat types are present within a 1 kilometre zone on either side of the road, including heath tundra, boulder field, sedge, riparian shrub, avens community, beach materials, birch seep, esker complex, lichen rock, and bedrock outcrop. A review of these habitat types, and the way in which habitat mapping was conducted along the BIPR proposed road can be found in Geowest (2003).

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Bathurst Inlet Proposed Port Location and Proposed Road

FIGURE 2-1

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3. POINT COUNT SURVEYS

3. Point Count Surveys

3.1 Methods

Variable range point count surveys (VRPC) were conducted between 18 and 25 June, 2007. Four observers covered all major habitat types along the 211 km of the proposed road alignment during the 7-day survey. Prior to commencement of field surveys, 50 one-kilometre transects were established along the road alignment by examining vegetation maps, topographic features, and aerial photos. The habitat along the road was sub-divided into 10 main habitat zones: avens community, beach materials, boulder field, birch seep, esker complex, heath tundra, lichen rock, bedrock outcrop, riparian shrub, and sedge. One kilometre transects were chosen along the proposed road such that they represented each habitat zone proportionally, and covered the length of the road. A higher density of transects were included in the northern portion of the road near Bathurst Inlet, as this region may be affected by both port and road development in the future. Transects that could be used as future controls were also selected at distances of approximately one to three kilometres from transects on the proposed road. Whenever possible, a control transect was chosen to run in parallel through similar habitat zones at the same latitude as each transect along the road (Figure 3.1-1).

A variable range point count method was used along each transect (Ralph *et al*. 1995). VRPC surveys are useful for identifying species and relative abundances of species. VRPC methods enabled the identification of a wide range of bird species with different singing styles. A well-designed VRPC also allows for the use of maximum point radii along transects (typically 100 m for open habitat), while enabling the observation of species that flush or are detectable at different distances. The distance estimates in VRPC are used mainly to help the observer differentiate between individual birds being counted and to avoid double counting. The accuracy of the distance estimates is not as critical to a successful survey as it might be to derive an estimate of density. However, accurate distance measures will enable comparisons with point count data from a variety of studies and between replicated monitoring studies in the future. To ensure that each observer estimated VPRC ranges similarly, all field personnel underwent a calibration session, whereby they learned to estimate distances of birds within a 100 m radius, and their estimates were tested in the field using a rangefinder. Each observer was competent at identifying all species in the project area by sight and sound and made similar distance estimates prior to surveys.

Surveys began at 4 a.m. each morning and were completed by 12 p.m. when bird activity decreased. Observers were transported to sites by helicopter, and were dropped near transects at a distance that minimized flushing birds from the transect sites. Each observer walked to the starting point of their transect using their GPS unit, and then proceeded for one kilometre at the pre-determined compass bearing for that transect. The observer stopped 5 times along each transect: the first stop point was 100 m from the starting point, and each subsequent stop was made at distances of 200 m thereafter so that no overlap of 100 m search radii occurred. At each stop interval, all birds were observed by sight and sound for 5 minutes and mapped within the following intervals: <10 m, 10-20 m, 20-30 m, 30-40 m, 40-50 m, 50-75 m, 75-100 m (Figure 3.1-2). Incidental observations were also made at > 100 m and as flyovers. Whenever

possible, breeding observations were made when birds were observed. Observations of breeding included copulations, nest material carries, food carries, fecal sac carries, nests distraction displays, and pairs. The times that observations began at each point along transects were recorded. Surveys were not conducted when wind speed exceeded approximately 5 km/h, or when raining or snowing.

3.1.1 VRPC Diversity Comparisons

A diversity index, such as "Shannon's *H*", is a mathematical measure of species diversity in a community. Diversity indices provide more information about community composition than species richness (*i.e.*, the number of species present) as they also take the relative abundance of different species into account, along with the number of species (Maggurran, 1988; Rosenweig, 1995). As such, diversity indices also provide important information about rarity and commonness of species in a community. The Shannon-Weiner index of diversity (H) was calculated for each habitat type in order to facilitate diversity comparisons between habitats found along the road alignment. Shannon's *H* index of diversity was calculated using the equation:

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

Where ***S*** is the total number of species in a community and ***Pi*** is the proportion of ***S*** made up by the *ith* species.

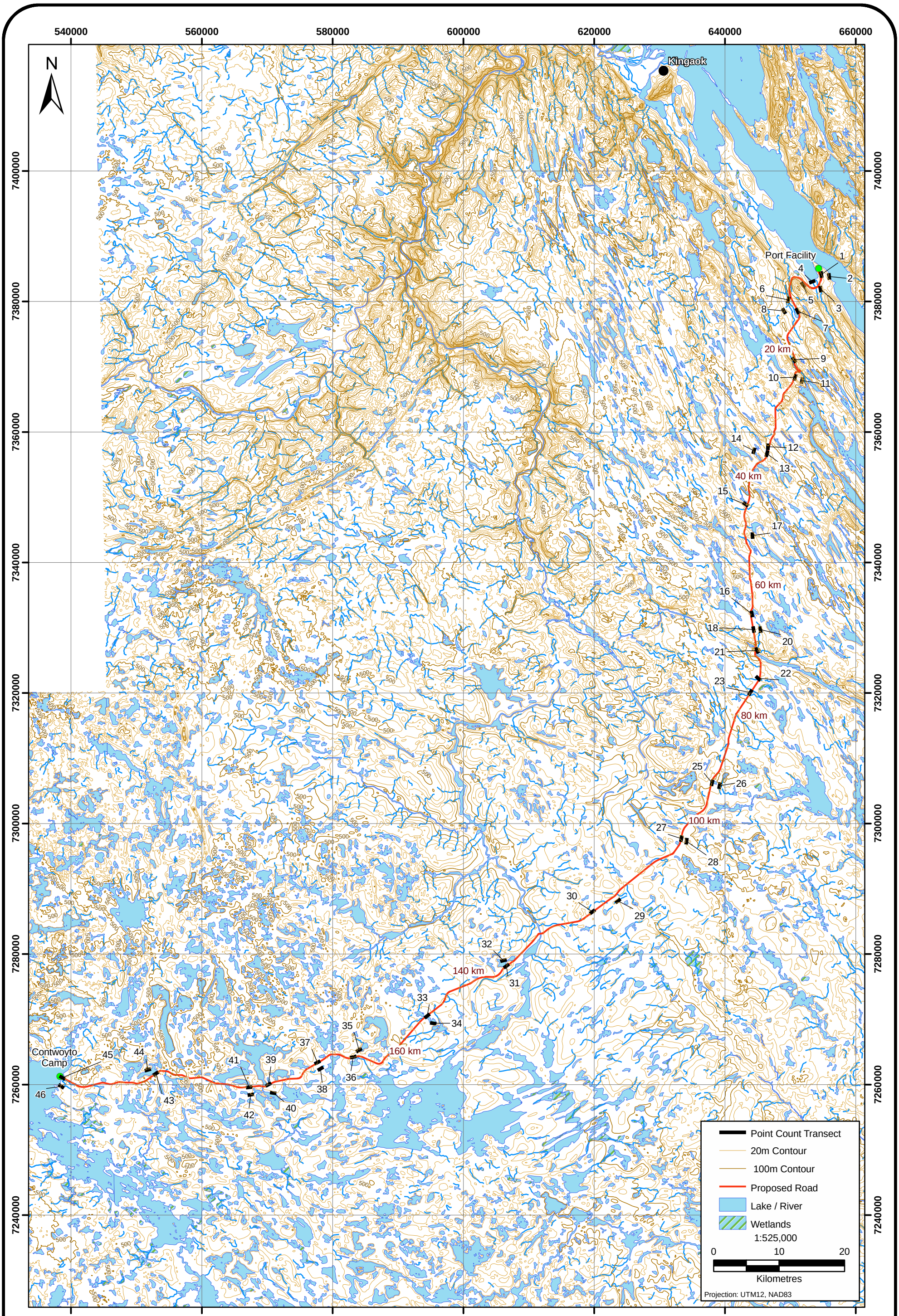
3.1.2 Equitability Comparisons

Following the calculation of *H*, Shannon's equitability (E_H) was calculated by dividing *H* by H_{max} ($H_{max} = \ln S$). Equitability assumes a value between 0 and 1 with 1 being complete evenness (*i.e.*, roughly equivalent numbers of birds belonging to each species recorded). The formula for Shannon's equitability is presented below.

$$E_H = H / H_{max} = H / \ln S$$

3.1.3 Community Cluster Analysis

A cluster analysis was performed to determine whether there were different configurations of species or communities that co-vary with general habitat categories. That is, cluster analysis seeks to identify a set of groups which both minimize within-group variation and maximize between-group variation. Prior to performing a cluster analysis, VRPC points were divided by habitat type. Some points along transects fell within mixed habitat zones, and these points were classified as their dominant habitat feature (for example, heath tundra, with a small proportion of boulder field was grouped as heath tundra). Most transect points used, however, fell within pure habitat zones. Classifying by dominant habitat types allowed for the simplification of the analysis, and increased the samples size per habitat type. A course grained analysis was sufficient for the type of resolution sought at the landscape level, as birds respond mainly to habitat structure (Wiens and Rotenberry 1981), differences in which were



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Layout of 1 km Variable Range Point Count Bird Survey Transects along the Bathurst Inlet Port and Proposed Road

FIGURE 3.1-1

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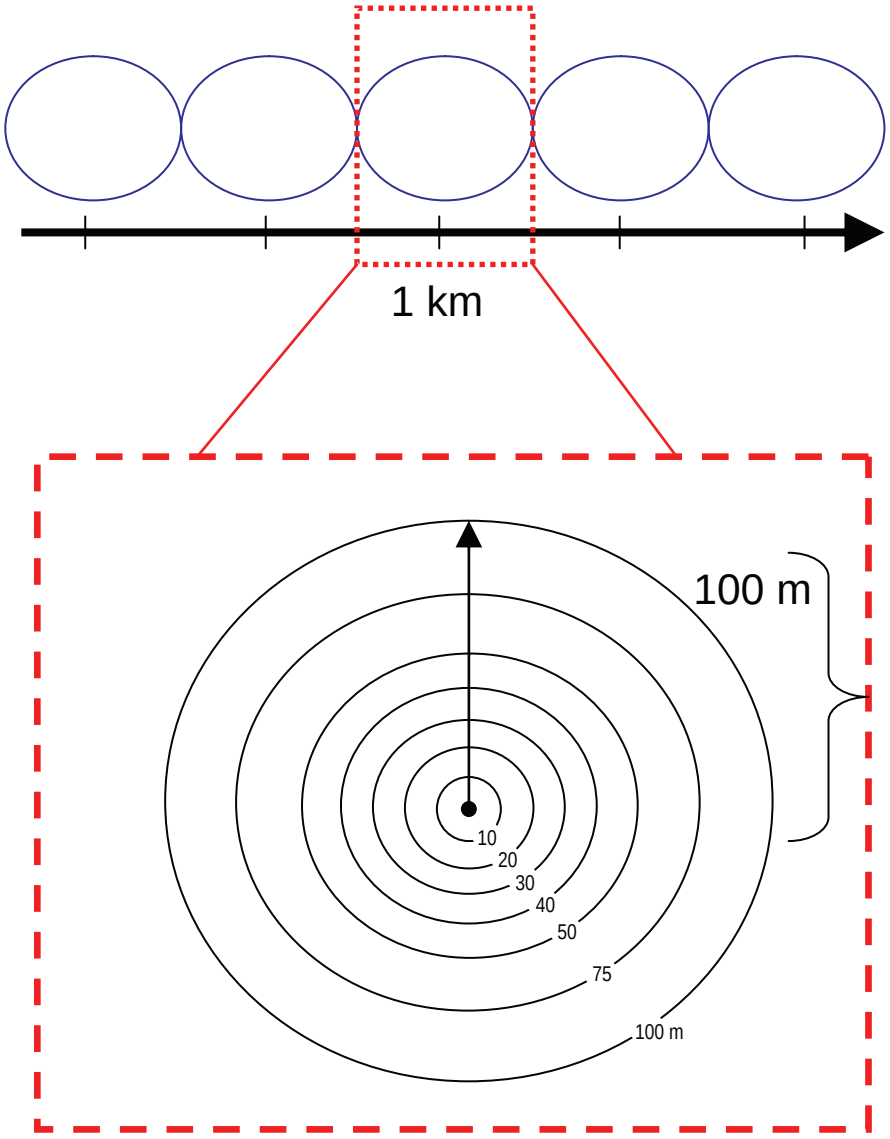


Schematic of VRPC Transect and VRPC Point along a Transect with Theoretical Lines for Making Distance Estimates

FIGURE 3.1-2

encompassed by the habitat classification system used. The habitat types used in this analysis were:

1. heath tundra
2. birch seep
3. riparian shrub
4. boulder field
5. sedge

It should be noted that points located within some habitats, such as avens, esker complex, and beach materials were not included in this analysis because the numbers of point counts in these relatively rare habitats were too few to allow community-level conclusions. These habitat types, which were not included in the cluster analysis, represented an extremely low proportion of the total available habitat along the BIPR road. However, it should be noted that inclusion of these habitats might have increased the numbers of communities found in cluster analysis if sufficient habitat was available to sample. Species that were only observed during a point count due to flying over the site, or which were seen > 100 m from the point count centre were also excluded from this analysis, as it was not possible to determine original habitat use from such observations.

Cluster analyses were computed using the hierarchical cluster analysis algorithm on SPSS 8.0 for Windows. The Average Linkage Distance (between groups) was used as the clustering method and Euclidian distance, a measure of average distance between community clusters, was used as the interval measure.

3.2 Results

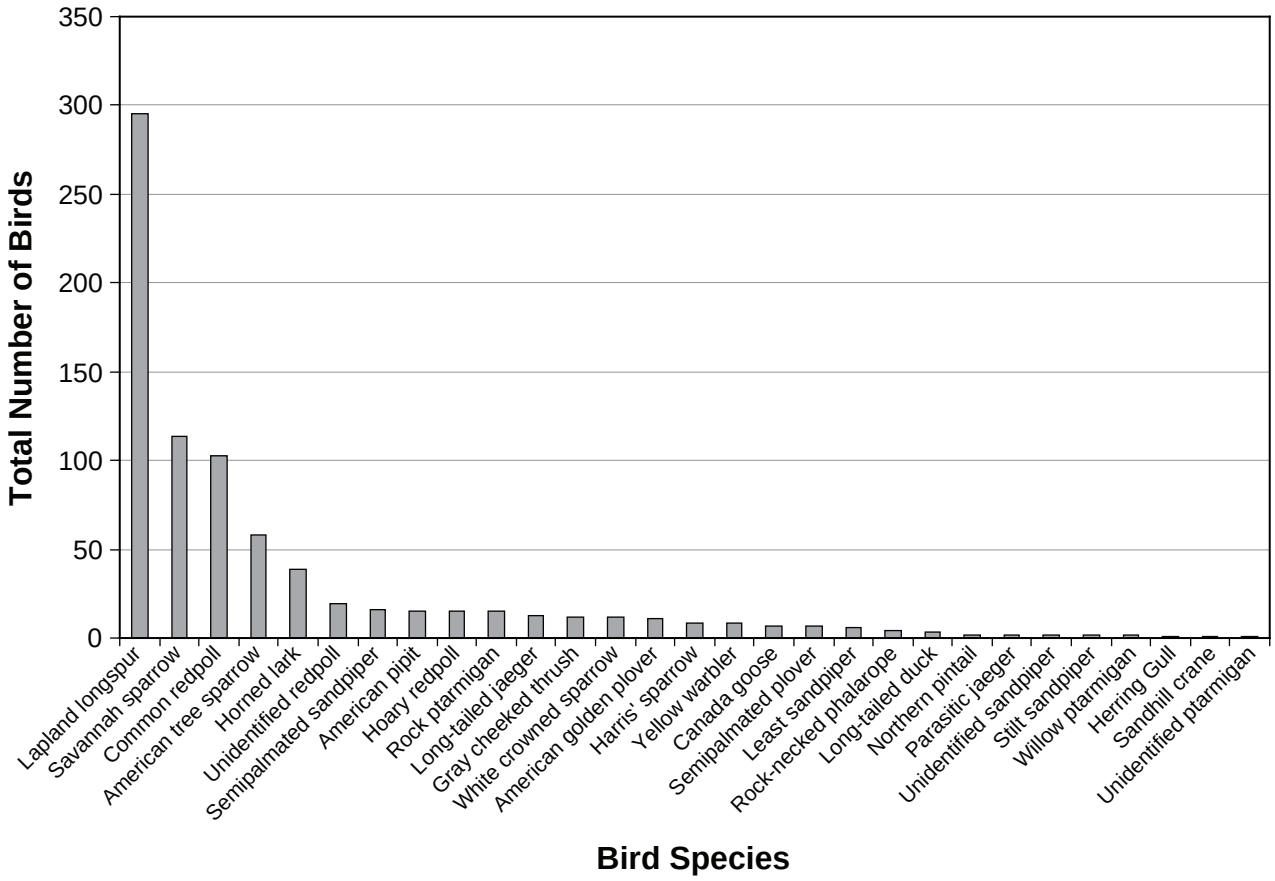
3.2.1 Species Observed and Reproductive Phenology

During the VRPC transect surveys, 41 species of birds were observed. Table 3.2-1 shows the composition of species in various avian groups. Definitive confirmation of nesting was made for species within each group by breeding observations and from finding incidental nests. All species observed along the BIPR road are listed in Table 3.2-1, which also notes any nests found as a confirmation of breeding from 18 June to 25 June, 2007. Plate 3.2-1 and plate 3.2-2 provide photographs of common bird species observed, and nests of some species that were found. Figure 3.2-1 shows the bird species seen and their relative abundance in the general study area.

Table 3.2-1
Species Observed along VRPC Transects along the BIPR Road

Avian Group	Species	No. Observations	Breeding Confirmed
Waterfowl	Canada Goose	7	N
and Geese	Long-tailed Duck	3	Y (Nest with eggs)
	Red-breasted Merganser	0	N
	Pacific Loon	0	N
	Yellow-billed Loon	0	N
	Tundra Swan	0	N
	Great White-fronted Goose	0	N
	Northern Pintail	2	N
	Greater Scaup	0	N
Gruids	Willow Ptarmigan	2	N
	Rock Ptarmigan	15	N
	Sandhill Crane	1	N
Corvids	Common Raven	0	Y (Nest)
Gulls	Herring Gull	1	Y (Nest nearby in Hackett)
	Galucous Gull	0	N
	Parasitic Jaeger	2	N
	Pomarine Jaeger	0	N
	Long-tailed Jaeger	13	Y (Nest with eggs)
	Arctic Tern	0	N
Songbirds	Lapland Longspur	295	Y (Nest with eggs
	Horned Lark	57	N
	Savannah Sparrow	114	Y (Nest with eggs)
	Common Redpoll	103	Y (Nest with eggs)
	American Tree Sparrow	36	Y (Nest with eggs)
	Hoary Redpoll	15	Y (Nest with eggs)
	Gray-cheeked Thrush	12	Y (Nest with eggs)
	American Pipit	15	Y (Nest with eggs)
	Yellow Warbler	8	Y (Nest with eggs)
	Harris' Sparrow	11	Y (Nest with eggs)
	White-crowned Sparrow	12	Y (Nest with eggs)
Shorebirds	American Golden-plover	8	Y (Aggressive defence behaviour)
	Semipalmated Plover	16	N
	Sanderling	0	N
	Semipalmated Sandpiper	16	N
	Least Sandpiper	7	N
	Stilt Sandpiper	2	N
	Red-necked Phalarope	4	N
Raptors	Rough-legged Hawk	0	N
	Peregrine Falcon	0	N
	Gyrfalcon	0	N
	Short-eared Owl	0	N

***Grouped by class, numbers observed, and whether or not they were confirmed as breeding between 18-25 of June. Species with 0 breeding observations were seen outside of the 100 m VRPC point count radii or were seen incidentally between transects.**



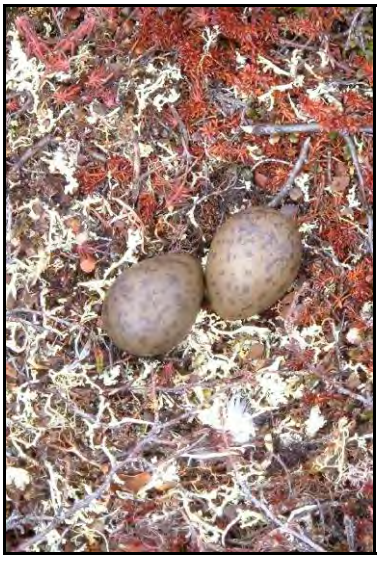
Note: Flying overs and birds detected over 100 m from point count are omitted.

(a) Lapland longspur, (b) Greater white-fronted goose, (c) Common redpoll, (d) Harris' sparrow, (e) American golden plover, (f) Rock ptarmigan, (g) Willow ptarmigan, (h) White-crowned sparrow, (i) Parasitic jaegar, (j) Horned Lark, (k) Semipalmated plover, (l) Savannah sparrow, (m) Canada goose, (n) Yellow warbler, (o) American tree sparrow, (p) Greater Scaup

Plate 3.2-1. Photographs of some common species seen along the proposed BIPR road.

Gray cheeked thrush

Harris' sparrow



Parasitic jaeger

Herring Gull

Savannah Sparrow

Long tailed jaeger

Lapland Longspur

Common Redpoll

Yellow Warbler

White-crowned sparrow

Plate 3.2-2. Examples of nests observed during BIPR bird surveys.

The number of species, and number of birds varied substantially among transects along the BIPR road (Figure 3.2-2). Transects 1, 3, 33, and 34 hosted the highest numbers of species. Transect 3, 4, 32, and 39 hosted the highest numbers of birds, when all species were considered together. Since collection methods included strict distance delineations, transects with the highest numbers of birds had the highest avian densities. Transects 1 and 3 are adjacent to Bathurst Inlet near the proposed port site location and remaining transects hosting high species and bird numbers are found between km 120 and 170.

3.2.2 Diversity Comparisons between Habitats

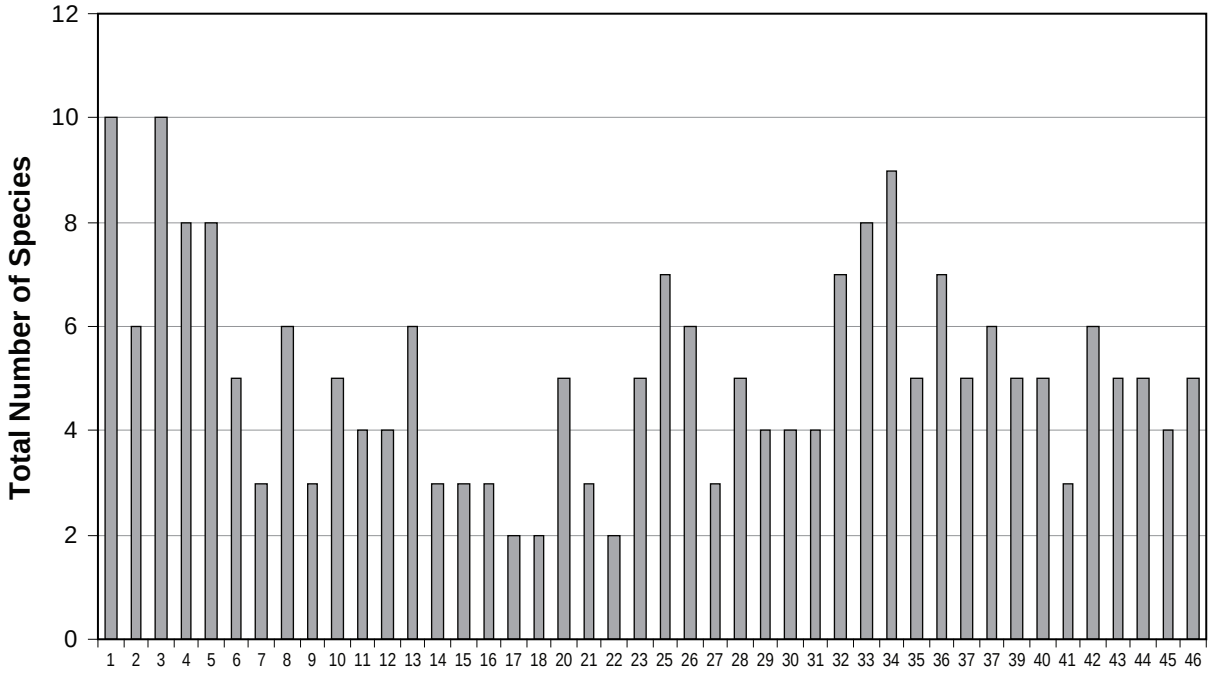
Shannon's H diversity indices indicated a wide range of diversity values among habitat types represented along the BIPR proposed road. The highest diversity values were observed in riparian shrub and birch seep habitats. Beach habitats, found along the shoreline at Bathurst Inlet, hosted the third highest species diversity followed by heath tundra, sedge (Plate 3.2-3), rocky outcrop, avens, boulder field, and esker complexes. Lichen rock habitats hosted the lowest species diversity (Table 3.2-2).

Table 3.2-2
Avian Diversity and Evenness Index Values by Habitat Type along the BIPR Proposed Road

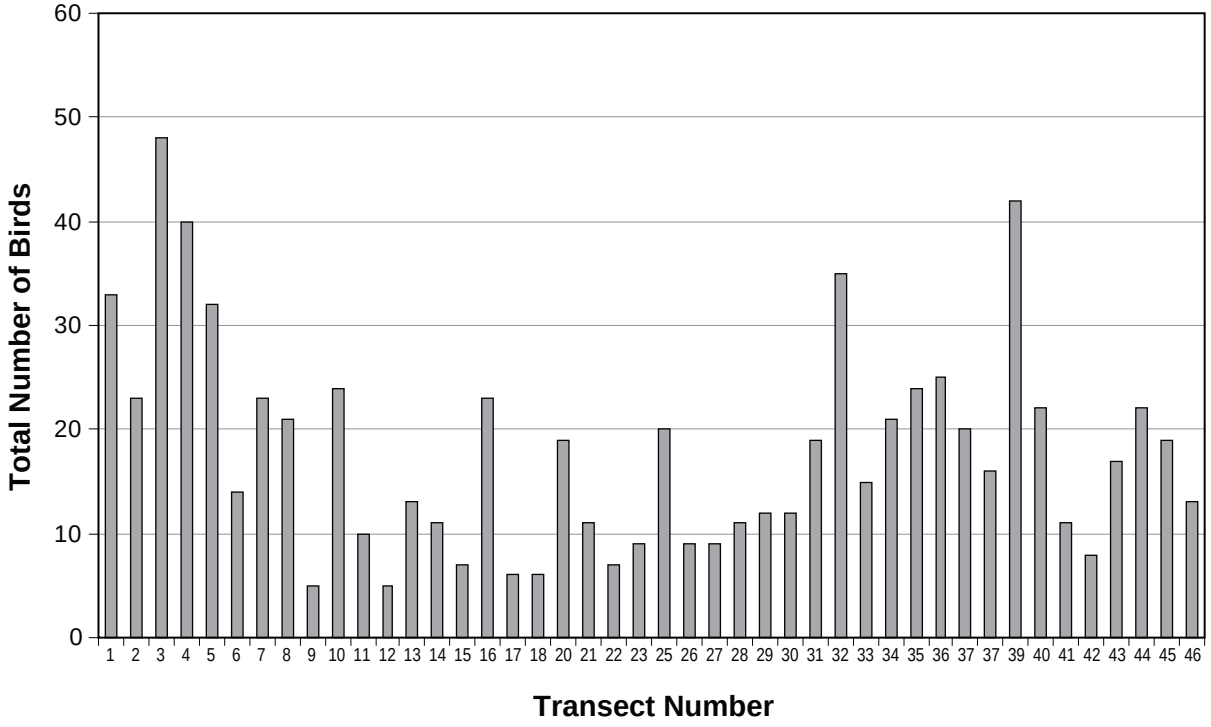
Habitat Type	Shannon's Diversity Index (H)	Equitability Value (EH)
Riparian Shrub	2.29	0.79
Birch Seep	2.13	0.69
Beach Materials	1.92	0.77
Heath Tundra	1.87	0.53
Sedge	1.86	0.62
Rocky Outcrop	1.66	0.72
Avens	1.45	0.58
Boulder Field	1.39	0.12
Esker Complex	1.33	0.96
Lichen Rock	0.45	0.33

Riparian habitats (Plate 3.2-4) also had high equitability values, meaning that the relative abundance of birds belonging to different species was well-balanced. The low equitability value for boulder fields and lichen rock communities, on the other hand, would indicate a disproportionately high abundance of few primary species, and low numbers of individuals of other species that contributed to the diversity value. The highest equitability value was observed in the esker complex, meaning that this community, although low in diversity, has a well-balanced proportional abundance of species (Table 3.2-2).

a) Number of Species



b) Number of Birds



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Number of Species and Birds Observed per Transect along the BIPR Road

FIGURE 3.2-2

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Plate 3.2-3. Example of birch seep habitat, which combines emergent birch vegetation with sedge tussocks in a generally wetter substratum than in heath / tundra habitat.

Note that leaves have not yet emerged on birch in this photograph, making the birch shrubs difficult to see.

Plate 3.2-4. Example of riparian shrub habitat with prominent vertical vegetation structure alongside river valleys.

Note: The significant shrub structures, found in both riparian shrub and birch seep habitats, promoted the highest species diversities, and hosted one of 3 unique community assemblages, consisting of a high number of shrub nesting species, along the BIPR road alignment.

3.2.3 Habitat Associations and Community Structure

Relative abundance values were calculated for each species within each of the habitat types included in the cluster analysis. Relative abundance values by habitat type for each species are summarized in Table 3.2-3.

Table 3.2-3
Relative Abundance (Proportion) of Bird Species in Five Habitat Types along the BIPR Project

Species code	Riparian shrub (n=34)	Birch seep (n=17)	Heath tundra (n=98)	Sedge (n=12)	Boulder field (n=25)
Common Redpoll	0.29	0.24	0.07	0.00	0.13
Lapland Longspur	0.16	0.21	0.49	0.46	0.42
Savannah Sparrow	0.16	0.24	0.13	0.26	0.06
American Tree Sparrow	0.09	0.04	0.05	0.03	0.01
Gray Cheeked Thrush	0.05	0.00	0.01	0.00	0.00
Hoary Redpoll	0.05	0.06	0.00	0.00	0.01
Yellow Warbler	0.05	0.00	0.00	0.00	0.00
White Crowned Sparrow	0.04	0.03	0.01	0.00	0.00
Canada Goose	0.03	0.00	0.00	0.06	0.00
Semipalmated Sandpiper	0.02	0.07	0.01	0.00	0.05
American Pipit	0.01	0.00	0.02	0.00	0.01
Long tailed Jaeger	0.01	0.01	0.01	0.00	0.05
Red Necked Phalarope	0.01	0.00	0.00	0.00	0.03
Harris' Sparrow	0.01	0.03	0.01	0.00	0.04
Horned Lark	0.01	0.01	0.10	0.00	0.10
Least Sandpiper	0.01	0.00	0.01	0.06	0.01
American Golden Plover	0.00	0.00	0.02	0.00	0.00
Herring Gull	0.00	0.00	0.00	0.00	0.00
Long tailed Duck	0.00	0.00	0.00	0.00	0.01
Northern Pintail	0.00	0.00	0.00	0.06	0.00
Parasitic Jaeger	0.00	0.00	0.00	0.00	0.00
Rock Ptarmigan	0.00	0.01	0.02	0.03	0.04
Sandhill Crane	0.00	0.00	0.00	0.00	0.00
Semipalmated Plover	0.00	0.00	0.01	0.03	0.01
Stilt Sandpiper	0.00	0.01	0.00	0.03	0.00
Willow Ptarmigan	0.00	0.01	0.00	0.00	0.00

(n= no. point counts sampled)

The cluster analysis revealed three main bird community assemblages associated with three main habitat features:

Cluster 1: A unique community assemblage of birds was found in combined **heath tundra** (Plate 3.2-5) and **boulder field** habitats, which are characterized by dry and low heterogeneous habitat structure. Common redpoll, Lapland longspurs, horned larks, rock ptarmigan, American pipit, and Harris' sparrow were highest in abundance in these habitats.

Cluster 2: A second unique community assemblage of birds was found in **birch seep** (Plate 3.2-3) and **riparian shrub** (Plate 3.2-4) habitats, which were characterized by the

presence of shrubs and significant vertical vegetation structure. Bird communities were composed of mainly shrub-nesting species in these areas. Common redpoll, hoary redpoll, American tree sparrow, white-crowned sparrow, and savannah sparrow occurred in both riparian shrub and birch seep habitats, and were all generally in higher abundance in these habitats compared to other habitats.

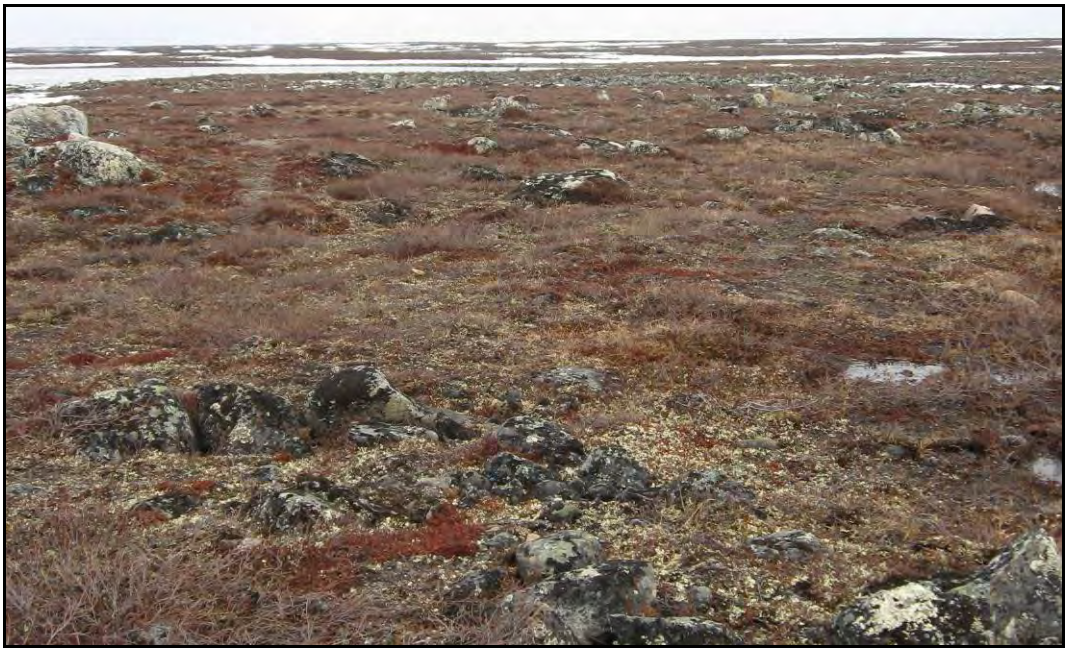

Plate 3.2-5. Example of heath tundra habitat.

Plate 3.2-6. Example of sedge habitat in the BIPR road alignment.

Cluster 3: A third unique community assemblage of birds was found in grassy, **sedge** habitat (Plate 3.2-6). Bird communities in sedge habitats were composed largely of wetland species, including savannah sparrow, Canada goose, lesser sandpiper, northern pintail, semipalmated plover, and stilt sandpiper.

3.2.4 Species of Conservation Concern

The conservation status, according to four ranking systems, International (NatureServe), National (Committee on the Status of Endangered Species in Canada; COESWIC), and local Northwest Territories (NWT) and Nunavut rankings were determined for each species observed (Table 3.2-4). Northwest Territories rankings were included due to proximity of the territory to Nunavut, and because some of the rankings consider trends that began prior to the separation of the NWT and Nunavut. Nunavut is also a relatively understudied area, and rankings may be based on fewer studies than the NWT. Two species were listed by COSEWIC as species of special concern: peregrine falcon (*Falco perigrinus tundrius*) and short-eared owl (*Asio flammeus*). The peregrine falcon was also listed as G4 status by Natureserve, meaning that there is some concern in the long-term for this species due to declines. Various other species observed were ranked as sensitive by local NWT and Nunavut ranking categories, and these species are listed in Table 3.2-4 with their level of ranking.

Table 3.2-4
List of Species and Conservation Ranking According to NatureServe, COSEWIC, and NWT Listings

	Common Name	Scientific Name	NatureServe	COSEWIC status	NWT ranking	Nunavut ranking
AMPI	American Pipit	*Anthus rubescens*	G5		sensitive	4
ATSP	American Tree Sparrow	*Spizella arborea*	G5		sensitive	3
AMGP	American Golden Plover	*Pluvialis dominica*	G5		sensitive	3
ARTE	Arctic Tern	*Sterna paradisaea*	G5		secure	4
BASA	Baird's Sandpiper	*Calidris bairdii*	G5		secure	4
CAGO	Canada Goose	*Branta canadensis*	G5		secure	4
COLO	Common Loon	*Gavia immer*	G5		secure	4
COME	Common Merganser	*Mergus merganser*	G5		secure	5
CORA	Common Raven	*Corvus corax*	G5		secure	4
CORE	Common Redpoll	*Carduelis flammea*	G5		secure	4
GOEA	Golden Eagle	*Aquila chrysaetos*	G5		secure	3
GCTH	Gray-cheeked Thrush	*Catharus minimus*	G5		secure	5
GRSC	Greater Scaup	*Aythya marila*	G5		secure	5
GWFG	Greater White-fronted Goose	*Anser albifrons*	G5		secure	4
GWTE	Green-winged Teal	*Anas crecca*	G5		secure	5
GYRF	Gyrfalcon	*Falco rusticolus*	G5		secure	4
HASP	Harris's Sparrow	*Zonotrichia querula*	G5		sensitive	3
HEGU	Herring Gull	*Larus argentatus*	G5		secure	4
HORE	Hoary Redpoll	*Carduelis hornemanni*	G5		Undetermined	4
HOLA	Horned Lark	*Eremophila alpestris*	G5		secure	4
LALO	Lapland Longspur	*Calcarius lapponicus*	G5		secure	4

(continued)

Table 3.2-4
List of Species and Conservation Ranking According to NatureServe, COSEWIC, and NWT Listings (completed)

	Common Name	Scientific Name	NatureServe	COSEWIC status	NWT ranking	Nunavut ranking
LESA	Least Sandpiper	*Calidris minutilla*	G5		sensitive	4
LTJA	Long-tailed Jaeger	*Stercorarius longicaudus*	G5		Undetermined	4
NOPI	Northern Pintail	*Anas acuta*	G5		sensitive	4
LTDU	Long-tailed Duck	*Clangula Hyemalis*	G5		sensitive	4
PALO	Pacific Loon	*Gavia pacifica*	G5		secure	4
PAJA	Parasitic Jaeger	*Stercorarius parasiticus*	G5		Undetermined	4
PEFA	Peregrine Falcon tundrius subspecies	*Falco peregrinus tundrius*	G4	Special concern	sensitive	4
RBME	Red-breasted Merganser	*Mergus serrator*	G5		secure	4
RNPL	Red-necked Phalarope	*Phalaropus lobatus*	G5		sensitive	4
RTLO	Red-throated Loon	*Gavia stellata*	G5		secure	4
ROPT	Rock Ptarmigan	*Lagopus mutus*	G5		secure	4
RLHA	Rough-legged Hawk	*Buteo lagopus*	G5		secure	4
SACR	Sandhill Crane	*Grus canadensis*	G5		secure	4
SAVS	Savannah Sparrow	*Passerculus sandwichensis*	G5		secure	4
SEPL	Semipalmated Plover	*Charadrius semipalmatus*	G5		secure	4
SESA	Semipalmated Sandpiper	*Calidris pusilla*	G5		sensitive	3
STSA	Stilt Sandpiper	*Calidris himantopus*	G5		Undetermined	4
TUSW	Tundra Swan	*Cygnus columbianus*	G5		secure	4
WCSP	White-crowned Sparrow	*Zonotrichia leucophrys*	G5		secure	3
WIPT	Willow Ptarmigan	*Lagopus lagopus*	G5		secure	4
YBLO	Yellow-billed Loon	*Gavia adamsii*	G5		Undetermined	4
SEOW	Short-eared Owl	*Asio flammeus*	G5	Special concern	sensitive	3

Species observed along the BIPR alignment with a conservation status (according to Natureserve, COSEWIC, or NWT/Nunavut ranking systems)
Natureserve status ranking definition:
G4: Apparently Secure — Uncommon but not rare; some cause for long-term concern due to declines or other factors.
G5: Secure — Common; widespread and abundant
COSEWIC species status ranking definition
Special Concern (SC) - A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
NWT General status ranking
Sensitive = Species that are not at risk of extinction or extirpation but may have require special attention or protection to prevent them from becoming at risk.
Secure = Species which are not at risk or sensitive.
Undetermined = Species for which insufficient information, knowledge, or data is available to reliably evaluate their general status.
Nunavut General status ranking (according to Nunavut Rankings from www.Wildspecies.ca)
3 = Sensitive - Species that are not believed to be at risk of immediate extirpation or extinction but may require special attention or protection to prevent them from becoming at risk.
4 = Secure - Species that are not believed to belong in the categories *Extirpated*, *Extinct*, *At Risk*, *May Be At Risk*, *Sensitive*, *Accidental* or *Exotic*. This category includes some species that show a trend of decline in numbers in Canada but remain relatively widespread or abundant.
5 = Undetermined - Species for which insufficient data, information, or knowledge is available with which to reliably evaluate their general status.

3.2.5 Incidental Wildlife Observations

All non-avian wildlife species that were observed incidentally during travel to and from transects, or on the ground during surveys was recorded as incidental observations. Locations of species, numbers of adults, and numbers of offspring observed are shown in Figure 3.2-3.

3.3 Discussion

3.3.1 Species Observed and Reproductive Phenology

Forty-one species were identified in the study area. The timing of surveys was ideal for songbirds, as many of the species observed had nests with eggs; however, some sandpipers and waterfowl may have arrived later in the season after a greater proportion of ice had melted from waterbodies.

Breeding among species of birds tends to be highly synchronous due to the short breeding and growing season in northern latitudes, as in other "extreme" environments (Bears *et al*., 2003). Hatchling and fledgling emergence is often timed to correspond to dates of insect emergence, as insects are the primary food item fed to most developing songbirds. Synchronous breeding was also observed along the BIPR proposed road; many species had nests with eggs at the same phenology stage at the same time during the survey period. Further, insects began to emerge by *ca*. 24 June, corresponding to the dates at which many of the nests hatched, or were forecasted to hatch by known, species-specific incubation schedules.

Transects that hosted the highest numbers of species were located at the northern portion of the road near the proposed port site, or between km 120 and 170. Transects that hosted the highest number of birds inclusive of all species, were again found near the north terminus of the road near the proposed port site, as well as between km 120 to 170. The port site and habitat associated with Bathurst Inlet may host higher numbers of bird species and densities because the area combines both marine and terrestrial habitats, including features that are unique (*i.e*. oceanic beach habitat along the inlet) and in relatively low abundance (*i.e*. riparian and birch seep habitat) in proportion to other habitat types along the rest of the road. These relatively unique or disparate habitat features are favoured by birds in the study region. The habitat composition between km 120 and 170 is also heterogeneous, in that a mosaic of different habitat are present in close proximity to one another compared to other areas of the road. The availability of unique or rare habitat attributes or a mosaic of habitat types also likely correlates with higher productivity and heterogeneity of food resources as well, which could explain why higher densities and more species can be supported in those areas. Higher densities may also exist in portions of the road with rare habitat types simply because a higher number of birds use a smaller available area of favoured habitat due to a shift in supply (rare habitats) and demand (favoured use of those habitats).

3.3.2 Diversity Comparisons among Habitats

Species richness and equitability values varied considerably between VRPC plots within the study area, which allows for a limited extrapolation of habitat characteristics associated with high and low species diversity. Songbird diversity and abundance in other studies were positively correlated with increased vegetative diversity and structural heterogenetity (*e.g.,* vertical stratification of vegetation; Whelan, 2001), shrubby buffer areas along water or where two habitat types transition (Peak and Thompson, 2006), and/or the availability of diverse food resources (Whelan, 2001). These data show that VRPC transects that hosted the highest songbird abundance and diversity were also located in habitats with the greatest vertical stratification of

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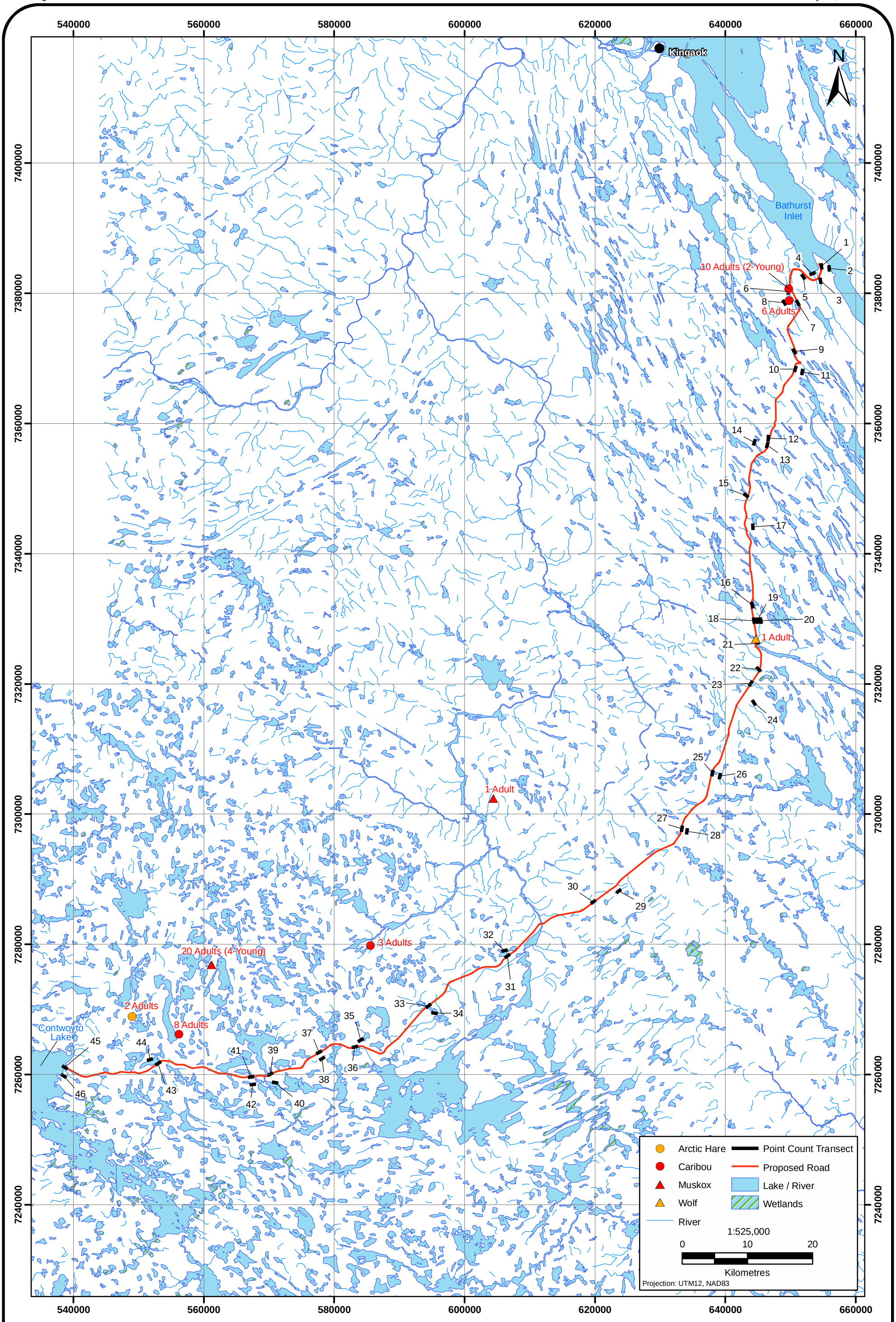

FIGURE 3.2-3

Incidental Wildlife Observations Made During BIPR Surveys

the Bathurst Inlet Port and Road Project

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vegetation (Riparian shrub and Birch Seep) and near water (Riparian shrub). Inversely, habitats with little to no vertical stratification or vegetation, such as lichen rock and avens habitats, hosted the lowest diversity of songbirds.

3.3.3 Habitat Associations and Community Structure

Three main bird communities were detected using cluster analysis. The first unique avian community was found in heath tundra and boulder habitats. Heath tundra and boulder habitat were the most common habitats in the study area. Heath tundra is considered the "climax community" for the area, and is dominated by a mixture of plant species of the Ericaceae (Heath) family, including Labrador tea, blueberry, Arctic heather, Alpine azalea, and bearberry, as well as species of dwarf shrubs (of a lower height), crowberry and sedge. Heath tundra and boulder habitats host many species that nest on the ground, or that nest in low lying vegetation.

The second unique avian community assemblage was associated with considerable vertical vegetative stratification, found in riparian shrub and birch. Riparian shrub habitat occurs in drainage channels, and the dominant species are dwarf birch with several species of willow in the more fluvial areas. Riparian shrub habitat tends to have little grasses and sedges occurring underneath the shrub species. Birch seep habitat, on the other hand, tends to occur on solifluction lobes and hummocks, usually on gentle slopes where moisture migrates downslope on top of permafrost, and dwarf birch, of considerable height, is the dominant species. Both riparian shrub and birch seep habitats hosted a high abundance of shrub nesting species, which prefer nesting well above the ground, relative to other habitats.

Finally, the third avian community assemblage was associated with grassy, sedge habitats. Sedges and cottongrass are dominant species in sedge communities. Sedge habitat tends to occur in poorly drained topographical depressions with peaty materials that overlay mineral soils and gradually sloping margins. Several types exist, from emergent and non-tussock associations in wetter areas to tussock associations. Sedge habitat hosted ground nesting species that utilize grass cover to limit nest conspicuousness, and species that are typically associated with wetlands, likely due to the greater availability of standing water.

While heath tundra/ boulder, and sedge habitats are relatively common along the road alignment, structured vegetation such as riparian shrub and birch seep are relatively low in availability. Furthermore, the vertical vegetation structure found in riparian shrub and birch seep habitats are unique across the tundra landscape, making the shrub and birch seep community assemblage most sensitive to habitat loss. Riparian shrub and birch seep habitats, therefore, not only host the highest diversity of species, but they also provide habitat for one of three unique species assemblages/clusters.

3.3.4 Species of Conservation Concern

Two species of concern according to national rankings were detected during songbird surveys, as well as during incidental observations, peregrine falcon and short-eared owl. Nationally, the *tundrius* subspecies of the peregrine falcon, *Falco peregrinus tundrius* is considered of 'special concern' by COSEWIC (2007). In the Northwest Territories, this species is classified as 'sensitive' which means that the species is not at risk of extinction but may require special

attention or protection to prevent the species from becoming at risk (Working Group on General Status of NWT Species, 2006). However, the peregrine falcon is listed as secure in Nunavut rankings. In the central Arctic, peregrine falcon nests predominately on south facing cliffs adjacent to or near bodies of water, most frequently on rocky cliffs along rivers or lakes. The availability of suitable cliffs for nesting is likely the most critical feature of its breeding habitat and the same cliffs can be occupied and reused for decades by this species (Sinclair *et al.* 2003). The second most important component of this species' breeding habitat in the Arctic is the proximity to wetlands and riparian areas where waterfowl and shorebirds, the main prey species of peregrine falcons, are common (Sinclair *et al*. 2003). During the songbird survey, the peregrine falcon was detected incidentally in proximity to wetlands. On one occasion, an adult falcon was seen hunting shorebirds along a partly frozen lake, confirming that this species utilizes shorebirds as prey in the Study Area under consideration.

The short-eared owl, *Asio flammeus*, is also classified as a species of 'special concern' by COSEWIC in Canada due to a national trend of declining numbers and due to its sensitivity to human disturbance in its habitat (COSEWIC 2007). In the Northwest Territories and Nunavut, the species is considered to be 'sensitive' (Working Group on General Status of NWT Species 2006). In the Arctic, populations of short-eared owl are known to fluctuate in numbers, concomitant with populations of lemmings which have a cyclic population cycle of high to low abundance every 3 to 4 years. In Nunavut, the short-eared owls inhabit mainly lowland tundra, such as meadow dominated by sedge, and nests on the ground. Along the BIPR proposed road, this species was observed several times flying above wet meadows near small lakes.

Additional species listed as sensitive in Nunavut, which were observed during our surveys included white-crowned sparrow, Harris' sparrow, American tree sparrow, American golden plover and semipalmated sandpiper. The listings for Nunavut are relatively new, and the territory is generally understudied. Therefore, the listings of sensitive species for Nunavut are likely to be updated in the near future as more information on bird communities becomes available. All of the species listed for Nunavut were relatively common in the Project study area. For example, Harris' sparrows, American golden plovers and white-crowned sparrows were the 15th, 14th and 13th most common species observed and the American tree sparrow was the 4th most common species. Therefore, some of the current Nunavut rankings may be equivocal, or questionable, in the local study area. It should be noted that the golden eagle, which is listed under the Nunavut ranking system, has been observed during surveys of the proposed Hackett mining footprint, and was indeed rarely observed. There is the potential for golden eagle to occur along the proposed BIPR road, although they were not observed during 2007 surveys, and their listing in the Nunavut ranking system may reflect their genuine rarity.

4. BATHURST INLET WATERFOWL SURVEY

4. Bathurst Inlet Waterfowl Survey

4.1 Aerial Survey Methods

An aerial survey of Bathurst Inlet was conducted on June 25, 2007, in order to document waterfowl using the open water of Bathurst Inlet, near the northern terminus of the BIPR road. During the survey, the species and numbers of species seen on the open water of the inlet were recorded. Two observers and one recorder were used during the survey. The helicopter covered the visual area of the Bathurst Inlet, and slowed down to circle and count waterbirds when they were observed. Bathurst Inlet was surveyed for an hour in a jet ranger helicopter.

4.2 Results

4.2.1 Species Observed

Eight species were recorded on the water of Bathurst Inlet (Table 4.2-1). None of the species observed are at risk according to any of the species ranking groups.

Table 4.2-1
Species and Numbers of Individuals Observed in Bathurst Inlet on June 25

Species	Number	Breeding Confirmed
Yellow-billed Loon	3	No
Greater Scaup	10	No
Common Loon	2	No
Red-throated Loon	1	No
Long-tailed Duck	12	No
Canada Geese	40	No
Herring Gull	2	No
Green-winged Teal	1	No

Incidental observations of flyovers made during VRPC surveys also indicated additional waterfowl species using the area that may move north to use the Inlet once the ice recedes to a greater degree. Waterfowl species observed during VRPC surveys, which were not recorded during surveys of Bathurst Inlet, included: red-breasted merganser, pacific loon, tundra swan, greater white-fronted goose, and northern pintail.

4.2.2 Reproductive Phenology and Observations

No breeding or nesting activity was recorded during the aerial waterfowl survey. A high degree of ice coverage remaining on the Inlet at the time of the survey may have delayed waterfowl breeding in the 2007 breeding season.

4.2.3 Species of Conservation Concern

All species observed during the waterfowl surveys are listed with their conservation ranking in Table 3.2-4. Long-tailed ducks were ranked as sensitive for the NWT, but were secure for Nunavut. No species of waterfowl observed on Bathurst Inlet had a conservation status. However, yellow-billed loons currently have an unknown species status ranking in the NWT.

4.3 Discussion

Only 8 species were identified on the water in Bathurst Inlet during the aerial survey on June 25th. In 2007, the ice melt from the lakes was delayed relative to previous years. The late spring in 2007 was probably responsible for the low number of species observed during the survey, as a higher diversity of waterfowl was expected. No nesting observations were made for any of the species recorded; however a herring gull nest was observed in a nearby area. The goal of the survey was not to document nesting activities, however, and it is unlikely that nests would have been noticed during overhead surveys to document species using open water. Therefore the reproductive phenology is unknown for the species recorded. Species observed during VRPC surveys that were not present on Bathurst Inlet are expected to arrive and use the Inlet as the ice recedes.

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APPENDIX I
SUMMARY OF POINT COUNT DATA BY TRANSECT AND POINT

Appendix I
Summary of Point Count Observations by Transect and Point

Transect No.	UTM Coordinates of points in the centre of transect	Point count #	Habitat Class	Species name	Total birds per pt count
1	13W 388253 7382047	1	HT	American Pipit	1
				Common Redpoll	3
				Gray-checked Thrush	2
				Lapland Longspur	4
		2	HT	Common Redpoll	3
				Horned Lark	1
				Lapland Longspur	4
				Sandhill Crane	1
				Semipalmated Sandpiper	1
		3	HT	Common Redpoll	2
				Lapland Longspur	3
		4	HT	American tree Sparrow	1
				Common Redpoll	1
				Lapland Longspur	1
		5	SE	Lapland Longspur	2
				Least Sandpiper	2
				Semipalmated Plover	1
2	13W 389402 7381645	1	BS	American tree Sparrow	1
				Savannah Sparrow	2
				Unidentified redpoll	1
				White-crowned Sparrow	1
		2	AV	Unidentified redpoll	3
				White-crowned Sparrow	1
		3	AV	Horned Lark	2
				Unidentified redpoll	2
		4	HT	American tree Sparrow	1
				Lapland Longspur	2
				Savannah Sparrow	1
		5	HT-BS	American tree Sparrow	1
				Savannah Sparrow	2
				Unidentified redpoll	1
				White-crowned Sparrow	2
3	13W 387903 7379838	1	RS	Common Redpoll	5
				Gray-checked Thrush	1
				White-crowned Sparrow	1
				Yellow Warbler	3
		2	RS	American tree Sparrow	2
		3	RS	Common Redpoll	11
				Gray-checked Thrush	1
				Lapland Longspur	1
				White-crowned Sparrow	2
				Yellow Warbler	1
		4	RS	Common Redpoll	3
				Gray-checked Thrush	2
				White-crowned Sparrow	1
		5	RS	Gray-checked Thrush	2
				Harris's Sparrow	1
				Hoary Redpoll	4
				Horned Lark	1
				Yellow Warbler	2
		6	RS	Savannah Sparrow	2
		7	RS	Yellow Warbler	2
4	13W 386770 7381089	1	BE	American tree Sparrow	1
				Common Redpoll	6
				Savannah Sparrow	1
				White-crowned Sparrow	1
		2	BE	Lapland Longspur	2
				Least Sandpiper	1
				Savannah Sparrow	2
		3	BE	Savannah Sparrow	1
		4	BE	Common Redpoll	2
				Savannah Sparrow	1
		5	BE	American tree Sparrow	1
				Common Redpoll	1
				Lapland Longspur	2
				Savannah Sparrow	1
		6	BE	Canada Goose	5
				Lapland Longspur	2
				Savannah Sparrow	1
		7	BE	American tree Sparrow	1
				Common Redpoll	4
				Gray-checked Thrush	1
				Lapland Longspur	1
				Savannah Sparrow	1
				White-crowned Sparrow	1

*** Transects 19 and 24 were not surveyed in 2007**

(continued)

Appendix I
Summary of Point Count Observations by Transect and Point (continued)

Transect No.	UTM Coordinates of points in the centre of transect	Point count #	Habitat Class	Species name	Total birds per pt count
5	13W 385321 7380727	1	BS	Hoary Redpoll	4
				Unidentified redpoll	5
		2	BS	Common Redpoll	2
				Savannah Sparrow	3
				Unidentified redpoll	5
		3	BS	American tree Sparrow	1
				Common Redpoll	2
				Savannah Sparrow	1
				Willow Ptarmigan	1
		4	BS	Common Redpoll	2
				Harris's Sparrow	2
				Savannah Sparrow	2
		5	BS	Lapland Longspur	1
				White-crowned Sparrow	1
6	13W 382860 7378673	1	RS	American tree Sparrow	1
				Common Redpoll	3
				Savannah Sparrow	1
		2	RS	American tree Sparrow	1
				Common Redpoll	1
		3	RS	Common Redpoll	2
				Hoary Redpoll	1
				Savannah Sparrow	2
		5	RS	American tree Sparrow	1
				Lapland Longspur	1
7	13W 384085 7376837	2	HT	American tree Sparrow	1
				Savannah Sparrow	2
		3	HT	American tree Sparrow	2
				Common Redpoll	2
				Savannah Sparrow	3
		4	HT	American tree Sparrow	2
				Common Redpoll	6
				Savannah Sparrow	2
		5	HT	American tree Sparrow	3
8	13W 382032 7377038	1	RS	American tree Sparrow	1
				Common Redpoll	1
				Gray-checked Thrush	1
				Savannah Sparrow	1
		2	RS	American tree Sparrow	1
				Common Redpoll	1
				Lapland Longspur	2
				Savannah Sparrow	2
		3	RS	American tree Sparrow	1
				Hoary Redpoll	1
				Savannah Sparrow	2
		4	RS	American tree Sparrow	1
				Hoary Redpoll	2
				Savannah Sparrow	1
		5	RS	American tree Sparrow	1
				Savannah Sparrow	2
9	13W 382842 7369443	1	EV	Savannah Sparrow	1
		3	EV	American tree Sparrow	1
				Common Redpoll	2
				Savannah Sparrow	1
10	13W 382759 7366752	1	HT-RO	Gray-checked Thrush	1
				Horned Lark	4
				Lapland Longspur	1
		2	HT	Horned Lark	1
				Lapland Longspur	4
				Unidentified redpoll	2
		3	HT	Gray-checked Thrush	1
				Horned Lark	1
				Lapland Longspur	3
		4	HT	Hoary Redpoll	2
				Savannah Sparrow	2
		5	SE-RO	Savannah Sparrow	2
11	13W 383762 7366174	1	HT	American Pipit	2
				Least Sandpiper	1
		2	HT	Horned Lark	1
		4	HT	Horned Lark	3
				Lapland Longspur	1
		5	HT	Lapland Longspur	2
12	13W 377598 7356582	1	BS	American tree Sparrow	1
				Common Redpoll	2
				Horned Lark	1
		4	BS	Savannah Sparrow	1

*** Transects 19 and 24 were not surveyed in 2007**

(continued)

Appendix I
Summary of Point Count Observations by Transect and Point (continued)

Transect No.	UTM Coordinates of points in the centre of transect	Point count #	Habitat Class	Species name	Total birds per pt count
13	13W 377348 7355532	1	HT	Herring Gull	1
				Horned Lark	1
				Savannah Sparrow	1
		2	HT	Horned Lark	1
		3	HT	Lapland Longspur	1
				Savannah Sparrow	1
		4	HT	American Pipit	1
				Horned Lark	1
				Lapland Longspur	1
		5	HT	American Pipit	1
				Horned Lark	2
				Savannah Sparrow	1
14	13W 375403 7356158	1	HT	Horned Lark	1
				Savannah Sparrow	1
		2	HT	Lapland Longspur	2
		3	HT	Lapland Longspur	2
				Savannah Sparrow	2
		4	HT	Horned Lark	1
		5	HT	Horned Lark	1
				Lapland Longspur	1
15	13W 373350 7348133	1	AV	American Pipit	1
		2	AV	American Pipit	2
		3	AV	Common Redpoll	1
				Horned Lark	3
16	13W 372698 7331290	1	HT-LA	Lapland Longspur	3
		2	HT-LA	Horned Lark	1
				Lapland Longspur	4
		3	HT-LA	Lapland Longspur	9
				Long-tailed Jaeger	2
		5	HT-LA	Lapland Longspur	4
17	13W 373946 7343267	1	HT	Lapland Longspur	2
		2	HT	Lapland Longspur	2
				Savannah Sparrow	1
		3	HT	Lapland Longspur	1
18	13W 372729 7328904	1	LR	Lapland Longspur	2
				Least Sandpiper	1
		2	LR	Lapland Longspur	1
		4	LR	Lapland Longspur	1
		5	LR	Lapland Longspur	1
20	13W 373774 7328790	1	BD	Horned Lark	1
				Lapland Longspur	3
				Long-tailed Jaeger	4
				Savannah Sparrow	1
		2	BD	Lapland Longspur	1
		3	BD	Lapland Longspur	1
				Savannah Sparrow	1
		4	BD	Lapland Longspur	3
		5	BD	Lapland Longspur	3
				Semipalmated Sandpiper	1
21	13W 372947 7325654	1	EV-HT	Horned Lark	2
				Lapland Longspur	2
				Savannah Sparrow	1
		2	EV-RS	Lapland Longspur	1
		4	EV-RS-SE-HT-AV	Lapland Longspur	2
				Savannah Sparrow	2
		5	HT-SE-Wa	Horned Lark	1
22	13W 372707 7321392	1	SE	Savannah Sparrow	2
		2	SE	Northern Pintail	2
				Savannah Sparrow	1
		5	SE	Savannah Sparrow	2
23	13W 371304 7319344	1	BS	Lapland Longspur	1
		2	BS	Savannah Sparrow	1
		3	HT	Horned Lark	2
		4	HT	American Golden Plover	1
				Common Redpoll	1
				Lapland Longspur	2
		5	BS	Savannah Sparrow	1
25	13W 364175 7306129	1	RS-HT	American Pipit	1
				Savannah Sparrow	1
		3	HT-BD-BS	Harris's Sparrow	2
				Lapland Longspur	2
				Long-tailed Duck	1
				Savannah Sparrow	1
		4	BD	Common Redpoll	2
				Horned Lark	1

*** Transects 19 and 24 were not surveyed in 2007**

(continued)

Appendix I
Summary of Point Count Observations by Transect and Point (continued)

Transect No.	UTM Coordinates of points in the centre of transect	Point count #	Habitat Class	Species name	Total birds per pt count
25	13W 364175 7306129			Lapland Longspur	1
				Savannah Sparrow	1
		5	BD	Common Redpoll	2
				Horned Lark	1
				Lapland Longspur	3
				Savannah Sparrow	1
26	13W 365264 7305600	1	RO	Horned Lark	1
				Lapland Longspur	1
		2	RO	Harris's Sparrow	1
		3	RO	Horned Lark	1
				Savannah Sparrow	1
				Semipalmated Plover	1
		4	RO	Common Redpoll	1
				Harris's Sparrow	1
				Lapland Longspur	1
27	12N 633342 7297692	1	HT	Common Redpoll	1
		2	HT-BD	Common Redpoll	1
				Lapland Longspur	2
		3	HT	Lapland Longspur	1
		4	HT	Lapland Longspur	2
				Rock Ptarmigan	1
		5	HT	Lapland Longspur	1
28	12N 634136 7297297	1	BD-HT	Lapland Longspur	1
		2	BD-HT	American Pipit	1
				Common Redpoll	1
				Horned Lark	1
				Lapland Longspur	2
		3	BD-HT	Lapland Longspur	2
		4	BD-HT	Common Redpoll	1
				Harris's Sparrow	1
		5	BD-HT	Common Redpoll	1
29	12N 623628 7288135	2	RS	Lapland Longspur	1
		3	RS	Lapland Longspur	2
		4	RS	Lapland Longspur	2
				Long-tailed Jaeger	2
				Red-necked Phalarope	2
		5	RS	Lapland Longspur	2
				Savannah Sparrow	1
30	12N 619748 7286477	1	HT	Lapland Longspur	2
		2	HT	Lapland Longspur	2
				Parasitic Jaeger	2
		4	HT	American Golden Plover	1
				Lapland Longspur	1
				Savannah Sparrow	1
		5	HT	American Golden Plover	1
				Lapland Longspur	1
				Savannah Sparrow	1
31	12N 606562 7278167	1	HT	Harris's Sparrow	2
				Lapland Longspur	4
				Savannah Sparrow	2
		3	HT	Lapland Longspur	6
		4	HT	Lapland Longspur	3
		5	HT-BS	Common Redpoll	1
				Lapland Longspur	1
32	12N 606124 7279006	1	BS	Common Redpoll	2
				Lapland Longspur	2
				Savannah Sparrow	1
		2	BS	Lapland Longspur	3
				Savannah Sparrow	3
		3	BS	Common Redpoll	2
				Lapland Longspur	5
				Rock Ptarmigan	1
				Semipalmated Sandpiper	1
				Stilt Sandpiper	1
		4	BS	Common Redpoll	2
				Lapland Longspur	3
				Semipalmated Sandpiper	2
		5	BS	Common Redpoll	2
				Long-tailed Jaeger	1
				Savannah Sparrow	2
				Semipalmated Sandpiper	2
33	12N 594460 7270516	1	HT	Lapland Longspur	1
				Savannah Sparrow	1
		2	HT	Horned Lark	2
				Lapland Longspur	1

*** Transects 19 and 24 were not surveyed in 2007**

(continued)

Appendix I
Summary of Point Count Observations by Transect and Point (continued)

Transect No.	UTM Coordinates of points in the centre of transect	Point count #	Habitat Class	Species name	Total birds per pt count
33	12N 594460 7270516			Least Sandpiper	1
		3	SE	American tree Sparrow	1
				Canada Goose	2
				Stilt Sandpiper	1
		4	SE	Lapland Longspur	2
				Savannah Sparrow	1
		5	RS	Common Redpoll	2
34	12N 595386 7269393	1	BD-SE	Hoary Redpoll	1
				Lapland Longspur	1
				Semipalmated Sandpiper	1
		2	BD-SE	Common Redpoll	1
				Horned Lark	2
				Long-tailed Duck	1
				Red-necked Phalarope	2
				Semipalmated Sandpiper	1
		3	BD-SE	Lapland Longspur	1
				Rock Ptarmigan	1
		4	BD-SE	Lapland Longspur	2
				Rock Ptarmigan	2
		5	BD-SE	American tree Sparrow	1
				Common Redpoll	1
				Lapland Longspur	2
				Semipalmated Sandpiper	1
35	12N 584050 7265263	1	HT	Common Redpoll	1
				Harris's Sparrow	1
				Lapland Longspur	2
				Semipalmated Plover	1
		2	HT	Common Redpoll	1
				Lapland Longspur	3
				Semipalmated Sandpiper	1
		3	HT	Lapland Longspur	3
		4	HT	Common Redpoll	1
				Lapland Longspur	4
				Semipalmated Plover	1
		5	HT	Horned Lark	2
				Lapland Longspur	3
36	12N 583168 7264227	1	HT	Horned Lark	1
				Lapland Longspur	3
				White-crowned Sparrow	1
		2	HT	American tree Sparrow	1
				Lapland Longspur	2
				Savannah Sparrow	1
		3	HT	Lapland Longspur	3
		4	HT	American Pipit	4
				Lapland Longspur	5
				Semipalmated Sandpiper	2
		5	HT	Lapland Longspur	1
				Savannah Sparrow	1
37	12N 577679 7263379	1	HT	Lapland Longspur	3
				Long-tailed Jaeger	1
				Rock Ptarmigan	1
		2	HT	Lapland Longspur	4
		3	HT	Lapland Longspur	1
				Rock Ptarmigan	1
				Savannah Sparrow	1
		4	SE-BS	Lapland Longspur	3
				Rock Ptarmigan	1
				Savannah Sparrow	1
		5	HT	Horned Lark	1
				Lapland Longspur	1
				Rock Ptarmigan	1
38	12N 578148 7262424	1	RS	American tree Sparrow	1
				Savannah Sparrow	1
				Semipalmated Sandpiper	1
		2	RS	American Pipit	1
				Lapland Longspur	2
				Semipalmated Sandpiper	1
		3	RS	Common Redpoll	2
				Lapland Longspur	3
		4	RS	Savannah Sparrow	1
				Semipalmated Sandpiper	1
		5	RS	Lapland Longspur	2
39	12N 570197 7260006	1	HT	American tree Sparrow	4
				Lapland Longspur	2
				Rock Ptarmigan	1

*** Transects 19 and 24 were not surveyed in 2007**

(continued)

Appendix I
Summary of Point Count Observations by Transect and Point (completed)

Transect No.	UTM Coordinates of points in the centre of transect	Point count #	Habitat Class	Species name	Total birds per pt count
39	12N 570197 7260006			Savannah Sparrow	4
		2	HT	American tree Sparrow	2
				Lapland Longspur	3
				Savannah Sparrow	1
				Willow Ptarmigan	1
		3	HT	Lapland Longspur	2
				Rock Ptarmigan	1
				Savannah Sparrow	5
		4	HT	Lapland Longspur	7
				Rock Ptarmigan	1
				Savannah Sparrow	1
		5	HT	Lapland Longspur	6
				Savannah Sparrow	1
40	12N 570917 7258723	1	HT	American Golden Plover	1
				Horned Lark	2
				Long-tailed Jaeger	2
				Savannah Sparrow	1
		2	HT	Lapland Longspur	4
				Savannah Sparrow	1
		3	HT	American Golden Plover	1
				Savannah Sparrow	3
		4	HT	Lapland Longspur	4
		5	HT	Lapland Longspur	2
				Savannah Sparrow	1
41	12N 567254 7259592	1	HT	Lapland Longspur	2
				Savannah Sparrow	1
		2	HT	Common Redpoll	2
				Lapland Longspur	1
		3	HT	Lapland Longspur	2
		4	SE	Lapland Longspur	2
		5	BS	Common Redpoll	1
42	12N 567498 7258443	1	(vide)	Least Sandpiper	1
				Long-tailed Jaeger	1
				Savannah Sparrow	1
		2	(vide)	American tree Sparrow	1
				Lapland Longspur	2
		3	(vide)	Lapland Longspur	1
		5	(vide)	Long-tailed Duck	1
43	12N 552981 7261686	1	HT	American Golden Plover	1
				Lapland Longspur	1
		2	Wa-SE	Lapland Longspur	2
		3	SE-Wa	Lapland Longspur	2
				Unidentified sandpiper	2
		4	HT-BS	Lapland Longspur	2
		5	HT	Horned Lark	2
				Lapland Longspur	3
				Savannah Sparrow	2
44	12N 551754 7262250	1	HT	Lapland Longspur	1
				Rock Ptarmigan	1
		2	HT	Lapland Longspur	1
		3	HT	Horned Lark	3
				Lapland Longspur	2
				Rock Ptarmigan	1
				Semipalmated Plover	1
		4	HT	Common Redpoll	3
				Horned Lark	1
				Lapland Longspur	6
		5	HT	Lapland Longspur	1
				Semipalmated Plover	1
45	12N 538680 7261063	1	HT	Lapland Longspur	5
		2	HT	Horned Lark	2
				Lapland Longspur	3
		3	HT	Horned Lark	1
				Lapland Longspur	2
				Unidentified Ptarmigan	1
		4	HT	Lapland Longspur	1
				Savannah Sparrow	1
		5	Wa	Lapland Longspur	3
46	12N 538516 7259738	1	HT-LA	Lapland Longspur	3
		2	HT-LA	American Golden Plover	2
				Horned Lark	1
				Lapland Longspur	1
		3	HT-LA	Lapland Longspur	2
		4	HT-LA	Lapland Longspur	1
				Savannah Sparrow	2
		5	HT-LA	Rock Ptarmigan	1

*** Transects 19 and 24 were not surveyed in 2007**

Appendix D-11
Plant Tissue Sampling

Author: **Rescan Environmental Services Ltd.**
Date: **November 2007**

Rescan™ Environmental Services Ltd.

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Refer To File No. A.1 - 6237_APD-11.DOC

November 2, 2007

Bathurst Inlet Port and Road Joint Venture Limited
340 Park Place 666 Burrard Street
Vancouver, B.C. V6C 2X8

Attention: Mr. Bob Gilroy, Project Manager

Dear Bob:

Re: Plant Tissue Sampling for the Bathurst Inlet Port and Road Project

Background

The collection of plant tissue samples for metals analysis provides information on the metal levels that occur naturally in vegetation growing within the study area. The data collected will be used to direct future monitoring plans.

Scope of Work

Plant tissue samples were collected at intervals along the proposed road as well as at the proposed port facility (Figure 1). Differences in site characteristics along the route resulted in the collection of willows, sedges, and cottongrass (*Salix*, *Carex*, and *Eriophorum*, respectively). The genera collected are those commonly consumed by wildlife in the area. Replicate samples were collected from two of those locations.

Sampling was carried out following common practices for plant tissue collection and methods specified by ALS Environmental who were conducting the analyses. Only the above-ground portion of herbaceous plants and newest/younger growth of woody species (shrubs) were collected. Samples consisted of several individual herbs of the same species or the stems and leaves from shrubs of the same species.

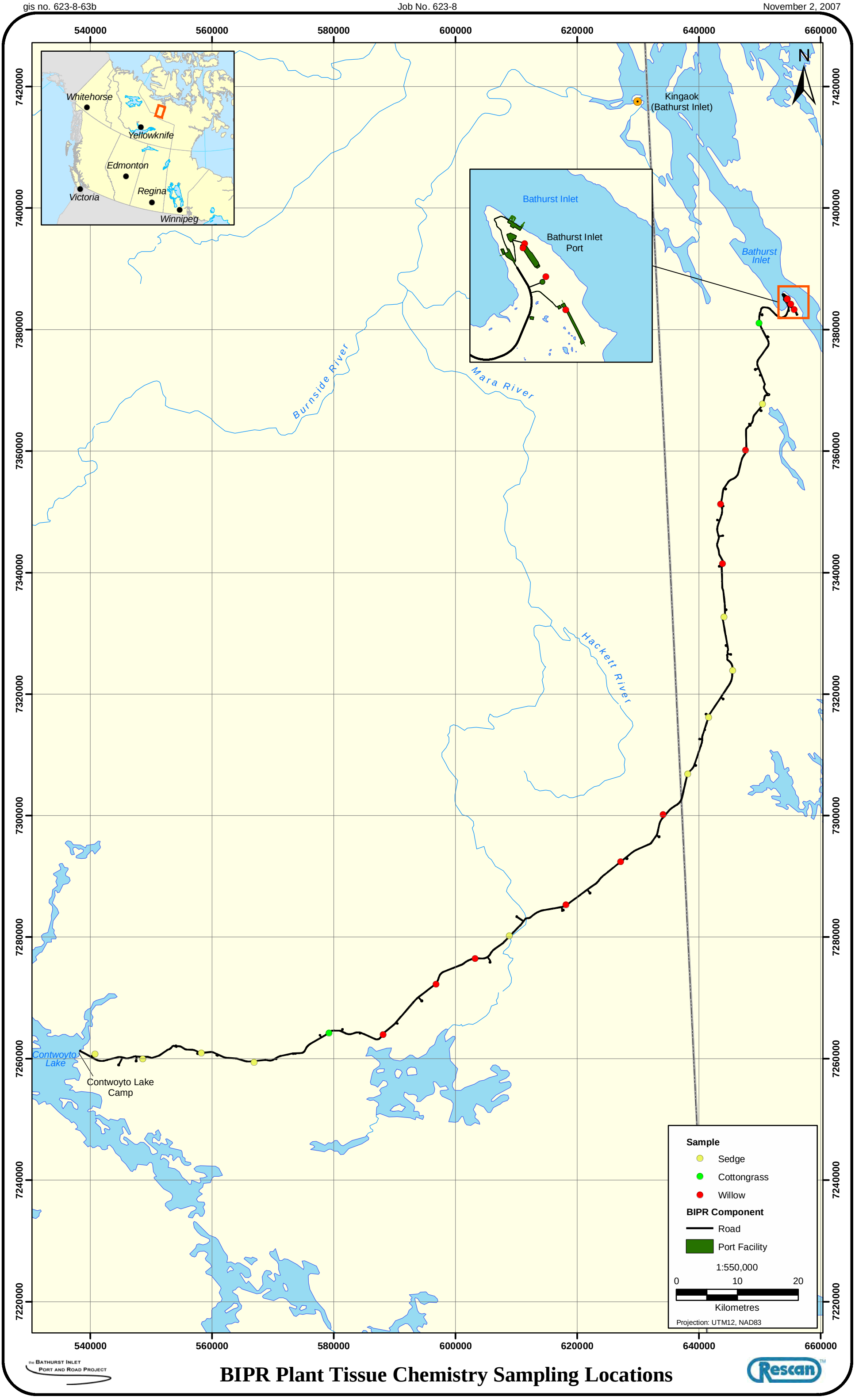
Sampling was conducted by hand. Care was taken to ensure hands were clean during sampling and that any dirt or root material was removed prior to placement into labelled, plastic sampling bags. Samples were kept frozen prior to shipment to ALS Environmental in Vancouver, BC, for analysis. Results are presented as both dry and wet weight. The list of metals analyzed and their associated detection limits are provided in Table 1. The list of samples collected and their geographic location is presented in Appendix 1.

CANADA EXPORT AWARD

Table 1
Analytical Detection Limits

Total Metals	Dry Weight (mg/kg)	Wet Weight (mg/kg wwt)
Aluminum (Al)	10	2
Antimony (Sb)	0.05	0.01
Arsenic (As)	0.05	0.01
Barium (Ba)	0.05	0.01
Beryllium (Be)	0.3	0.1
Bismuth (Bi)	0.3	0.03
Cadmium (Cd)	0.03	0.005
Calcium (Ca)	10	2
Chromium (Cr)	0.5	0.1
Cobalt (Co)	0.1	0.02
Copper (Cu)	0.05	0.01
Iron (Fe)	1	0.2
Lead (Pb)	0.1	0.02
Lithium (Li)	0.5	0.1
Magnesium (Mg)	3	1
Manganese (Mn)	0.05	0.01
Mercury (Hg)	0.005	0.001
Molybdenum (Mo)	0.05	0.01
Nickel (Ni)	0.5	0.1
Phosphorus (P)	20	5
Potassium (K)	100	20
Selenium (Se)	1	0.2
Sodium (Na)	100	20
Strontium (Sr)	0.05	0.01
Thallium (Tl)	0.03	0.01
Tin (Sn)	0.2	0.05
Titanium (Ti)	0.5	0.1
Uranium (U)	0.01	0.002
Vanadium (V)	0.5	0.1
Zinc (Zn)	0.5	0.1

To ensure adequate coverage, sample locations were initially identified at roughly 10 km intervals along the road alignment. Final locations in the field were identified based on the presence and amount of appropriate vegetation available for collection. Where possible, samples were collected adjacent the road alignment where the potential for dust deposition was anticipated to be higher.



the Bathurst Inlet Port and Road Project

BIPR Plant Tissue Chemistry Sampling Locations

Rescan™

Results

Summary results of the laboratory analyses are presented as both dry and wet weight (Table 2 and Table 3, respectively). All laboratory data are presented in Appendix 2. Dry weight displays the metal levels present in plant tissues irrespective of moisture status, while wet weight better reflects *in situ* conditions and provides an approximation of the conditions under which consumers (*e.g.*, wildlife) may naturally encounter and ingest these plants.

Table 2
Dry Weight Metal Concentrations (mg/kg) in Plant Tissues within the BIPR Study Area

	Willow (n=15)			Sedge (N=10)			Cottongrass (n=2)	
Total Metals	**Median (mg/kg)**	**Mean (mg/kg)**	**Range (mg/kg)**	**Median (mg/kg)**	**Mean mg/kg)**	**Range (mg/kg)**	**Median (mg/kg)**	**Range (mg/kg)**
Aluminum (Al)	24.0	27.2	11-73	19.5	30.1	11-133	9.0	5-13
Antimony (Sb)	0.03	0.03	0.025-0.08	0.03	0.03	0.02-0.11	0.03	0.025-0.025
Arsenic (As)	0.03	0.03	0.025-0.07	0.07	0.08	0.02-0.18	0.03	0.025-0.025
Barium (Ba)	24	28	9.08-65.1	17	22	3.31-66.2	10	8.64-12.3
Beryllium (Be)	0.15	0.15	0.15-0.15	0.15	0.15	0.15-0.15	0.15	0.15-0.15
Bismuth (Bi)	0.15	0.15	0.15-0.15	0.15	0.15	0.15-0.15	0.15	0.15-0.15
Cadmium (Cd)	0.73	0.84	0.16-1.98	0.11	0.19	0.04-0.52	0.04	0.04-0.05
Calcium (Ca)	5,760	6,376	4,250-10,300	2,285	2,863	1,570-7,470	1,020	959-1,080
Chromium (Cr)	0.25	0.25	0.25-0.25	0.25	0.25	0.25-0.25	0.25	0.25-0.25
Cobalt (Co)	2.00	2.91	0.1-6.45	0.35	0.39	0.05-0.86	0.05	0.05-0.05
Copper (Cu)	5.53	5.48	4.1-6.92	10.52	10.45	7.36-16.3	3.82	3.15-4.48
Iron (Fe)	44	48	28-83	122	125	48-187	41	31-51
Lead (Pb)	0.05	0.13	0.05-0.59	0.12	0.16	0.05-0.67	0.08	0.05-0.1
Lithium (Li)	0.25	0.25	0.25-0.25	0.25	0.25	0.25-0.25	0.25	0.25-0.25
Magnesium (Mg)	3,600	3,602	2,230-6,560	1,945	1,936	1,520-2,750	955	910-1,000
Manganese (Mn)	257	248	104-404	204	197	56.4-491	109	62.7-155
Mercury (Hg)	0.01	0.01	0.002-0.008	0.00	0.00	0.002-0.01	0.00	0.002-0.005
Molybdenum (Mo)	0.14	0.15	0.02-0.36	0.61	1.28	0.11-4.02	0.73	0.31-1.16
Nickel (Ni)	3.46	6.35	1.18-20.5	9.93	8.73	0.25-14.6	0.75	0.72-0.77
Phosphorus (P)	1,480	1,605	1,130-3,040	1,580	1,758	1,110-2,620	1,190	1,010-1,370
Potassium (K)	8,080	8,413	5,580-12,000	15,700	15,410	10,500-19,100	5,705	4,970-6,440
Selenium (Se)	0.50	0.50	0.5-0.5	0.50	0.50	0.5-0.5	0.50	0.5-0.5
Sodium (Na)	50	85	50-160	50	80	50-150	50	50-50
Strontium (Sr)	36.20	33.18	7.44-66.3	8.77	10.68	3.81-28.7	3.69	3.17-4.2
Thallium (Tl)	0.02	0.02	0.015-0.015	0.02	0.02	0.01-0.01	0.02	0.015-0.015
Tin (Sn)	0.10	0.11	0.1-0.24	0.10	0.10	0.1-0.1	0.10	0.1-0.1
Titanium (Ti)	0.54	0.53	0.25-1.7	0.63	0.55	0.25-1.02	0.25	0.25-0.25
Uranium (U)	0.005	0.005	0.005-0.005	0.005	0.005	0.005-0.005	0.005	0.005-0.005
Vanadium (V)	0.25	0.25	0.25-0.25	0.25	0.25	0.25-0.25	0.25	0.25-0.25
Zinc (Zn)	111.0	118.4	25.6-252	36.9	38.4	18.3-67.1	30	28.4-30.8

Table 3
Wet Weight Metal Concentrations (mg/Wkg) in Plant Tissues within the BIPR Study Area

	Willow (n=15)			Sedge (N=10)			Cottongrass (n=2)	
Total Metals	**Median (mg/Wkg)**	**Mean (mg/Wkg)**	**Range (mg/Wkg)**	**Median (mg/Wkg)**	**Mean (mg/Wkg)**	**Range (mg/Wkg)**	**Median (mg/Wkg)**	**Range (mg/Wkg)**
Aluminum (Al)	8.9	9.77	3.9-22.2	6.6	10.2	4-45.4	3.7	2.3-5
Antimony (Sb)	0.01	0.01	0.005-0.026	0.01	0.01	0.005-0.039	0.01	0.005-0.011
Arsenic (As)	0.01	0.01	0.005-0.026	0.02	0.03	0.005-0.061	0.01	0.011-0.011
Barium (Ba)	10.10	10.10	3.48-20.20	5.56	7.33	1.12-22.7	3.96	3.25-4.67
Beryllium (Be)	0.05	0.05	0.05-0.05	0.05	0.05	0.05-0.05	0.05	0.05-0.05
Bismuth (Bi)	0.015	0.015	0.015-0.015	0.015	0.015	0.015-0.015	0.015	0.015-0.015
Cadmium (Cd)	0.26	0.30	0.06-0.69	0.037	0.064	0.012-0.188	0.017	0.014-0.019
Calcium (Ca)	2,130	2,315	1,560-3,840	760	987	534-2,790	386	361-411
Chromium (Cr)	0.05	0.05	0.05-0.12	0.05	0.05	0.05-0.05	0.05	0.05-0.05
Cobalt (Co)	0.78	1.05	0.04-2.39	0.12	0.13	0.01-0.28	0.01	0.01-0.01
Copper (Cu)	1.96	1.99	1.61-2.57	3.55	3.53	2.42-5.41	1.45	1.19-1.7
Iron (Fe)	16.1	17	10.7-29.9	40.9	42.3	18-64	15.5	11.8-19.2
Lead (Pb)	0.03	0.04	0.01-0.18	0.04	0.05	0.01-0.23	0.03	0.03-0.04
Lithium (Li)	0.05	0.06	0.05-0.16	0.05	0.06	0.05-0.12	0.05	0.05-0.05
Magnesium (Mg)	1,320	1,309	810-1,990	635	658	500-942	362	346-378
Manganese (Mn)	100	91	35.5-153	68	66	21-163	41	23.8-58.4
Mercury (Hg)	0.003	0.002	0.001-0.003	0.002	0.002	0.001-0.003	0.002	0.001-0.002
Molybdenum (Mo)	0.05	0.05	0.02-0.13	0.20	0.44	0.04-1.50	0.28	0.12-0.44
Nickel (Ni)	1.26	2.25	0.5-7.6	3.23	2.91	0.13-4.96	0.28	0.27-0.29
Phosphorus (P)	544	580	417-922	560	589	415-837	451	381-520
Potassium (K)	2,960	3,061	2,140-4,440	5,205	5,192	3,590-6,500	2,160	1,870-2,450
Selenium (Se)	0.10	0.10	0.1-0.1	0.10	0.10	0.1-0.1	0.10	0.1-0.1
Sodium (Na)	10	24	10-69	10	18	10-32	10	10-10
Strontium (Sr)	13.70	11.99	2.86-20.30	2.91	3.58	1.29-9.84	1.40	1.19-1.60
Thallium (Tl)	0.005	0.005	0.005-0.005	0.005	0.005	0.005-0.005	0.005	0.005-0.005
Tin (Sn)	0.025	0.028	0.025-0.071	0.025	0.029	0.025-0.063	0.025	0.025-0.025
Titanium (Ti)	0.18	0.21	0.05-0.52	0.16	0.16	0.05-0.35	0.09	0.05-0.12
Uranium (U)	0.001	0.001	0.001-0.001	0.001	0.001	0.001-0.003	0.001	0.001-0.001
Vanadium (V)	0.05	0.05	0.05-0.05	0.05	0.05	0.05-0.05	0.05	0.05-0.05
Zinc (Zn)	41.7	44.2	9.8-100	12.1	12.9	6.8-22.8	11.2	10.8-11.6

A total of 27 samples were analyzed: 15 willow (including two replicate samples), ten sedge, and two cottongrass. Many of the samples were below the analytical detection limits. In these cases, half of the detection limit value was used for data summaries.

These baseline plant tissue metal concentrations will be used for future monitoring during the operations and closure and reclamation phases. Future metal levels in plant tissue will be compared to baseline values in order to determine if changes in metal levels are occurring. Additional sampling may be conducted in conjunction with the monitoring program for dustfall and fugitive dust.

Results associated with the cottongrass samples should be viewed as anecdotal due to the small sample size (N=2). The identification of possible trends in metals concentrations in plant tissues will focus on those associated with willows and sedges, due to their larger sample sizes. Noticeable changes in metal levels over time could be further analyzed using a risk assessment approach to determine the potential exposure risks to wildlife that may be using the plants of the area as a food source.

Yours truly,

RESCAN™ ENVIRONMENTAL SERVICES LTD.
per:

Tania Perzoff, M.Sc., R.P.Bio.

Appendix 1
Plant Chemistry Sample Locations

Waypoint	Sample	Date	Zone	Northing	Easting	Genus	Replicate
km10	Erio10	7/22/2007	13	7379548	383130	Eriophorum	
km25	Carex25	7/22/2007	13	7366187	382390	Carex	
km34	Salix34	7/22/2007	13	7358920	378889	Salix	
km44	Salix44	7/22/2007	13	7350446	373963	Salix	
km54	Salix54	7/22/2007	13	7340670	373356	Salix	y - 54b
km63	Carex63	7/21/2007	13	7331963	372723	Carex	
km72	Carex72	7/21/2007	13	7323059	373326	Carex	
km81	Carex81	7/21/2007	13	7315717	368631	Carex	
km91	Carex91	7/21/2007	13	7306773	364320	Carex	
km100	Salix100	7/21/2007	12	7300183	634070	Salix	
km111	Salix111	7/21/2007	12	7292460	627104	Salix	
km122	Salix122	7/21/2007	12	7285399	618157	Salix	
km133	Carex133	7/21/2007	12	7280262	608836	Carex	
km140	Salix140	7/21/2007	12	7276537	603189	Salix	
km148	Salix148	7/21/2007	12	7272289	596781	Salix	y - 148b
km160	Salix160	7/21/2007	12	7264011	588108	Salix	
km170	Erio170	7/21/2007	12	7264310	579223	Eriophorum	
km183	Carex183	7/21/2007	12	7259458	566896	Carex	
km193	Carex193	7/21/2007	12	7260977	558275	Carex	
km203	Carex203	7/21/2007	12	7260006	548631	Carex	
km212	Carex212	7/21/2007	12	7260794	540778	Carex	
PortSalix1	PortSalix1	7/18/2007	13	7381212	389065	Salix	
PortSalix2	PortSalix2	7/18/2007	13	7382148	388622	Salix	
PortSalix3	PortSalix3	7/18/2007	13	7383095	388132	Salix	
PortSalix4	PortSalix4	7/18/2007	13	7382987	388078	Salix	

Appendix 2
Laboratory Analysis of Plant Tissue Chemistry

Sample ID	B1PR-SALIX122	B1PR-SALIX111	B1PR-CAREX91	B1PR-SALIX44	PORTSALIX3	B1PR-CAREX212
Date Sampled	21-JUL-07	21-JUL-07	21-JUL-07	22-JUL-07	18-JUL-07	21-JUL-07
Time Sampled	15:20	15:35	16:05	10:30	15:36	11:57
ALS Sample ID	L540099-1	L540099-2	L540099-3	L540099-4	L540099-5	L540099-6
Matrix	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
Physical Tests						
% Moisture	65.2	69.7	65.4	69.5	63.3	65.7
Total Metals						
Aluminum (Al) - dry	25.0	73.0	19.0	13.0	24.0	133
Aluminum (Al) - wet	8.9	22.2	6.7	3.9	8.9	45.4
Antimony (Sb) - dry	<0.050	0.085	<0.050	<0.050	<0.050	0.114
Antimony (Sb) - wet	<0.010	0.026	<0.010	<0.010	<0.010	0.039
Arsenic (As) - dry	<0.050	<0.050	<0.050	<0.050	<0.050	0.107
Arsenic (As) - wet	<0.010	<0.010	0.013	<0.010	<0.010	0.037
Barium (Ba) - dry	33.7	65.1	14.3	32.9	54.9	66.2
Barium (Ba) - wet	11.7	19.7	4.94	10.1	20.2	22.7
Beryllium (Be) - dry	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Beryllium (Be) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bismuth (Bi) - dry	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Bismuth (Bi) - wet	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Cadmium (Cd) - dry	1.98	1.15	0.086	1.20	0.164	0.519
Cadmium (Cd) - wet	0.689	0.349	0.0299	0.367	0.0601	0.178
Calcium (Ca) - dry	5220	7300	2140	10300	4250	3500
Calcium (Ca) - wet	1820	2210	741	3150	1560	1200
Chromium (Cr) - dry	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chromium (Cr) - wet	<0.10	0.12	<0.10	<0.10	<0.10	<0.10
Cobalt (Co) - dry	6.45	3.70	0.34	2.00	0.69	0.64
Cobalt (Co) - wet	2.25	1.12	0.118	0.612	0.255	0.220
Copper (Cu) - dry	5.61	6.02	9.35	6.56	5.53	7.68
Copper (Cu) - wet	1.96	1.82	3.24	2.01	2.03	2.63
Iron (Fe) - dry	39.0	59.5	90.6	70.7	32.7	187
Iron (Fe) - wet	13.6	18.0	31.4	21.6	12.0	64.2
Lead (Pb) - dry	0.15	0.59	0.11	<0.10	<0.10	0.67
Lead (Pb) - wet	0.051	0.179	0.037	<0.020	<0.020	0.229
Lithium (Li) - dry	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Lithium (Li) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	0.12
Magnesium (Mg) - dry	2830	6560	1710	4320	3890	2750
Magnesium (Mg) - wet	985	1990	591	1320	1430	942
Manganese (Mn) - dry	307	117	274	396	170	110
Manganese (Mn) - wet	107	35.5	94.9	121	62.5	37.6
Mercury (Hg) - dry	0.0056	0.0061	<0.0050	0.0060	0.0072	0.0098
Mercury (Hg) - wet	0.0019	0.0019	0.0017	0.0018	0.0027	0.0033
Molybdenum (Mo) - dry	0.131	0.131	2.08	0.152	<0.050	0.586
Molybdenum (Mo) - wet	0.046	0.040	0.722	0.047	0.016	0.201
Nickel (Ni) - dry	8.29	17.4	10.1	2.34	2.59	9.76
Nickel (Ni) - wet	2.89	5.27	3.51	0.72	0.95	3.35
Phosphorus (P) - dry	1310	3040	2010	1600	2140	1560
Phosphorus (P) - wet	458	922	697	489	785	534
Potassium (K) - dry	6140	11000	18800	7540	10400	10500
Potassium (K) - wet	2140	3330	6500	2300	3800	3590
Selenium (Se) - dry	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Selenium (Se) - wet	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Sodium (Na) - dry	<100	<300	<100	<100	160	<100
Sodium (Na) - wet	25	<60	<20	<20	57	32
Strontium (Sr) - dry	38.5	66.3	8.27	24.2	16.6	28.7
Strontium (Sr) - wet	13.4	20.1	2.86	7.39	6.10	9.84
Thallium (Tl) - dry	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Thallium (Tl) - wet	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tin (Sn) - dry	<0.20	0.24	<0.20	<0.20	<0.20	<0.20
Tin (Sn) - wet	<0.050	0.071	<0.050	<0.050	<0.050	<0.050
Titanium (Ti) - dry	0.54	1.7	<0.50	<0.50	<0.50	1.02
Titanium (Ti) - wet	0.19	0.52	0.16	0.11	0.16	0.35
Uranium (U) - dry	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U) - wet	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	0.0028
Vanadium (V) - dry	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Vanadium (V) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Zinc (Zn) - dry	150	58.9	42.5	63.7	51.5	29.0
Zinc (Zn) - wet	52.2	17.9	14.7	19.4	18.9	9.93

(continued)

Appendix 2
Laboratory Analysis of Plant Tissue Chemistry (continued)

Sample ID	B1PR-CAREX183	PORTSALIX2	B1PR-SALIX160	B1PR-CAREX133	B1PR-SALIX34	B1PR-CAREX81
Date Sampled	21-JUL-07	18-JUL-07	21-JUL-07	21-JUL-07	22-JUL-07	21-JUL-07
Time Sampled	12:42	14:48	14:20	15:02	10:50	16:23
ALS Sample ID	L540099-7	L540099-8	L540099-9	L540099-10	L540099-11	L540099-12
Matrix	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
Physical Tests						
% Moisture	68.1	57.8	58.3	66.9	61.6	66.1
Total Metals						
Aluminum (Al) - dry	20.0	18.0	37.0	21.0	14.0	13.0
Aluminum (Al) - wet	6.4	7.7	15.6	6.8	5.4	4.4
Antimony (Sb) - dry	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Antimony (Sb) - wet	<0.010	<0.010	<0.010	0.014	<0.010	<0.010
Arsenic (As) - dry	0.057	<0.050	<0.050	0.075	<0.050	0.058
Arsenic (As) - wet	0.018	<0.010	<0.010	0.025	<0.010	0.020
Barium (Ba) - dry	37.0	11.9	24.2	13.9	10.1	3.31
Barium (Ba) - wet	11.8	5.01	10.1	4.61	3.87	1.12
Beryllium (Be) - dry	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Beryllium (Be) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bismuth (Bi) - dry	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Bismuth (Bi) - wet	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Cadmium (Cd) - dry	0.146	0.375	0.481	0.200	0.407	0.055
Cadmium (Cd) - wet	0.0465	0.158	0.201	0.0664	0.157	0.0188
Calcium (Ca) - dry	2320	6970	4840	2060	9990	1570
Calcium (Ca) - wet	741	2940	2020	681	3840	534
Chromium (Cr) - dry	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chromium (Cr) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cobalt (Co) - dry	0.35	1.86	5.73	0.28	0.10	0.46
Cobalt (Co) - wet	0.113	0.784	2.39	0.092	0.040	0.156
Copper (Cu) - dry	11.9	4.72	4.58	11.4	4.72	9.83
Copper (Cu) - wet	3.79	1.99	1.91	3.77	1.82	3.34
Iron (Fe) - dry	89.8	53.4	44.5	175	36.9	139
Iron (Fe) - wet	28.7	22.5	18.6	57.9	14.2	47.2
Lead (Pb) - dry	0.12	<0.10	<0.10	0.14	<0.10	<0.10
Lead (Pb) - wet	0.037	0.022	0.041	0.046	0.026	<0.020
Lithium (Li) - dry	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Lithium (Li) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Magnesium (Mg) - dry	1910	4400	2720	1540	3600	1520
Magnesium (Mg) - wet	609	1860	1130	511	1380	517
Manganese (Mn) - dry	268	257	367	223	125	231
Manganese (Mn) - wet	85.5	108	153	73.7	48.0	78.3
Mercury (Hg) - dry	<0.0050	0.0083	0.0077	<0.0050	0.0069	0.0078
Mercury (Hg) - wet	0.0015	0.0035	0.0032	0.0015	0.0027	0.0027
Molybdenum (Mo) - dry	1.23	0.258	0.084	0.528	0.129	0.111
Molybdenum (Mo) - wet	0.392	0.109	0.035	0.175	0.049	0.038
Nickel (Ni) - dry	10.4	1.18	7.05	6.53	1.36	14.6
Nickel (Ni) - wet	3.33	0.50	2.94	2.16	0.52	4.96
Phosphorus (P) - dry	2620	1130	1300	1420	1240	1590
Phosphorus (P) - wet	837	474	544	471	478	538
Potassium (K) - dry	19100	8080	5580	15300	5710	18500
Potassium (K) - wet	6110	3400	2330	5060	2200	6270
Selenium (Se) - dry	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Selenium (Se) - wet	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Sodium (Na) - dry	<300	160	<100	<300	<100	<100
Sodium (Na) - wet	<60	69	<20	<60	<20	<20
Strontium (Sr) - dry	16.2	36.0	39.5	8.95	8.12	3.81
Strontium (Sr) - wet	5.19	15.2	16.5	2.96	3.12	1.29
Thallium (Tl) - dry	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Thallium (Tl) - wet	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tin (Sn) - dry	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Tin (Sn) - wet	<0.050	<0.050	<0.050	0.063	<0.050	<0.050
Titanium (Ti) - dry	<1.5	0.62	<0.50	<1.5	<0.50	<0.50
Titanium (Ti) - wet	<0.30	0.26	0.15	<0.30	0.19	<0.10
Uranium (U) - dry	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U) - wet	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Vanadium (V) - dry	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Vanadium (V) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Zinc (Zn) - dry	43.3	157	240	46.6	25.6	67.1
Zinc (Zn) - wet	13.8	66.3	100	15.4	9.85	22.8

(continued)

Appendix 2
Laboratory Analysis of Plant Tissue Chemistry (continued)

Sample ID	B1PR-ERIO10	PORTSALIX1	B1PR-CAREX203	B1PR-SALIX140	B1PR-SALIX148	B1PR-ERIO170
Date Sampled	22-JUL-07	18-JUL-07	21-JUL-07	21-JUL-07	21-JUL-07	21-JUL-07
Time Sampled	11:25	14:20	12:10	14:50	14:35	13:00
ALS Sample ID	L540099-13	L540099-14	L540099-15	L540099-16	L540099-17	L540099-18
Matrix	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
Physical Tests						
% Moisture	62.3	58.4	62.9	68.1	63.8	62.0
Total Metals						
Aluminum (Al) - dry	13.0	24.0	30.0	35.0	37.0	<10
Aluminum (Al) - wet	5.0	10.1	11.0	11.1	13.3	2.3
Antimony (Sb) - dry	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Antimony (Sb) - wet	0.011	<0.010	0.018	<0.010	<0.010	<0.010
Arsenic (As) - dry	<0.050	<0.050	0.088	<0.050	0.072	<0.050
Arsenic (As) - wet	0.011	<0.010	0.032	0.011	0.026	0.011
Barium (Ba) - dry	8.64	32.7	18.9	24.0	29.1	12.3
Barium (Ba) - wet	3.25	13.6	7.00	7.65	10.5	4.67
Beryllium (Be) - dry	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Beryllium (Be) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bismuth (Bi) - dry	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Bismuth (Bi) - wet	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Cadmium (Cd) - dry	0.038	0.576	0.507	0.810	1.44	0.049
Cadmium (Cd) - wet	0.0145	0.240	0.188	0.259	0.523	0.0186
Calcium (Ca) - dry	959	4660	2140	5320	6610	1080
Calcium (Ca) - wet	361	1940	795	1700	2390	411
Chromium (Cr) - dry	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chromium (Cr) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cobalt (Co) - dry	<0.10	1.29	0.14	2.71	5.28	<0.10
Cobalt (Co) - wet	<0.020	0.536	0.050	0.865	1.91	<0.020
Copper (Cu) - dry	3.15	4.10	11.2	6.14	6.20	4.48
Copper (Cu) - wet	1.19	1.70	4.15	1.96	2.25	1.70
Iron (Fe) - dry	51.0	46.5	168	40.1	82.6	31.0
Iron (Fe) - wet	19.2	19.4	62.2	12.8	29.9	11.8
Lead (Pb) - dry	0.10	<0.10	0.19	0.16	0.16	<0.10
Lead (Pb) - wet	0.038	0.026	0.070	0.052	0.057	0.026
Lithium (Li) - dry	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Lithium (Li) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Magnesium (Mg) - dry	1000	4170	1990	2540	2500	910
Magnesium (Mg) - wet	378	1740	739	810	906	346
Manganese (Mn) - dry	155	104	56.4	199	404	62.7
Manganese (Mn) - wet	58.4	43.3	20.9	63.4	146	23.8
Mercury (Hg) - dry	0.0050	<0.0050	<0.0050	0.0070	<0.0050	<0.0050
Mercury (Hg) - wet	0.0019	0.0014	0.0013	0.0022	0.0016	0.0014
Molybdenum (Mo) - dry	1.16	0.168	0.306	0.186	0.066	0.308
Molybdenum (Mo) - wet	0.436	0.070	0.113	0.059	0.024	0.117
Nickel (Ni) - dry	0.77	2.78	4.45	9.38	8.00	0.72
Nickel (Ni) - wet	0.29	1.16	1.65	3.00	2.90	0.27
Phosphorus (P) - dry	1010	2050	1570	1870	1220	1370
Phosphorus (P) - wet	381	855	582	596	442	520
Potassium (K) - dry	4970	10300	12400	9280	8180	6440
Potassium (K) - wet	1870	4280	4600	2960	2960	2450
Selenium (Se) - dry	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Selenium (Se) - wet	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Sodium (Na) - dry	<100	<300	<300	<100	<300	<100
Sodium (Na) - wet	<20	<60	<60	<20	<60	<20
Strontium (Sr) - dry	3.17	36.2	10.4	42.7	53.2	4.20
Strontium (Sr) - wet	1.19	15.1	3.85	13.7	19.3	1.60
Thallium (Tl) - dry	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Thallium (Tl) - wet	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tin (Sn) - dry	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Tin (Sn) - wet	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Titanium (Ti) - dry	<0.50	<1.5	<1.5	0.56	<1.5	<0.50
Titanium (Ti) - wet	0.12	0.46	<0.30	0.18	<0.30	<0.10
Uranium (U) - dry	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U) - wet	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Vanadium (V) - dry	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Vanadium (V) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Zinc (Zn) - dry	30.8	123	18.3	111	252	28.4
Zinc (Zn) - wet	11.6	51.2	6.80	35.4	91.1	10.8

(continued)

Appendix 2
Laboratory Analysis of Plant Tissue Chemistry (continued)

Sample ID	B1PR-SALIX100	PORTSALIX4	B1PR-SALIX54	B1PR-SALIX54B	B1PR-SALIX148B	B1PR-CAREX25
Date Sampled	21-JUL-07	18-JUL-07	22-JUL-07	22-JUL-07	21-JUL-07	22-JUL-07
Time Sampled	15:50	15:45	10:18	10:21	14:35	11:04
ALS Sample ID	L540099-19	L540099-20	L540099-21	L540099-22	L540099-23	L540099-24
Matrix	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
Physical Tests						
% Moisture	63.0	63.6	61.6	62.9	64.0	62.6
Total Metals						
Aluminum (Al) - dry	36.0	18.0	12.0	11.0	31.0	11.0
Aluminum (Al) - wet	13.4	6.4	4.5	4.1	11.1	4.0
Antimony (Sb) - dry	<0.050	<0.050	<0.050	<0.050	0.064	<0.050
Antimony (Sb) - wet	<0.010	<0.010	<0.010	<0.010	0.023	<0.010
Arsenic (As) - dry	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Arsenic (As) - wet	<0.010	<0.010	<0.010	<0.010	0.016	<0.010
Barium (Ba) - dry	43.4	19.4	9.08	10.4	23.6	22.7
Barium (Ba) - wet	16.1	7.05	3.48	3.88	8.49	8.48
Beryllium (Be) - dry	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Beryllium (Be) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Bismuth (Bi) - dry	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Bismuth (Bi) - wet	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Cadmium (Cd) - dry	1.13	0.684	0.488	0.729	0.978	0.037
Cadmium (Cd) - wet	0.420	0.249	0.187	0.271	0.352	0.0137
Calcium (Ca) - dry	5760	7270	5230	6590	5330	7470
Calcium (Ca) - wet	2130	2640	2010	2450	1920	2790
Chromium (Cr) - dry	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Chromium (Cr) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Cobalt (Co) - dry	5.46	1.07	0.76	1.03	5.46	<0.10
Cobalt (Co) - wet	2.02	0.389	0.292	0.382	1.96	<0.020
Copper (Cu) - dry	4.82	4.44	6.55	6.92	5.34	7.36
Copper (Cu) - wet	1.79	1.61	2.51	2.57	1.92	2.75
Iron (Fe) - dry	43.5	37.8	28.5	28.9	72.9	48.1
Iron (Fe) - wet	16.1	13.7	11.0	10.7	26.2	18.0
Lead (Pb) - dry	0.11	<0.10	<0.10	<0.10	0.26	<0.10
Lead (Pb) - wet	0.040	<0.020	<0.020	<0.020	0.092	0.027
Lithium (Li) - dry	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Lithium (Li) - wet	<0.10	0.16	<0.10	<0.10	<0.10	<0.10
Magnesium (Mg) - dry	4110	5090	2230	2690	2380	2160
Magnesium (Mg) - wet	1520	1850	854	999	857	809
Manganese (Mn) - dry	145	276	213	324	320	59.7
Manganese (Mn) - wet	53.6	100.0	81.8	120	115	22.3
Mercury (Hg) - dry	<0.0050	0.0074	0.0066	0.0067	0.0075	0.0053
Mercury (Hg) - wet	0.0017	0.0027	0.0025	0.0025	0.0027	0.0020
Molybdenum (Mo) - dry	0.145	0.361	0.144	0.153	0.081	4.02
Molybdenum (Mo) - wet	0.054	0.131	0.055	0.057	0.029	1.50
Nickel (Ni) - dry	20.5	3.46	2.07	2.28	6.57	<0.50
Nickel (Ni) - wet	7.60	1.26	0.79	0.85	2.36	0.13
Phosphorus (P) - dry	1590	1480	1460	1490	1160	1110
Phosphorus (P) - wet	589	538	560	554	417	415
Potassium (K) - dry	12000	10800	6940	7470	6770	13100
Potassium (K) - wet	4440	3920	2660	2770	2430	4890
Selenium (Se) - dry	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Selenium (Se) - wet	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Sodium (Na) - dry	<100	<100	<100	<100	<100	<100
Sodium (Na) - wet	<20	36	<20	<20	<20	<20
Strontium (Sr) - dry	54.7	24.9	7.44	9.11	40.2	4.22
Strontium (Sr) - wet	20.3	9.06	2.86	3.38	14.4	1.58
Thallium (Tl) - dry	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Thallium (Tl) - wet	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Tin (Sn) - dry	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Tin (Sn) - wet	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Titanium (Ti) - dry	<0.50	0.56	<0.50	<0.50	0.72	<0.50
Titanium (Ti) - wet	0.17	0.20	0.10	<0.10	0.26	0.16
Uranium (U) - dry	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U) - wet	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Vanadium (V) - dry	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Vanadium (V) - wet	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Zinc (Zn) - dry	34.9	78.4	109	128	193	23.0
Zinc (Zn) - wet	12.9	28.5	41.7	47.7	69.5	8.60

(continued)

Appendix 2
Laboratory Analysis of Plant Tissue Chemistry (completed)

Sample ID	B1PR-CAREX72	B1PR-CAREX63	B1PR-CAREX193
Date Sampled	21-JUL-07	21-JUL-07	21-JUL-07
Time Sampled	16:39	16:54	12:26
ALS Sample ID	L540099-25	L540099-26	L540099-27
Matrix	Tissue	Tissue	Tissue
Physical Tests			
% Moisture	66.7	66.9	70.4
Total Metals			
Aluminum (Al) - dry	22.0	13.0	19.0
Aluminum (Al) - wet	7.4	4.4	5.7
Antimony (Sb) - dry	<0.050	<0.050	<0.050
Antimony (Sb) - wet	<0.010	<0.010	<0.010
Arsenic (As) - dry	0.185	0.123	<0.050
Arsenic (As) - wet	0.061	0.041	0.011
Barium (Ba) - dry	4.43	15.5	20.2
Barium (Ba) - wet	1.48	5.13	5.99
Beryllium (Be) - dry	<0.30	<0.30	<0.30
Beryllium (Be) - wet	<0.10	<0.10	<0.10
Bismuth (Bi) - dry	<0.30	<0.30	<0.30
Bismuth (Bi) - wet	<0.030	<0.030	<0.030
Cadmium (Cd) - dry	0.105	0.117	0.088
Cadmium (Cd) - wet	0.0351	0.0389	0.0261
Calcium (Ca) - dry	2340	2840	2250
Calcium (Ca) - wet	779	940	666
Chromium (Cr) - dry	<0.50	<0.50	<0.50
Chromium (Cr) - wet	<0.10	<0.10	<0.10
Cobalt (Co) - dry	0.53	0.86	0.29
Cobalt (Co) - wet	0.177	0.285	0.087
Copper (Cu) - dry	16.3	11.3	8.19
Copper (Cu) - wet	5.41	3.76	2.42
Iron (Fe) - dry	170	104	74.7
Iron (Fe) - wet	56.7	34.6	22.1
Lead (Pb) - dry	<0.10	<0.10	0.14
Lead (Pb) - wet	<0.020	<0.020	0.042
Lithium (Li) - dry	<0.50	<0.50	<0.50
Lithium (Li) - wet	<0.10	<0.10	<0.10
Magnesium (Mg) - dry	1980	2110	1690
Magnesium (Mg) - wet	660	699	500
Manganese (Mn) - dry	185	491	71.5
Manganese (Mn) - wet	61.7	163	21.2
Mercury (Hg) - dry	0.0060	0.0052	<0.0050
Mercury (Hg) - wet	0.0020	0.0017	0.0014
Molybdenum (Mo) - dry	0.616	2.75	0.596
Molybdenum (Mo) - wet	0.205	0.912	0.177
Nickel (Ni) - dry	11.5	9.24	10.5
Nickel (Ni) - wet	3.83	3.06	3.12
Phosphorus (P) - dry	1330	2300	2070
Phosphorus (P) - wet	443	762	613
Potassium (K) - dry	16100	16600	13700
Potassium (K) - wet	5350	5500	4050
Selenium (Se) - dry	<1.0	<1.0	<1.0
Selenium (Se) - wet	<0.20	<0.20	<0.20
Sodium (Na) - dry	<100	<100	<100
Sodium (Na) - wet	<20	<20	<20
Strontium (Sr) - dry	3.88	8.58	13.8
Strontium (Sr) - wet	1.29	2.84	4.08
Thallium (Tl) - dry	<0.030	<0.030	<0.030
Thallium (Tl) - wet	<0.010	<0.010	<0.010
Tin (Sn) - dry	<0.20	<0.20	<0.20
Tin (Sn) - wet	<0.050	<0.050	<0.050
Titanium (Ti) - dry	0.73	<0.50	0.53
Titanium (Ti) - wet	0.24	<0.10	0.16
Uranium (U) - dry	<0.010	<0.010	<0.010
Uranium (U) - wet	<0.0020	<0.0020	<0.0020
Vanadium (V) - dry	<0.50	<0.50	<0.50
Vanadium (V) - wet	<0.10	<0.10	<0.10
Zinc (Zn) - dry	57.9	31.2	25.4
Zinc (Zn) - wet	19.3	10.3	7.51